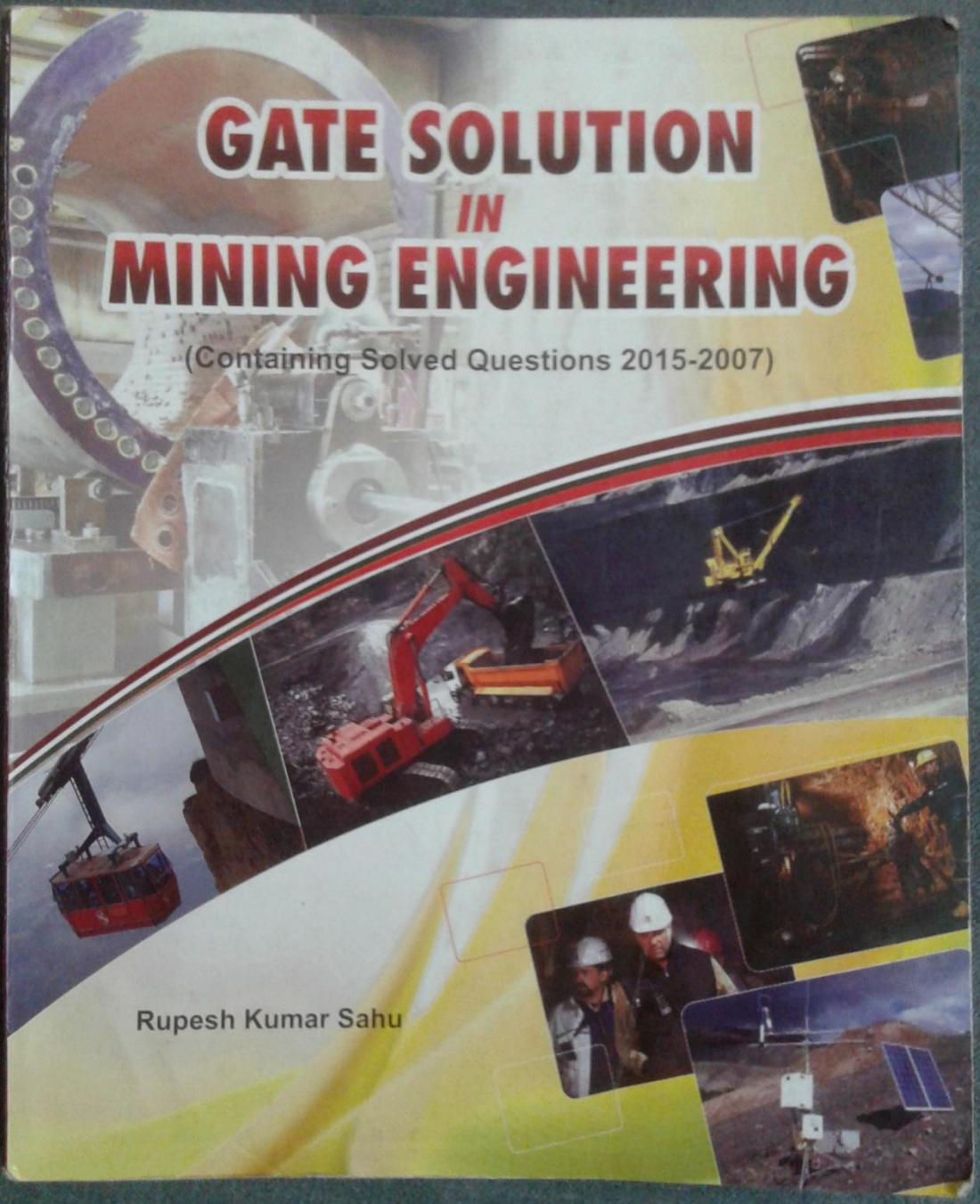
GATE SOLUTION *IN* MINING ENGINEERING

(Containing Solved Questions 2015-2007)



Rupesh Kumar Sahu

GATE SOLUTION IN MINING ENGINEERING

(Containing Solved Questions 2015 - 2007)

By

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Dedicated
to
my mother **Mrs. Santoshi Sahu**
my father **Mr. Khamhan Prasad Sahu**
&
Beloved Friends

PREFACE

I have great pleasure in presenting the book on Gate Solution in Mining Engineering for the student seeking admission to the post graduate course. The book mainly dealt with the numerical questions and their solutions. An attempt has been made to present solutions of Gate Mining questions from 2007 to 2015. The questions have been solved in comprehensible manner thereby creating confidence and encouragement in the aspirants.

I hope that the Gate Mining aspirants will find solution extremely useful. Any suggestions for improving the quality of the Gate Solution shall be thankfully acknowledged and appreciated.

I would like to express sincere thanks to my colleagues Yashwanth Kumar Gujjala, Saumyadeep Paty, Vikas Kumar Sahu, Ashish Sahu, and Mr. Nutan Prakash(presently working as Assistant Manager, Coal India Limited), who encouraged, assisted, without their help publication of this book would not be possible. My thanks will go to Lovely Prakashan, Dhanbad for bringing out this book.

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Contents

	Page
Preface	v
1. Gate Solution 2015	1
2. Gate Solution 2014	47
3. Gate Solution 2013	100
4. Gate Solution 2012	144
5. Gate Solution 2011	190
6. Gate Solution 2010	233
7. Gate Solution 2009	270
8. Gate Solution 2008	302
9. Gate Solution 2007	356
Bibliography	410

Gate solution -2015

Q.1 Out of support categories given for an underground coal mine, identify the 'active support'.

(A) wire mesh

(B) shotcrete

(C) fully grouted roof bolt

(D) hydraulic prop

Answer (D)

Q.2 Massive sandstone in immediate roof delays the local fall in goaf of a coal mine. Under this condition, crushing of the pillars at outbye side is called

(A) coal bump

(B) overriding of pillars.

(C) stiffening of pillars

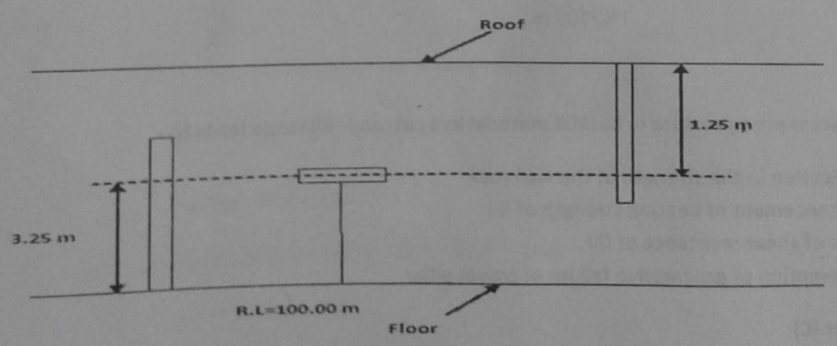
(D) spalling of pillars

Answer (B)

Q.3 A back sight on a bench mark RL 100.00 m on the floor of a tunnel is 3.25 m. The inverse staff reading on a floor station of the tunnel is 1.25 m. The RL of the roof station in m is _____

Answer : 104 to 105 .

Solution .



∴ RL of the roof station is = 100 + 3.25 + 1.25

= 104.5 m

Q.4 The angle in degrees at which a ridge line intersects contours is

(A) 0 (B) 30 (C) 45 (D) 90

Answer (D)

Q.5 In a drum hoisting system through a vertical shaft, overwinding is prevented by

(A) Lilly controller (B) detaching hook
(C) caliper brake (D) safety catch

Answer (B)

Q. 6 The temperature of a parcel of air decreases from 30.2°C to 28.9°C as it rises from an altitude of 20 m to 120 m. The lapse rate for the the atmosphere is

(A) subadiabatic (B) adiabatic (C) superadiabatic (D) transadiabatic

Answer (C)

Solution .

Lapse rate -The rate at which atmospheric temperature decreases with increase in altitude.

Superadiabatic lapse rate - This occurs when the atmosphere temperature drops more than 1°C/100 m.

Q.7 The excess pore pressure in backfill material in a cut- and- fill stope leads to

(A) reduction in the strength of the wall rock
(B) enhancement of bearing strength of fill
(C) loss of shear resistance of fill
(D) prevention of progressive failure of crown pillar

Answer (C)

Q.8 The primary purpose of cut holes for blasting in an underground drivage is to

(A) provide additional free face
(B) have smooth surface after blasting
(C) prevent over-breakage
(D) reduce noise

Answer (A)

Q.9 In a triangle ABC, the bearings of the sides AB, BC and CA are 60^0, 130^0, and 270^0 respectively. The interior angles A,B and C in degrees respectively are

(A) 110, 40, 30

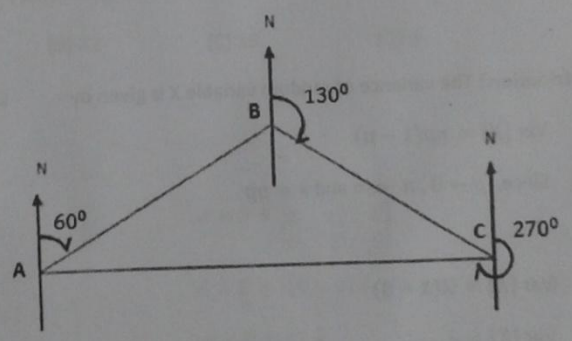
(B) 40, 110, 30

(C) 30, 40, 110

(D) 30, 110, 40

Answer (D)

Solution .



$\because$ bearing of AB = 60^0

$\therefore$ bearing of BA = $60^0 + 180^0 = 240^0$ and

$\because$ bearing of BC = 130^0

$\therefore$ bearing of CB = $130^0 + 180^0 = 310^0$ and

$\because$ bearing of CA = 270^0

$\therefore$ bearing of AC = $270^0 - 180^0 = 90^0$

Therefore ,

$\angle A$ = bearing of AC−bearing of AB

$\angle A = 90^0 - 60^0 = 30^0$, and

$\angle B$ = bearing of BA − bearing of BC

$\angle B = 240^0 - 130^0 = 110^0$, and

$\angle C = 180^0 - \angle B - \angle A = 180^0 - 110^0 - 30^0$

$\angle C = 40^0$

Q.10 **In a binomial distribution, the probability of success p→ 0 and number of trials n → ∞ such that $\lambda = np$ approaches to a finite value. The variance of the distribution is**

(A) npλ (B) nλ (C) pλ (D) λ

Answer (D)

Solution .

In binomial distribution : The variance of random variable X is given by -

$$\text{Var}\,[X] = np(1-p)$$

Since, $p \to 0$, $n \to \infty$ and $\lambda = np$

Therefore,

$$\text{Var}\,[X] = \lambda(1-0)$$

$$\text{Var}\,[X] = \lambda$$

Q.11 **For a function $f(x)$, it is given that $f(0) = 2$ and $f'(0) = 4$. Ignoring all other higher order derivative terms, the value of $f(0.5)$ is _____**

Answer : 4.

Solution .

Suppose that, $f(x) = x^4 + 4x + 2$ .....(1)

When $x = 0$, then

$$f(x) = 2$$

Differentiating equation (1) w.r.t, x, then

$$f'(x) = 4x^3 + 4$$

When $x = 0$, then

$$f'(0) = 4$$

When $x = 0.5$, then from equation (1)

$$f(0.5) = 0.5^4 + 4 \times 0.5 + 2$$

$$f(0.5) = 4$$

Q.12 **The two sides of a parallelogram are given by the vectors $A = 2\hat{i} - 3\hat{j}$ and $B = 3\hat{i} + 2\hat{j}$. The area of the parallelogram is**

(A) 13 **(B) 12** **(C) 10** **(D) 5**

Answer (A)

Solution .

$$A \times B = \begin{vmatrix} i & j & k \\ 2 & -3 & 0 \\ 3 & 2 & 0 \end{vmatrix}$$

$$A \times B = i(0-0) - j(0-0) + k(4+9)$$

$$A \times B = 13\,\hat{k}$$

∴ Area of parallelogram having two side vectors A and B, is given by $= |A \times B|$

$$= |13\,\hat{k}|$$

$$= 13$$

Q.13 **In a BOD test, 5 ml of wastewater is diluted with pure water to fill a 300 ml BOD bottle. The initial and final dissolved oxygen contents of the mix are 9.0 mg/l and 7.0 mg/l respectively.**

The BOD of wastewater, in mg/l, is

(A) 2 (B) 10 (C) 120 (D) 600

Answer (C)

Solution .

We have,

$$C_1 \times V_1 = C_2 \times V_2$$

Or Sample BOD × Sample Volume = BOD Diluted × Volume Diluted

Or BOD Sample = $\frac{BOD\ Diluted}{Sample\ Volume}$ × Volume Diluted

Or BOD Sample (mg/l) = $\frac{D.O.\ Depletion\ (mg/l)}{Sample\ Volume\ (ml)}$ × Volume Diluted (ml)

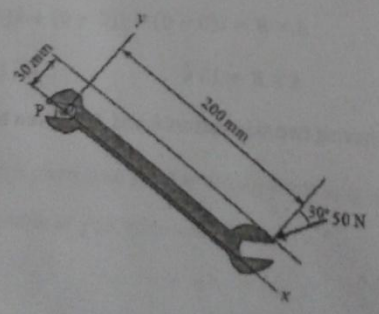
[∵ D.O. Depletion = D.O. Initial − D.O. final or D.O. 5 Day]

∴ Sample BOD in mg/L = $\frac{(9-7) \times 300}{5}$

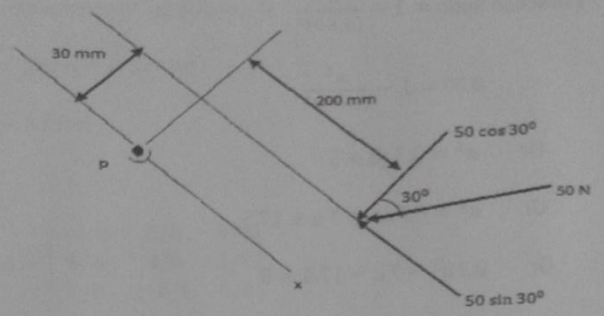
= 120 mg/L

Q.14 A force of 50 N is applied to a wrench as shown in the figure. The magnitude of the moment in N-mm of this force about the point P is _____

Answer : 7900 to 7920.



Solution .



Magnitude of moment about P $= 50 \times \cos 30^0 \times 200 - 50 \times \sin 30^0 \times 30$

$= 7910$ N-mm

Q.15 **Dilatancy of rock is associated with**

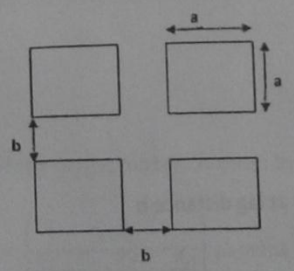
(A) increase in surface area after fragmentation
(B) decrease in volume due to compression of rock
(C) increase in shear strain due to cracking of rock
(D) increase in volume due to cracking of rock

Answer (D)

Q.16 **A bord and pillar panel having square pillars is designed for 30% extraction during development. If the gallery width is 5 m, the side of the pillar in m is _____**

Answer : 25 to 26.

Solution .



$$\text{Extraction Ratio} = 1 - \frac{a^2}{(a+b)^2}$$

$$0.30 = 1 - \frac{a^2}{(a+5)^2}$$

Or $\quad a^2 = 0.7\,(a+5)^2$

Or $\quad a^2 = 0.7\,a^2 + 7\,a + 17.5$

Or $\quad 0.3\,a^2 - 7\,a - 17.5 = 0$

$\therefore \quad a = 25.6\ \&\ -2.28$

Hence, pillar size is 25.6 m.

Q.17 Low shock and high gas pressure explosive is generally used for the blasting of

(A) hard and brittle rock mass
(B)soft and joint rock mass
(C) hard and massive intact rock mass
(D) soft and massive intact rock mass

Answer (B)

Q. 18 The covariance of copper grade for a certain lag distance in an ore body is 6.0 $(\%)^2$. If the sill is 10 $(\%)^2$, the semivariogram for the same lag distance in $(\%)^2$ is

(A) 4.0 (B) 16.0 (C) 2.0 (D) 64.0

Answer (A)

Solution .

We have,

$$\gamma(h) = C - c(h)$$

Where,

$\gamma(h)$ = semivariogram at lag distance h

C = sill

$c(h)$ = covariance at lag distance h

$\therefore \quad \gamma(h) = 10\ (\%)^2 - 6\ (\%)^2$

$\therefore \quad \gamma(h) = 4\ (\%)^2$

Q.19 The matrix $A = \begin{bmatrix} -4/6 & 2/6 & 4/6 \\ 4/6 & 4/6 & 2/6 \\ 2/6 & -4/6 & 4/6 \end{bmatrix}$

(A) orthogonal (B) diagonal (C) skew - symmetry (D) symmetric

Answer (A)

Solution .

$$A = \begin{bmatrix} -4/6 & 2/6 & 4/6 \\ 4/6 & 4/6 & 2/6 \\ 2/6 & -4/6 & 4/6 \end{bmatrix}$$

$$\therefore \quad A' = \begin{bmatrix} -4/6 & 4/6 & 2/6 \\ 2/6 & 4/6 & -4/6 \\ 4/6 & 2/6 & 4/6 \end{bmatrix}$$

$$\therefore \quad AA' = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\therefore \quad AA' = I$$

Q.20 A gas mixture contains CH_4, C_2H_6 and H_2 with respective concentrations of 75%, 15% and 10% by volume. The lower explosibility limit of CH_4, C_2H_6 and H_2 are 5%, 3.3% and 4.2 % respectively. The lower explosibility limit of the gas mixture, in percentage , is _____

Answer : 4.2 to 5.

Solution .

The lower explosibility limit (%) for gas mixture is given by:-

$$X = \left[\frac{100}{\frac{P_1}{N_1} + \frac{P_2}{N_2} + \frac{P_3}{N_3} + \cdots \frac{P_n}{N_n}}\right] \text{percent}$$

Where,

P_1, P_2, P_3 ..... = contents, in percent by volume, of each combustible component of the mixture

N_1, N_2, N_3 ..... = lower explosion limit of each components

$$X = \left[\frac{100}{\frac{95}{5} + \frac{15}{3.3} + \frac{10}{4.2}}\right] \%$$

$$X = 4.56\ \%$$

Q.21 **Intake air containing 0.2% methane enters a section of an underground mine where emission rate of methane is 0.05 m^3/s. Assuming that the threshold limit value of methane is 1.25 %, the minimum quantity of fresh air required in m^3/s is _____**

Answer : 4.6 to 4.9.

Solution .

We have,

$$Q = \frac{100\,q}{C_P - C_a} - q\ ,\ m^3/\text{sec}$$

Where, q = gas emission , m^3/sec

C_a = gas in the intake air, percent

C_P = permissible or safe maximum percent of gas in the return air

$$Q = \frac{100 \times 0.05}{1.25 - 0.2}$$

$$Q = 4.7\ m^3/s$$

Q.22 **In a fully mechanized bord and pillar mining system, winning of coal and its transportation from the face is commonly carried out with the combination of**

(A) Continuous miner ,shuttle car, feeder breaker and belt conveyor
(B) Continuous miner, LHD, feeder breaker and chain conveyor
(C) Continuous miner , SDL, feeder breaker and belt conveyor
(D) Continuous miner, shuttle car, feeder breaker and chain conveyor

Answer (A)

Q.23 An underground coal mine employing 1200 persons experiences 2 fatal injuries, 6 serious injuries and 8 reportable injuries during the year 2013. The total injury rate per 1000 persons employed for the year is _____

Answer : 13.0 to 13.6

Solution .

Total injury rate per 1000 persons employed $= \frac{2+6+8}{1200} \times 1000 = 13.4$

Q.24 In self-contained chemical- oxygen self rescuer, oxygen is produced by

(A) Hopcalite
(B) potassium peroxide
(C) sodium hydroxide
(D) Protosorb

Answer (B)

Q. 25 The failure data of an equipment follows an exponential distribution. If the mean time between failures is 3000 hours, the reliability of the equipment for 750 hours is _____

Answer : 0.75 to 0.81.

Solution .

The reliability that the equipment run up to time t for exponential distribution is given by –

$$R(t) = e^{\frac{-t}{m}} = e^{-\lambda.t}$$

Where,

$m = \frac{1}{\lambda}$ =mean time between failure

Or $\lambda = \frac{1}{m} = \frac{1}{3000}$ per hours

And $t = 750$ hours

$$\therefore \quad R(t) = e^{\frac{-750}{3000}} = 0.78$$

Q.26 **In a 4.2 m wide and 3.0 m high gallery in a coal seam, twelve shot holes are blaster per round. The holes are charged with 2 explosive cartridge of 435 g each. If the powder factor of the blast is 2.2 tonne/kg and specific gravity of coal is 1.4, the pull per round of blast in m is**

(A) 1.45 **(B) 1.70** **(C) 1.30** **(D) 4.06**

Answer (C)

Solution .

we have,

$$\text{Powder factor} = \frac{coal\ produced\ (tonne)}{explosive\ required\ (kg)}$$

$$\therefore \quad 2.2 = \frac{4.2 \times 3 \times pull \times 1.4\ \ per\ round}{12 \times 2 \times \frac{435}{1000}\ per\ round}$$

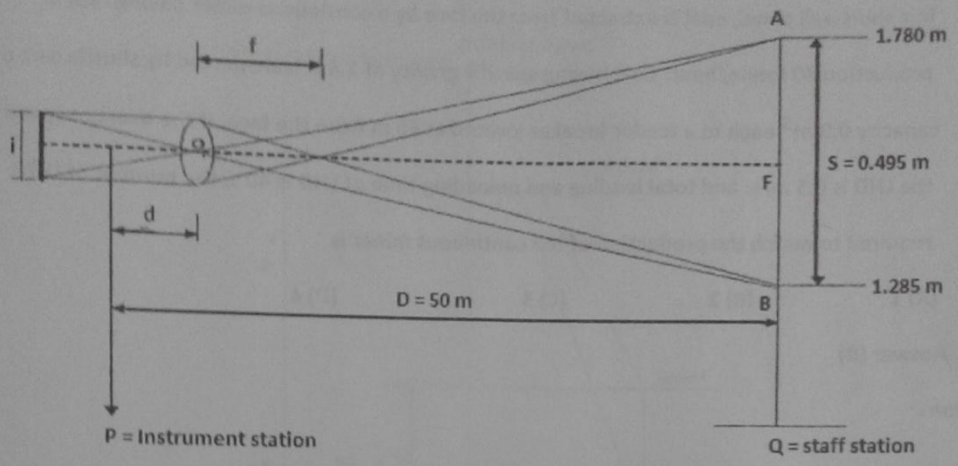
$\therefore$ pull = 1.30 m

Q.27 **The stadia reading with horizontal sight on a vertical staff held at 50 m from a tacheometer are 1.285 and 1.780 m. The focal length of the object glass is 25 cm and the distance between the object glass and the vertical axis of the tacheometer is 15 cm. the stadia interval in mm is**

_____

Answer: 2.48 to 2.52

Solution .



We know,

Multiplying constant (K) = $\frac{f}{i}$

Additive constant (C) = (f + d) and

D = k. s + C

Where, f – focal length

i – stadia interval

D – distance between instrument axis and objective

s – staff intercept

∴ D = k. s + f + d

∴ 50 = k × 0.495 + 0.25 + 0.15

∴ k = 100.2

Now, k = $\frac{f}{i}$

∴ i = $\frac{0.25}{100}$ = 0.00249 m = 2.5 mm

Q. 28 In a shortwall panel, coal is extracted from the face by a continuous miner having rate of production 30 tonne/hour. Coal having specific gravity of 1.4 is transported by shuttle cars of capacity 0.9 m^3 each to a feeder breaker located at 60 m from the face. If the average speed of the LHD is 0.5 m/s. and total loading and unloading time of LHD is 40 s, the number of LHDs required to match the production of the continuous miner is

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

Answer (B)

Solution .

$$\text{Continuous miner production} = 30 \text{ t/h} = \frac{30}{1.4 \times 3600}\ m^3/sec$$

$$= 0.00595\ m^3/sec$$

$$\text{Speed} = \frac{distance}{time}$$

$$0.5 = \frac{60}{time}$$

∴ Travel time = 120 sec and

∴ Cycle time of LHD = $2 \times 120 + 40$ = 280 sec

Coal transported by LHD in one cycle time = 0.00595 ×280

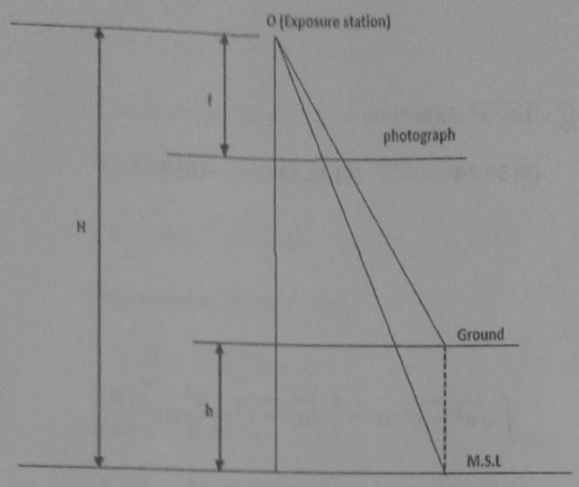
$$= 1.67\ m^3$$

$$\therefore \text{ No. of LHD} = \frac{1.67}{0.9} = 1.9 = 2$$

Q.29 Vertical photographs of an area lying 500 m above the mean sea level are to be taken at a scale of 1:20000 from an aircraft. If the camera has a focal length of 210 mm, the flying height of the aircraft above the mean sea level in m is _____

Answer : 4700.

Solution .



We have ,

$$\text{Scale} = \frac{map\ distance}{ground\ distance}$$

$$S = \frac{f}{H-h}$$

$$\frac{1}{20000} = \frac{0.210}{H-500}$$

$$\therefore \quad H = 4700\ m$$

Q .30 Match the following locations with support types in coal mines.

Location	Support type
P. Roadway junctions	1. powered support
Q. Between adjacent panels	2. Chock and bolt
R. Longwall face	3. Back fill
S. Goaf	4. Barrier pillar

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

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

Answer (C)

Q.31 The value of $\int_0^4 \sqrt{16-x^2}\,dx$ is

(A) 12.57 (B) 50.24 (C) 25.12 (D) 3.14

Answer (A)

Solution .

We have,

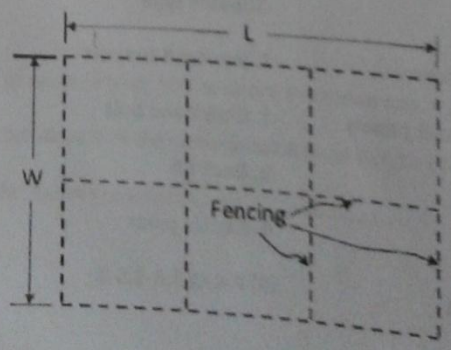
$$\int \sqrt{a^2-x^2}\,dx = \frac{x}{2}\sqrt{a^2-x^2} + \frac{a^2}{2}\sin^{-1}\frac{x}{a}$$

$$\therefore \int \sqrt{4^2-x^2}\,dx = \frac{x}{2}\sqrt{4^2-x^2} + \frac{4^2}{2}\sin^{-1}\frac{x}{4}$$

$$\therefore \int_0^4 \sqrt{4^2-x^2}dx = \left|\frac{x}{2}\sqrt{4^2-x^2} + \frac{4^2}{2}\sin^{-1}\frac{x}{4}\right|_0^4$$

$$\therefore \int_0^4 \sqrt{4^2-x^2}dx = 12.56$$

Q.32 A rectangular field of area 20000 m^2 is to be divided in to 6 different plots by fencing as shown in the figure. The value of L in m for which the total length of fencing becomes minimum is _____



Answer : 161 to 165.

Solution .

Let total fencing length , $Z = 4W + 3L$

$\because$ Area of rectangular = W × L = 20000 m^2

$\therefore \quad Z = 4 \times \frac{20000}{L} + 3L$ .....(1)

Differentiating (1) w. r. t to L

$$\frac{dZ}{dL} = -\frac{80000}{L^2} + 3$$

For minimum value,

$$\frac{dZ}{dL} = 0$$

Hence,

$$-\frac{80000}{L^2} = -3$$

$$\therefore L = 163.3 \text{ m}$$

Q.33 Match the following for a drilling system

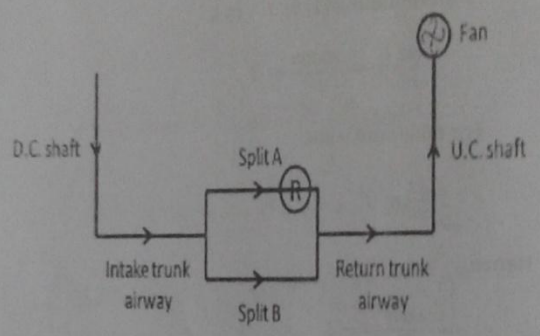
Component	Function
P. Drill	1. Utilization of energy in fragmenting rock
Q. Drill rod	2. Reduction of energy loss due to regrinding
R. Drill bit	3. Conversion of original form of energy in to mechanical energy
S. Flushing medium	4. Transmission of energy from prime mover to applicator

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

Answer (C)

Q.34 For the ventilation system shown, the combined resistance of the trunk airways and the shaft is 2.2 Ns^2m^{-8}. The resistance of the split A and B are 0.5 Ns^2m^{-8} and 0.8 Ns^2m^{-8} respectively. A regulator of size 2.0 m^2 is placed in split A. Considering the fan generates a pressure of 1000 Pa, the air flow in m^3/s in split B is _____

Answer : 10.2 to 10.8.



Solution .

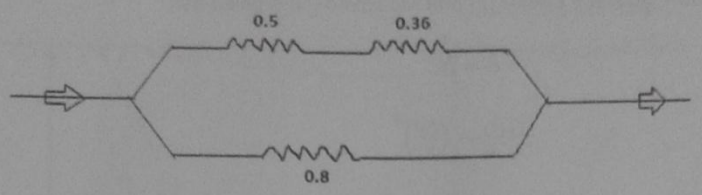
We have,

$$\text{Area of regulator} = \frac{1.2}{\sqrt{R}}, m^2$$

Where, R - resistance of regulator

$$\therefore \quad 2 = \frac{1.2}{\sqrt{R}},$$

$$\therefore \quad R = 0.36\ Ns^2m^{-8}$$



$$\frac{1}{\sqrt{R_1}} = \frac{1}{\sqrt{0.5 + 0.36}} + \frac{1}{\sqrt{0.8}}$$

$\therefore \quad R_1 = 0.2\ Ns^2m^{-8}$

Total resistance of mine = 2.2 + 0.2 = 2.4 Ns^2m^{-8}

$\because \quad P = R_T.Q^2{}_T$

$\therefore \quad 1000 = 2.4 \times Q^2{}_T$

$\therefore \quad Q_T = 20.4\ m^3/sec$

Here , Pressure drop = pressure drop in trunk roadway + pressure drop in split A

$1000 = 2.2 \times (20.4)^2 + 0.86 \times Q^2{}_A$

$\therefore \quad Q_A = 9.9\ m^3/sec$ and

Now, $\quad Q_T = Q_A + Q_B$

$20.3 = 9.9 + Q_B$

$\therefore \quad Q_B = 10.5\ m^3/sec$

Q.35 A mine fan running at 300 rpm delivers 150 m^3/s of air at a pressure of 900 Pa. Fan and motor efficiencies are 75% and 90% respectively. If the fan speed is reduced to 250 rpm, the saving in electric power input to motor in kW is _____

Answer : 82 to 86.

Solution .

Actual power developed $(P_{ac}) = PQ \times 10^{-3} kW$

$$P_{ac} = 900 \times 150 \times 10^{-3} = 135\ kW$$

The relation between power (P) and fan speed (N) is given by-

$$P \propto N^3$$

$$\therefore \quad \frac{(P_{ac})_1}{(P_{ac})_2} = \left(\frac{N_1}{N_2}\right)^3$$

$$\frac{135}{(P_{ac})_2} = \left(\frac{300}{250}\right)^3$$

$$\therefore \quad (P_{ac})_2 = 78.12\ kW$$

$\because$ Input power to the motor = $\dfrac{output\ power}{efficiency}$

Therefore ,

Saving in electric power input to the motor $= \dfrac{135 - 78.12}{0.75 \times 0.90}$,kW

= 84.27 kW

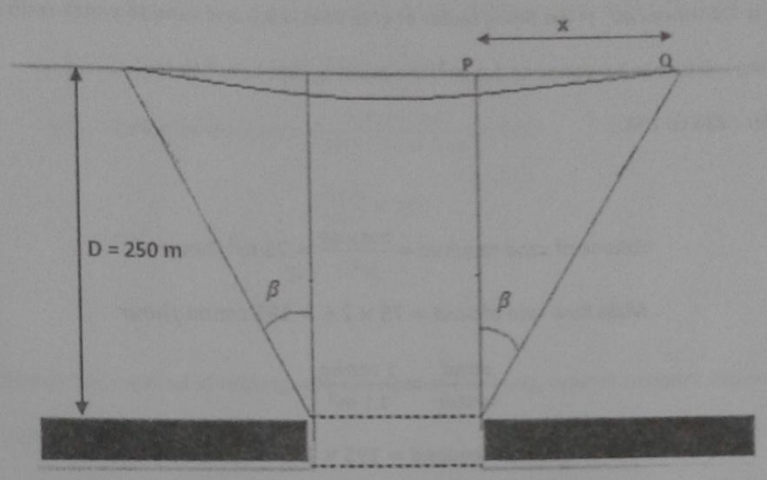
Q.36 **Subsidence profile function , s(x), along the lateral cross- section over a flat longwall panel is given as**

$$s(x) = 0.8\left[0.996 - \tan h\left(\frac{8.3\,x}{D}\right)\right], m$$

Where x = distance (m) from the inflection point and D = depth (m) of seam. Considering that the inflection point lies vertically above the edge of the panel, the angle of draw in degrees for a depth of 250 m is _____

Answer : 20 to 21.

Solution .



Where,

P - point of inflection

Q - point of zero subsidence

$$s(x) = 0.8\left[0.996 - \tan h\left(\frac{8.3\,x}{D}\right)\right], \text{m}$$

At point Q , $s(x) = 0$; then

$$0 = 0.8\left[0.996 - \tan h\left(\frac{8.3\,x}{250}\right)\right]$$

$$0.0332x = \tan h^{-1}(0.996)$$

$$0.0332x = \frac{1}{2}\,ln\left(\frac{1 + 0.996}{1 - 0.996}\right)$$

$$\therefore \qquad x = 93.56\,m$$

Therefore,

$$\text{Angle of draw } (\beta) = \tan^{-1}\left(\frac{93.26}{250}\right)$$

$$\therefore \qquad \beta = 20.5^0$$

Q. 37 A goaf void of 250 m^3 is filled in 3 hours by hydraulic sand stowing method. Density of the

sand is 2.6 tonne/m^3. If the filling factor of goaf void is 0.9 and sand to water ratio in the stowing mixture is 1.0 tonne to 1.1 m^3, the stowing rate in m^3/h is _____

Answer : 286 to 293.

Solution .

$$\text{Volume of sand required} = \frac{250 \times 0.9}{3} = 75\ m^3/hour$$

$$\text{Mass flow rate of sand} = 75 \times 2.6 = 195\ tonne\ /hour$$

$$\because \quad \frac{sand}{water} = \frac{1\ tonne}{1.1\ m^3}$$

$$\text{Volume of water required} = 195 \times 1.1 = 214.5\ m^3/hour$$

Hence,

$$\text{Stowing rate} = volume\ of\ (water + sand) required\ , m^3/hour$$

$$= 75 + 214.5, m^3/hour$$

$$= 289.5\ m^3\ /\text{hour}$$

Q.38 A single-acting reciprocating pump delivers 0.018 m^3/s of water when running at 45 cycles per minute. The piston diameter is 300 mm and stroke length is 400 mm. The volumetric efficiency of the pump in % is _____

Answer : 83 to 87.

Solution .

$$\text{Volumetric displacement} = \text{piston area} \times \text{stroke length}$$

$$= \frac{\pi}{4} \times 0.3^2 \times 0.4\ , m^3$$

$$= 0.028\ m^3$$

$$\text{Theoretical discharge} = \text{volumetric displacement} \times \text{rpm}$$

$$= 0.028 \times 45\ m^3/min$$

$$= 0.021\ m^3/sec$$

$$\because \text{volumetric efficiency } (\eta_v) = \frac{Actual\ flow}{Theoritical\ flow} \times 100$$

$$= \frac{0.018}{0.021} \times 100$$

$$\eta_v = 86\ \%$$

Q.39 Match the method of mining with strength of ore body, type of support and ore body geometry

Strength	Support	Geometry	Method
P. Strong	L. Unsupported	X. Tabular and steep	1.Cut –and- fill
Q. Moderate	M. Artificially supported	Y. Tabular and flat	2. Block caving
R. Weak	N. Self supporting	Z. Massive and steep	3. Room and pillar

(A) P-M-X-3, Q-N-Z-2, R-L-Y-1

(B) P-L-X-1, Q-N-Z-3, R-M-Y-2

(C) P-N-Y-3, Q-M-X-1, R-L-Z-2

(D) P-L-Z-1, Q-N-Y-3, R-M-X-2

Answer (C)

Q.40 A mine air samples contains $CH_4, CO, H_2, N_2 and\ O_2$. The mine air analysis using Haldane apparatus gives the following results expressed in percentage of total sample volume.

Total contraction after combustion : 10.0

CO_2 formed after combustion : 6.0

O_2 consumed in combustion : 9.5

The percentage of CH_4 in the sample analysed is _____

Answer : 3.8 to 4.2.

Solution .

Hydrogen, methane and carbon dioxide react with oxygen as follows :-

$$2H_2 + O_2 = 2H_2O \text{ .....(1)}$$

$$CH_4 + 2O_2 = CO_2 + 2H_2O \text{ .....(2)}$$

$$2CO + O_2 = 2CO_2 \text{ .....(3)}$$

From equation (1), (2) & (3), the following relations are obtained :-

$$\text{Contraction} = \frac{3}{2}H_2 + 2CH_4 - \frac{1}{2}CO \text{ .....(4)}$$

$$\text{Carbon dioxide} = CH_4 + CO \text{ .....(5)}$$

$$\text{Oxygen consumed} = \frac{1}{2}H_2 + 2CH_4 + \frac{1}{2}CO \text{ .....(6)}$$

From equation (4), (5) & (6)

$$H_2 = \text{Contraction} - \text{oxygen consumed} \text{ .....(7)}$$

$$CH_4 = \frac{2 \times contraction - CO_2}{3} - H_2 \text{ .....(8)}$$

$$\therefore \quad H_2 = 10 - 9.5 = 0.5\%$$

$$\therefore \quad CH_4 = \frac{2 \times 10 - 6}{3} - 0.5 = 4.2\ \%$$

Q.41 **The initial investment for a small scale mining project is Rs. 5.0 crore. Annual cash inflow for a life period of 4 years is given below.**

Year	Cash inflow (Rs. crore)
1	1.5
2	2.0
3	2.0
4	1.5

The net present value of the project at an annual discount rate of 10 % in Rs. crore is _____

Answer : 0.5 to 0.6.

Solution .

We have,

$$\text{Net present value} = -X + \frac{R_1}{(1+i)} + \frac{R_2}{(1+i)^2} + \cdots + \frac{R_n}{(1+i)^n}$$

$$\text{NPV} = -5 + \frac{1.5}{(1+0.1)} + \frac{2}{(1+0.1)^2} + \frac{2}{(1+0.1)^3} + \frac{1.5}{(1+0.1)^4}$$

$\therefore$ NPV = 0.6 Crore rupees

Q.42 Given the following linear programming problem,

Maximize $z = 3x_1 + 4x_2$

Subject to $2x_1 + x_2 \leq 6$

$2x_1 + 3x_2 \leq 9$

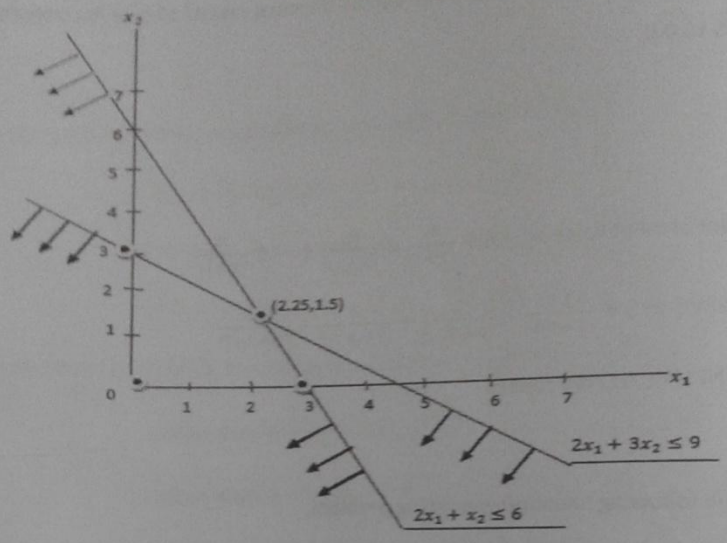
$x_1 \geq 0, x_2 \geq 0$

The corner point feasible solution in terms of (x_1, x_2) is

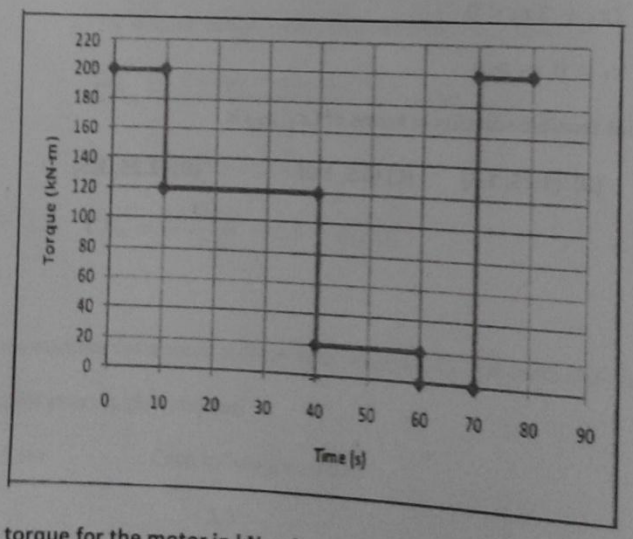
(A) (1.5,0) (B) (1.25, 1.5) (C) (0.5, 1.0) (D) (2.25, 1.5)

Answer (D)

Solution .



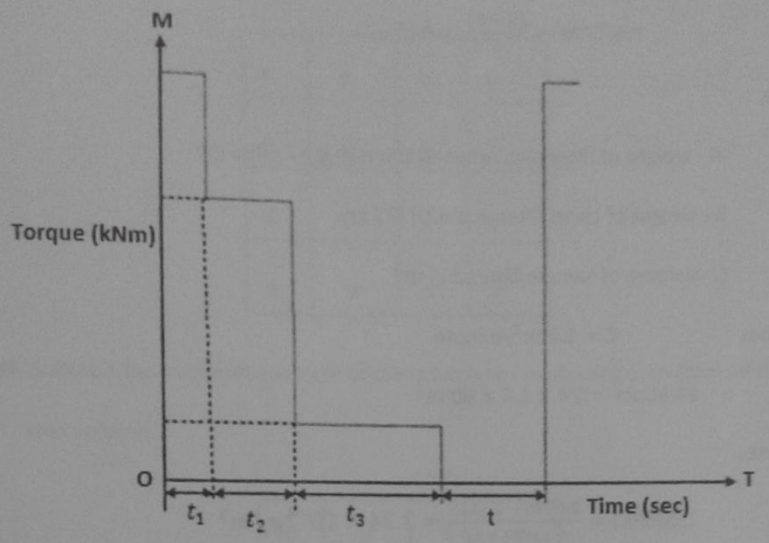
Q. 43 The 3 period torque – time diagram of a stastically balanced hoist is shown in the figure.



The rms torque for the motor in kN-m is _____

Answer : 106 and 113 .

Solution .



$$\text{r.m.s torque, } M_{rms} = \sqrt{\frac{\sum_0^{n_i}\int_0^{t_i} M^2 dt}{T+t}}$$

where,

$$T = t_1 + t_2 + t_3 = \text{running time and } t = rest\ time$$

$$\text{r.m.s torque, } M_{rms} = \sqrt{\frac{200^2 \times 10 + 120^2 \times 30 + 20^2 \times 20}{10 + 30 + 20 + 10}}$$

$$\therefore \quad M_{rms} = 109.55\ kN.m$$

Q.44 **Airborne PM_{10} concentration in a residential area is monitored for 24 hours by a respirable dust sampler. Initial and final weights of the filter paper are 2.3125 g and 2.6996 g respectively. The average airflow rate during sampling is $1.2\ m^3/min$. The PM_{10} concentration of the area in μgm^{-3} is _____**

Answer : 220 and 228.

Solution .

Total suspended solids/suspended particulate matter is given by-

$$\text{TSS/SPM} = \frac{(A-B)}{C}, g/m^3$$

Where,

A - weight of filter plus retained solids in g =2.6996 gm

B - weight of clean filter in g =2.3125 gm

C - volume of sample filtered in m^3

Given that C = $1.2\, m^3$/minute

$\therefore$ 24 hours = $24 \times 1.4 \times 60\, m^3$

Therefore,

$$\text{TSS/SPM} = \frac{2.6996 - 2.3125}{1.2 \times 24 \times 60} = 2.24 \times 10^{-4} g/m^3$$

$$\text{TSS/SPM} = 224\, \mu g/m^3$$

Q.45 **The assignment problem given requires four different jobs to be done on four different machines.**

Job	Machine			
	M_1	M_2	M_3	M_4
J_1	27	35	36	30
J_2	33	37	36	35
J_3	30	26	28	24
J_4	38	29	35	33

The minimum cost of assignment is _____

Answer : 116.

Solution .

Step 01. Subtract the smallest element of each row from all the element of the row . S o there will be at least one zero in each row.

0	8	9	3
0	4	3	2
6	2	4	0
9	0	6	4

Step 02. Subtract the minimum element of the column not containing zero from all the elements of that column.

0	8	6	3
0	4	0	2
6	2	1	0
9	0	3	4

Step 03. Draws minimum number of lines to cover all the zeros in the table. If number of lines drawn equal to the order of the matrix, then optimum solution is obtained. If not, then subtract the smallest uncovered element from all the uncovered elements . add it to the elements that lies at the intersection of lines.

0	8	6	3
0	4	0	2
6	2	1	0
9	0	3	4

Step 04. Examine rows successively until a row with exactly one unmarked zero is found. Mark (□) this zero. Mark (X) all other zeros in the same column .

$\boxed{0}$	8	6	3
0	4	$\boxed{0}$	2
6	2	1	$\boxed{0}$
9	$\boxed{0}$	3	4

This is feasible solution.

Hence,

$$\text{Minimum cost of assignment} = 27 + 36 + 24 + 29$$

$$= 116$$

Q. 46 Acceleration of a particle moving in a straight line is expressed by

$$\frac{d^2s}{dt^2} = 2t$$

Where, s denotes distance (m) and t , time (s). At time t=0, the distance and velocity of the particle are 0 m and 3 m/s respectively. The distance travelled by the particle in m after 3 s is

(A)3 (B) 6 (C) 9 (D) 18

Answer (D)

Solution .

$$\frac{d^2s}{dt^2} = 2\,t$$

Or $a = 2t$

Or $\frac{dv}{dt} = 2t$

Now, $\int dv = \int 2t\, dt$

$V = t^2 + c$ .....(1)

at $t = 0$

$V = 3$

$\therefore \quad 3 = 0 + c$

$\therefore \quad C = 3$

Equation (1) becomes,

$V = t^2 + 3$.....(2)

Or $\frac{ds}{dt} = t^2 + 3$

$\int ds = \int (t^2 + 3)\, dt$

$s = \frac{t^3}{3} + 3t + k$ .....(3)

at $t = 0$

$s = 0$

$\therefore \quad 0 = 0 + 0 + k$

$K = 0$

Equation (3) becomes

$S = \frac{t^3}{3} + 3t$

at $t = 3$ sec

$s = 18$ m

Q .47 Rock bolt have length L = (150 + X) cm, where X is a random variable with probability density function

$$f(x) = \frac{1}{4}(1-3x), if -2 \le x \le 2$$

$$0, \quad \text{otherwise}$$

If 95% bolt length (L) lie in the interval 150 - c to 150 + c cm, the value of c is_____

Answer : 1.88 to 1.92.

Solution .

Probability density function of random variable X is defined by-

$$\int_{-\infty}^{+\infty} f(x)\, dx = 1$$

Here, $\int_{-c}^{+c} \frac{1}{4}(1-3x)dx = 0.95$

$$\left[\frac{1}{4}x - \frac{1}{4}.\frac{3x^2}{2}\right]_{-c}^{+c} = 0.95$$

$$\frac{1}{4}c - \frac{1}{4}.\frac{3c^2}{2} + \frac{1}{4}c + \frac{1}{4}.\frac{3c^2}{2} = 0.95$$

$$\frac{1}{2}c = 0.95$$

$$\therefore \quad c = 1.90$$

Q. 48 The properties for a bivariate distribution of two random variables X and Y are given below.

$E(X) = 24,\ E(Y) = 36,\ E(X^2) = 702,\ E(Y^2) = 1524,\ E(XY) = 1004$

The correlation coefficient between X and Y is _____

Answer : 0.8 and 0.85

Solution .

The correlation coefficient of the bivariate distributed random variable X and Y is-

$$\text{Corr}(X,Y) = \frac{Cov\,(X,Y)}{\sigma_X . \sigma_Y} \quad \text{.....(1)}$$

Where,

Cov (X,Y) = covariance between bivariate distributed random variables X and Y

Corr (X,Y) $= E(XY) - \mu_x\mu_y$

E(X) = μ_x = mean value of X

E(Y) = μ_y = mean value of Y , and

Variance of X = $\sigma^2{}_x = E(X^2) - [E(X)]^2$

Variance of Y = $\sigma^2{}_y = E(Y^2) - [E(Y)]^2$

Therefore,

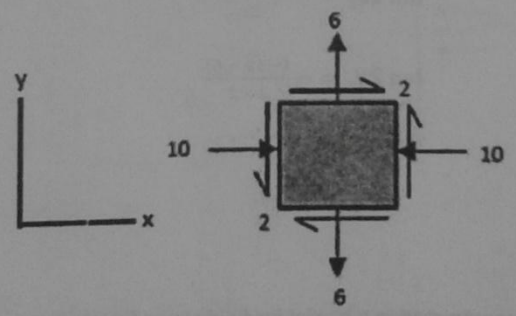
From equation (1)

$$\text{Corr (X,Y)} = \frac{E(XY) - \mu_x\mu_y}{\sqrt{E(X^2) - [E(X)]^2}\sqrt{E(Y^2) - [E(Y)]^2}}$$

$$\text{Corr (X,Y)} = \frac{1004 - 24 \times 36}{\sqrt{702 - 24^2}\sqrt{1524 - 36^2}}$$

Corr (X,Y) = 0.83

Q. 49 Biaxial stresses at a point inside a pillar are shown in the figure.



All stress values are in Mpa

The magnitude of the maximum shear stress in MPa and its direction with the x-axis in degrees at the same point respectively are

(A) 8.25, 37.98 (B) 7.49, 37.98 (C) 8.25, 52.02 (D) 7.49, 52.02

Answer (A)

Solution .

$$\text{Here, } \sigma_{xx} = -10\ MPa$$

$$\sigma_{yy} = 6\ MPa$$

$$\tau_{xy} = 2\ MPa$$

Principal stresses :- considering $\sigma_1 > \sigma_3$

$$\sigma_{1,3} = \left(\frac{\sigma_{xx} + \sigma_{yy}}{2}\right) \pm \sqrt{\frac{1}{4}\left(\sigma_{xx} - \sigma_{yy}\right)^2 + \tau^2{}_{xy}}$$

$$\sigma_{1,3} = \left(\frac{-10 + 6}{2}\right) \pm \sqrt{\frac{1}{4}(-10 - 6)^2 + 2^2}$$

$$\sigma_{1,3} = -2 \pm 8.25$$

$\sigma_1 = 6.25$ MPa ($\because$ taking +ve) and

$\sigma_3 = -10$ MPa ($\because$ taking $-$ve)

$\therefore$ Maximum shear stress (τ_{max}) $= \frac{\sigma_1 - \sigma_3}{2} = 8.25$ MPa , and

Direction of shear stress with x- axis is given by:-

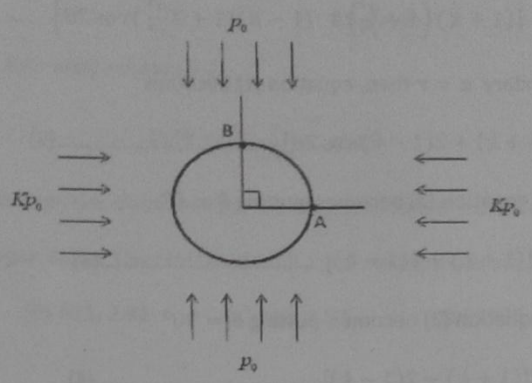
$$\tan 2\theta_s = -\frac{(\sigma_{xx} - \sigma_{yy})}{2\tau_{xy}}$$

$$\tan 2\theta_s = -\frac{(-10 - 6)}{2 \times 2}$$

$$\tan 2\theta_s = 4$$

$$\therefore\ \theta_s = 37.98^0$$

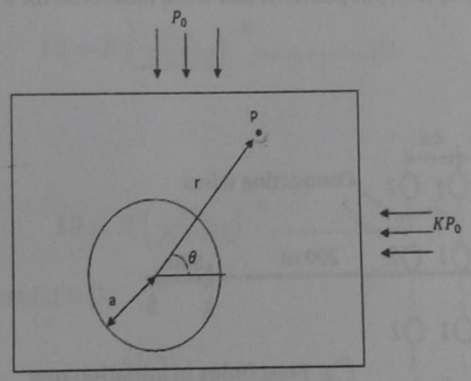
Q.50 **A circular tunnel is constructed in a biaxial far field stress (vertical stress p_0 and horizontal stress Kp_0) as shown in the figure.**

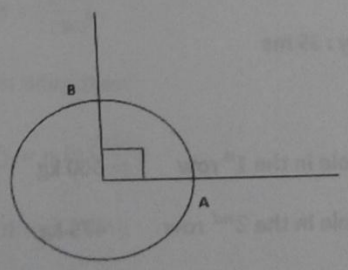


If the ratio of the tangential stress measured at the boundary points A and B is 3:1, the value of K is _____

Answer : 0.6.

Solution .





Tangential stress(σ_θ) is given by:

$$\sigma_{\theta\theta} = \frac{1}{2}P_z \left\{(1+K)\left(1+\frac{a^2}{r^2}\right) + (1-K)(1+3\frac{a^4}{r^4})\cos 2\theta\right\} \text{.....(1)}$$

But at boundary $a = r$ then, equation (1) becomes

$$\sigma_{\theta\theta} = P[(1+k) + 2(1-k)\cos 2\theta] \text{ .....(2)}$$

At point A, equation (2) becomes ,putting $\theta = 0^o$

$$(\sigma_{\theta\theta})_A = P[(1+k) + 2(1-k)] \text{ .....(3)}$$

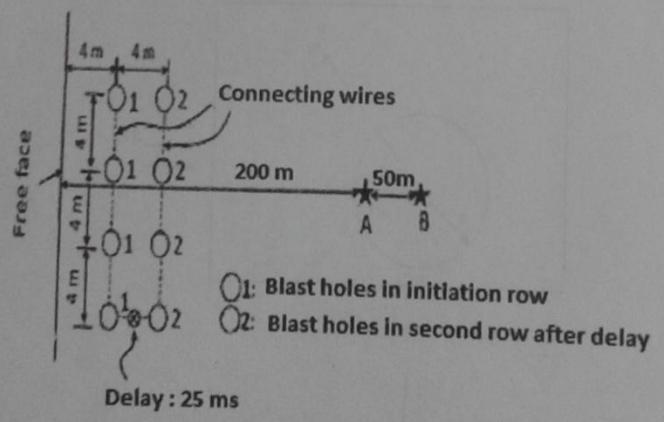
At point B equation (2) becomes, putting $\theta = 90^o$

$$(\sigma_{\theta\theta})_B = P[(1+k) - 2(1-k)] \text{ .....(4)}$$

$$\therefore \quad \frac{(\sigma_{\theta\theta})_A}{(\sigma_{\theta\theta})_B} = \frac{3}{1} = \frac{P\,[(1+k)+2(1-k)]}{P[(1+k)-2(1-k)]}$$

$$\therefore \quad k = 0.6$$

Q.51 **Peak particle velocity (PPV) at points A and B are measured for a blast pattern as shown in the figure.**



The relevant data are :

Amount of explosive per hole in the 1st row : 500 kg

Amount of explosive per hole in the 2nd row : 475 kg

PPV at point A : 18 mm/s

PPV at point B : 10 mm/s

Considering the following relationship,

$$PPV = K\left(\frac{D}{\sqrt{Q}}\right)^{-n}, \text{mm/s}$$

Where D (in m) denotes the distance from the blast row to the measuring point and Q (in kg), maximum charge per delay. The site constant K and n respectively are

(A) 1002, 3.13 (B) 622, 2.92 (C) 823, 2.59 (D) 1245, 2.99

Answer (C)

Solution .

We have,

$$PPV = K\left(\frac{D}{\sqrt{Q}}\right)^{-n}, \text{mm/sec}$$

At point A,

$$18 = K\left(\frac{196}{\sqrt{4 \times 500}}\right)^{-n} \text{.....(1)}$$

At point B,

$$10 = K\left(\frac{246}{\sqrt{4 \times 500}}\right)^{-n} \text{.....(2)}$$

From equation (1) & (2)

$$1.8 = \left(\frac{196}{246}\right)^{-n}$$

Or $$1.8 = \left(\frac{246}{196}\right)^{n}$$

Taking logarithm both sides, then

$$\ln(1.8) = n\, ln\left(\frac{246}{196}\right)$$

$$\therefore\ n = 2.5868$$

Putting n = 2.59, in equation (1), then

$\therefore$ K = 823

Q.52 Copper ore of average grade 0.65% is mined, milled, smelted and then refined. The following information is available:

Mill recovery rate	: 85%
Average grade in mill concentrate	: 20%
Loss in smelting process	: 5 kg/tonne of concentrate
Loss in refining process	: 2 kg/tonne of blister copper

The amount of refined copper obtained per tonne of ore in kg is

(A) 5.10 (B) 5.37 (C) 5.52 (D) 6.50

Answer (B)

Solution .

Grade of ore = 0.65 %

a) Copper content per tonne of ore $= \frac{0.65}{100} \times 1000 = 6.5\ kg$

b) Copper recovered by mill $= 6.5 \times \frac{85}{100} = 5.52\ kg$

c) Concentration ratio (r) $= \frac{amount\ of\ copper\ per\ tonne\ of\ concentrate}{amount\ of\ copper\ per\ tonne\ of\ ore}$

Now,

100 kg of concentrate has = 20 kg of copper

1000 kg of concentrate has = 200 kg of copper

$$\therefore r = \frac{200}{5.52} = 36.23$$

d) smelting loss per tonne of ore = 5 kg/tonne of concentrate

= 5 kg/36.17 tonne of ore

$\therefore$ smelting loss = 0.138 kg/tonne of ore

Blister copper produced per tonne of ore = 5.52 − 0.138 = 5.38 kg

e) Refinery loss for 5.38 kg of blister copper $= \frac{2 \times 5.38}{1000} = 0.0107$ kg

Hence,

Refined copper produced per tonne of ore = 5.38 – 0.0107

= 5.37 kg

Q.53 **The ratio of horizontal to vertical in-situ stresses, K, at a mine field varies with depth, D (in m) as**

$$K = \frac{267}{D} + 1.25$$

If the unit weight of overburden rock is 25 kN/m^3 , the horizontal stress in MPa at a depth of 400 m is _____

Answer : 19.10 and 19.25.

Solution .

Vertical stress (σ_V) = $\gamma\ h$

Where,

γ- unit weight of rock

h – depth below earth surface

σ_V = 25 × 400 = 10000 kN/m^3, and

$$K = \frac{267}{D} + 1.25$$

$$K = \frac{267}{400} + 1.25$$

$$K = 1.9175$$

Now, relation between horizontal stress (σ_h) and vertical stress (σ_v) is given by-

σ_h = k. σ_V

= 1.9175 × 10000 kN/m^3

$\therefore \quad \sigma_h = 19.2$ MPa

Q.54 A coal seam of 2 m thickness is extracted by a longwall retreating panel with face length of 120 m. Web depth of shearer is 0.6 m. Average manpower in the longwall face in a shift is 20. The specific gravity of in-situ coal is 1.4. If the shearer makes 4 full-face cuts in 3 shifts, the face OMS in tonne is _____

Answer : 13 to 14.

Solution .

$$\text{OMS} = \frac{production\ in\ one\ shift\ (tonne)}{numbers\ of\ workers\ in\ one\ shift}$$

In 3 shift = 4 full face cut , then

In 1 shift = $\frac{4}{3}$ full face cut = 1.34 full face cut

$$\text{OMS} = \frac{production\ in\ one\ shift\ (tonne)}{numbers\ of\ workers\ in\ one\ shift}$$

$$\text{OMS} = \frac{2 \times 120 \times 0.6 \times 1.4 \times 1.34}{20}$$

$$\text{OMS} = 13.5\ tonnes$$

Or

$$\text{OMS} = \frac{production\ in\ three\ shifts\ (tonne)}{numbers\ of\ workers\ in\ three\ shifts}$$

$$\text{OMS} = \frac{2 \times 120 \times 0.6 \times 1.4 \times 4}{3 \times 20}$$

$$\text{OMS} = 13.5\ tonnes$$

Q.55 A loaded dumper of total mass 75 tonne, having wheel diameter 1250 mm, runs on a haul road which offers an average specific rolling resistance of 260 N/tonne. The engine develops

an axle torque of 15 kN-m. The starting acceleration of the dumper in m/s^2 is_____

Answer : 0.055 and 0.065

Solution -

We know,

$$\text{Torque} = \text{Tractive force} \times \text{radius}$$

$$15 \text{ kN.m} = \text{Tractive force} \times \frac{1.25}{2}$$

$$\therefore \text{ Tractive force} = 24\ kN$$

The tractive force exerted by engine is given by :-

$$\text{Tractive force} = \text{accelerating force} + \text{frictional resistance}$$

$$24 = \text{accelerating force} + \frac{75 \times 260}{1000}$$

$\therefore$ Accelerating force = 4.5 kN = 4500 N

Now, Accelerating force = Mass ×acceleration

$$4500 = 75000 \times \text{acceleration}$$

$$\therefore \text{ Acceleration} = 0.6\ m^2/sec$$

Q.56 Choose the appropriate word/phrase ,out of the four options given below, to complete the following sentence:

Apparent lifelessness _____ dormant life.

(A) harbours (B) leads to (C) supports (D) affects

Answer (A)

Q.57 Fill in the blank with correct idiom/phrase.

That boy from the town was a _____ in the sleepy village.

(A) dog out of herd (B) sheep from the heap

(C) fish out of water (D) bird from the flock

Answer (C)

Q.58 Choose the statement where underlined word is used correctly.

(A) When the teacher eludes to different authors, he is being elusive.

(B) When the thief keeps eluding the police, he is being elusive.

(C) Matters that are difficult to understand, identify or remember are allusive.

(D)Mirages can be allusive, but a better way to express them is illusory.

Answer (B)

Q.59 Tanya is older than Eric.

Cliff is older than Tanya.

Eric is older than Cliff.

If the first two statements are true, then the third statement is :

(A) True

(B) False

(C) Uncertain

(D) Data insufficient

Answer (B)

Q.60 Five teams have to complete in a league, with every team playing every other team exactly once, before going to the next round. How many matches will have to be held to complete the league round of matches ?

(A) 20 (B) 10 (C) 8 (D) 5

Answer (B)

Solution .

The number of all combinations of n things, taken r at a time is :-

$$n_{C_r} = \frac{n!}{r!\,(n-r)!}$$

$$5_{C_2} = \frac{5!}{2!\,(5-2)!}$$

$$= \frac{5 \times 4}{2}$$

$$5_{C_2} = 10$$

Q.61 Select the appropriate option in place of underlined part of sentence.

Increased productivity necessary reflects greater efforts made by the employees.

(A) Increases in productivity necessary
(B) Increase productivity is necessary
(C) Increase in productivity necessarily
(D) No improvement required

Answer (C)

Q.62 Given below are two statements followed by two conclusions. Assuming these statements to be true, decide which one logically follows.

Statements :

1. No manager is leader.
2. All leaders are executives.

Conclusions :

1. No manager is an executive.

2. No executive is a manager.

(A) Only conclusion 1 follows.

(B) Only conclusion 2 follows.

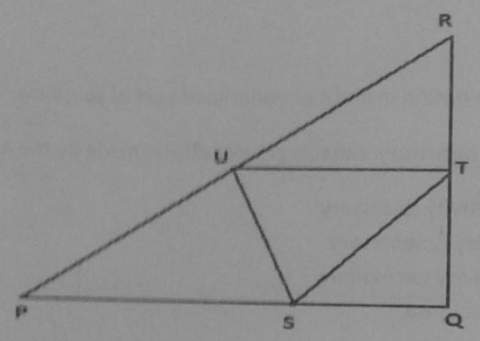
(C) Neither conclusion 1 nor 2 follows.

(D) Both conclusions 1 and 2 follows.

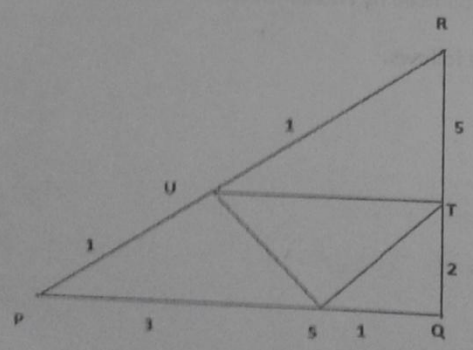
Answer (C)

Q.63 In the given figure angle Q is a right angle, PS:QS = 3:1, RT:QT= 5:2 and PU:UR = 1:1. If area of triangle QTS is 20 cm^2, then the area of triangle PQR in cm^2 is _____

Answer : 280.



Solution .



In similar triangles ΔPQR and ΔQTS

$$\frac{QS}{PQ} = \frac{QT}{RQ}$$

Area of $\Delta QTS = \frac{1}{2} \times QT \times QS$

$$20 = \frac{1}{2} \times QT \times QS \text{ .....(1)}$$

Area of $\Delta PQR = \frac{1}{2} \times PQ \times QR$

$$\frac{QS}{PQ} = \frac{1}{1+3} = \frac{1}{4}$$

$$\therefore QS = \frac{PQ}{4}$$

And $\frac{QT}{RQ} = \frac{2}{2+5} = \frac{2}{7}$

$$\therefore QT = \frac{2 \times RQ}{7}$$

From equation (i),

$$20 = \frac{2}{4 \times 7}\left(\frac{1}{2} \times PQ \times QR\right)$$

$$20 = \frac{1}{14}(area\ of\ \Delta PQR)$$

Hence,

Area of $\Delta PQR = 280\ cm^2$

Q.64 Right triangle PQR is to be constructed in the xy-plane so that the right angle triangle is at P and line PR is parallel to the x axis. The x and y coordinates of P,Q and R are to be integers that satisfy the inequalities : $-4 \leq x \leq 5$ and $6 \leq y \leq 16$. How many different triangles could be constructed with these properties?

(A) 110 (B) 1,100 (C) 9,900 (D) 10,000

Answer (C)

Solution .

$$X_1 \rightarrow -4 \leq X_1 \leq 5$$

$$Y_1 \rightarrow 6 \leq Y_1 \leq 16$$

$$X_2 \rightarrow 9 \text{ chairs } (\because X_1 \neq X_2)$$

$$Y_2 \rightarrow 10 \text{ chairs } (\because\ Y_1 \neq Y_2)$$

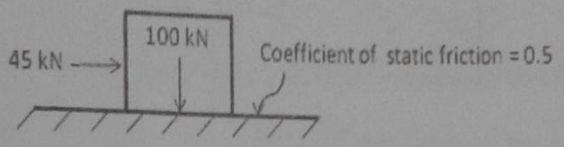
$$\therefore \text{Total triangles } = 10 \times 11 \times 9 \times 10 = 9900$$

Q.65 A coin is tossed thrice. Let X be the event that head occurs in each of the first two tosses. Let Y be the event that a tail occurs on the third toss. Let Z be the event that two tails occur in three tosses. Based on the above information, which one of the following statement is TRUE ?

(A) X and Y are not independent (B) Y and Z are dependent
(C) Y and Z are independent (D) X and Z are independent

Answer (B)

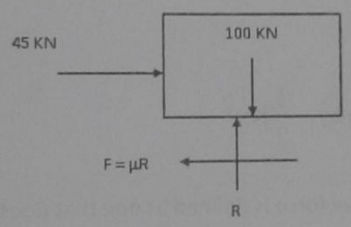
Q.1 A block of weight 100 kN rests on a floor as shown in the figure. The coefficient of static friction between the block and the floor is 0.5. A force of 45 kN is applied horizontally on the block. The static frictional force in kN is



(A) 22.5 (B) 50.0 (C) 55.0 (D) 100.0

Answer (B)

Solution.



Where , F - is frictional force

R – Reaction force

$\mu = 0.5$ = Coefficient of static friction

Now $\sum V = 0$

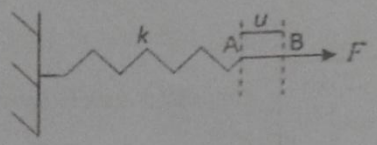
$R - 100 = 0$

$R = 100KN$

Hence , frictional force (F) , $F = \mu R$

F = 0.5 x 100 = 50 N

Q.2 A spring of constant stiffness k is stretched from point A to point B (displacement u in the figure) by a force F. The potential energy of the spring is expressed by



(A) $\frac{1}{2}ku - Fu$ (B) $\frac{1}{2}ku + Fu$

(C) $ku - F$ (D) $ku + F$

Answer (A)

Solution.

Potential Energy of spring is given by = $\frac{1}{2}Kx^2$

Conservative force – Conservative force is defined as one that does mechanical work independent of path of motion and such that the work is reversible or recoverable.

Therefore, in case of spring, the mechanical work of a conservative force is considered to be loss in potential energy of spring and that is : -

$$U_F = -W = -Fu$$

Hence, potential Energy (P_s) of spring is given by

$$P_s = \frac{1}{2}Kx^2 - Fu$$

Q.3 If σ_s is the induced stress and σ_i is the insitu stress at a point below ground, the 'stress concentration' at that point is

(A) $\sqrt{\frac{\sigma_s}{\sigma_i}}$ (B) $\sqrt{\frac{\sigma_i}{\sigma_s}}$ (C) $\frac{\sigma_i}{\sigma_s}$ (D) $\frac{\sigma_s}{\sigma_i}$

Answer (D)

Q.4 The components of state of stress at a point in x–y plane are given as σ_{xx} =5 MPa, σ_{yy}= 10MPa and τ_{xy} = – 2MPa. The sum of the principal stresses acting on the x–y plane in MPa is _____

Answer : 15 to 15.

Solution.

Given that

$$\sigma_{xx} = 5 \text{ MPa}$$

$$\sigma_{yy} = 10 \text{ MPa}$$

$$\tau_{xy} = -2 \text{ MPa}$$

Major principal stress is given by : -

$$\sigma_1 = \frac{1}{2}(\sigma_{xx} + \sigma_{yy}) + \left\{\frac{1}{4}(\sigma_{xx} - \sigma_{yy})^2 + \tau_{xy}^2\right\}^{1/2}$$

$$\sigma_1 = \frac{1}{2}(5+10) + \left\{\frac{1}{4}(5-10)^2 + (-2)^2\right\}^{1/2}$$

$$\sigma_1 = 10.7015 \text{ MPa.}$$

and minor principal stress is given by :-

$$\sigma_2 = \frac{1}{2}(\sigma_{xx} + \sigma_{yy}) - \left\{\frac{1}{4}(\sigma_{xx} - \sigma_{yy})^2 + \tau_{xy}^2\right\}^{1/2}$$

$$\sigma_2 = \frac{1}{2}(5+10) - \left\{\frac{1}{4}(5-10)^2 + (-2)^2\right\}^{1/2}$$

$\sigma_2 =$ 4.30 MPa

Hence, Sum of principal stresses is given by

$$\sum\sigma = \sigma_1 + \sigma_2$$

= 10.70 + 4.30

= 15 MPa

Q.5 The angle $5^\circ 15' 25''$ is expressed in hours, minutes, and seconds as

(A) $1^h 20^{min} 1.67^s$ **(B) $1^h 20^{min} 16.00^s$**

(C) $0^h 21^{min} 1.67^{min}$ **(D) $0^h 21^{min} 16.00^s$**

Answer (C)

Solution.

We know, $1^o = \frac{1}{15} h$

$$5^o = \frac{5}{15} h$$

$$5^o = 0^h 20^m 0^S$$

and $1' = \frac{1}{15}$ m

$$15' = \frac{15}{15} \text{m}$$

$$15' = 0^h 1^m 0^s$$

and $$1'' = \frac{1}{15} s$$

$$25'' = \frac{25}{15} s$$

$$25'' = 0^h 0^m 1.67^s$$

Hence, Angle $5^0 15' 25'' = 0^h 21^m 1.67^s$

Q. 6 **A circular curve has a radius of 200 m and deflection angle of 65^0. The length of the curve in m is**

(A) 221 **(B) 227** **(C) 235** **(D) 262**

Answer (B)

Solution.

We know,

$$\text{Angle} = \frac{Arc}{radius}$$

Or Length of curve = Angle x radius

$$= \frac{\pi}{180^0} \times 65^0 \times 200$$

$$= 227 \text{ m}$$

Q.7 **The weight strength of ANFO of specific gravity 0.8 is 912 kcal/kg. The weight strength of an emulsion explosive of specific gravity 1.2 is 850 kcal/kg. Bulk strength of the emulsion explosive relative to ANFO in percentage is**

Answer : 135 to 142.

Solution.

$$\text{Relative bulk strength} = \frac{\textit{Relative weight strength of explosive} \times \textit{S.G. of explosive}}{\textit{Relative weight strength of ANFO} \times \textit{S.G. of ANFO}}$$

So, Bulk strength of emulsion explosive $= \dfrac{850 \times 1.2}{912 \times 0.8}$

$= 1.40$

$= 140\%$

Q.8 In a cut-and-fill stope, the main purpose of back filling is to

(A) reduce ore dilution

(B) prevent high stress concentrations in far field domain

(C) prevent displacement due to dilation of fractured wall rock

(D) improve ore rehandling

Answer (C)

Q.9 Bypass valve in a compressed oxygen type self-contained breathing apparatus is meant to

(A) release accumulated nitrogen in the breathing bag

(B) release excess pressure in the breathing bag

(C) supply oxygen directly to wearer in case pressure reducing valve does not function

(D) flush out the apparatus with oxygen on opening the cylinder valve

Answer (C)

Q.10 Given S is the setting load and Y is the yield load of a hydraulic prop, the correct relationship is

(A) $S < Y$ (B) $S > Y$ (C) $S = Y$ (D) $S = Y^2$

Answer (A)

Q.11 **Solution of the differential equation dy/dx = ky follows exponential decay (where k is a constant) for x $\in$ [0, ∞] if**

(A) k >0 **(B) k <0** **(C) k = 0** **(D) k = e**

Answer (B)

Solution.

Note – Quantity is subjected to exponential decay if it decreases at a rate proportional to its current value. This can be expressed by differential equation where y is quantity and K is exponential decay constant.

$$\frac{dy}{dx} = -ky \text{ for } x \in [0, \infty]$$

but given differential equation

$$\frac{dy}{dx} = Ky \text{, so here } K < 0$$

Q.12 **The value of k for which the vectors a = 2i - 3j and b = ki + 4j are orthogonal to each other is** _____

Answer : 6 to 6.

Solution.

Given vectors

a = 2i – 3j

b = Ki + 4j

when two vectors are orthogonal to each other then,

a.b = 0

(2i – 3j) . (Ki + 4j) = 0

$2K - 12 = 0$

$\therefore \quad K = 6$

Q.13 **Which one of the following is the most likely mode of slope failure for waste dump**

(A) Circular **(B) Wedge** **(C) Plane** **(D) Toppling**

Answer (A)

Q.14 **The occurrence of head in a single toss of an unbiased coin is given by a random variable X.**

The variance of X is _____

Answer : 0.25 to 0.25.

Solution.

The occurrence of head in single toss of an unbiased coin = $\frac{1}{2}$

So, random variable = $\frac{1}{2}$.

Hence, variance of random variable X = $\left(\frac{1}{2}\right)^2$

$= \frac{1}{4} = 0.25$

Q.15 **The divergence of the vector v = (x + y) (- yi + xj) is**

(A) y – x **(B) x – y** **(C) $x^2 - y^2$** **(D) $y^2 - x^2$**

Answer (B)

Solution.

Given vector is, $v = (x + y)(-yi + xj)$

We know,

Divergence $F = \nabla.F = \nabla.V$

and $\nabla = I.\frac{\partial}{\partial x} + J.\frac{\partial}{\partial y} + K\frac{\partial}{\partial z}$

$$\text{div. } F = \nabla.V = \left(I.\frac{\partial}{\partial x} + J.\frac{\partial}{\partial y} + K\frac{\partial}{\partial z}\right).(x + y)(-yi + xj)$$

$$\text{div. } F = \left(I\frac{\partial}{\partial x} + J\frac{\partial}{\partial y} + K\frac{\partial}{\partial z}\right).\left\{-\left(xy + y^2\right)i + \left(x^2 + xy\right)j\right\}$$

$$\text{div. } F = -\frac{\partial}{\partial x}\left(xy + y^2\right) + \frac{\partial}{\partial y}\left(x^2 + xy\right)$$

$$\text{div. } F = -y + x$$

$$\text{div. } F = x - y$$

Q.16 **The value of $\lim_{x\to 0}\frac{|x|}{x}$ is**

(A) –1 **(B) 0** **(C) 1** **(D) non-existent**

Answer (D).

Solution.

Given function, $f(x) = \lim_{x\to 0}\frac{|x|}{x}$

Putting x = 0+h, when $x \to 0$ then $h \to 0$

$$Rf(0+h) = \lim_{h\to 0}\frac{|0+h|}{0+h}$$

$$= \lim_{h \to 0} \frac{|h|}{h}$$

$$= \lim_{h \to 0} \frac{h}{h}$$

$$= 1.$$

Now putting x = 0 – h, when x → 0, then h → 0

$$Lf(0-h) = \lim_{h \to 0} \frac{|0-h|}{0-h}$$

$$= \lim_{h \to 0} \frac{h}{-h} = -1$$

Hence, $Rf\ (0+h) \neq Lf\ (0-h)$

Therefore , given function is not existent.

Q.17 **For Indian coal mines, the 'maximum allowable concentration' of respirable dust containing 7.5% free silica in mg/m³ is**

(A) 2.0 **(B) 2.2** **(C) 2.5** **(D) 2.7**

Answer (A)

Solution.

We know

$$\text{Threshold limit} = \frac{15}{\%\,\text{respirable silica}}\ \text{mg/m}^3$$

$$= \frac{15}{7.5}\ \text{mg/m}^3$$

$$= 2\text{mg/m}^3$$

Q.18 Given k is the thermal conductivity, ρ is density and c is specific heat of a rock sample, the thermal diffusivity of the rock sample is

(A) $\frac{k\rho}{c}$ (B) $\frac{\rho c}{k}$ (C) $\frac{kc}{\rho}$ (D) $\frac{k}{\rho c}$

Answer (D)

Q.19 Cyclone, bag filter and scrubber can be used for control of

(A) water pollution (B) air pollution

(C) soil pollution (D) noise pollution

Answer (B)

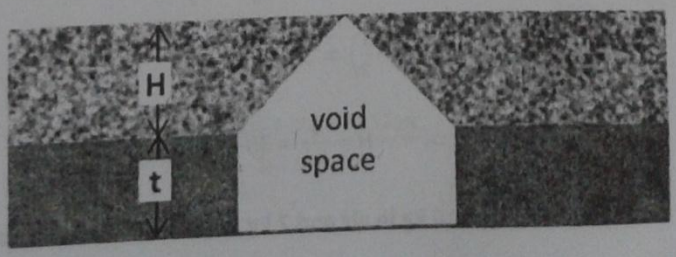
Q.20 A mine waste dump of pH 5.2 can be neutralized by adding

(A) urea (B) calcium carbonate (C) sulphuric acid (D) sodium chloride

Answer (B)

Q.21 A flat coal seam of thickness (t) 3 m is excavated and broken roof rock has completely filled the space created due to extraction as shown in the figure. If the bulking factor of roof rock is 1.2, the caving height (H) in m is _____

Answer : 30 to 30.

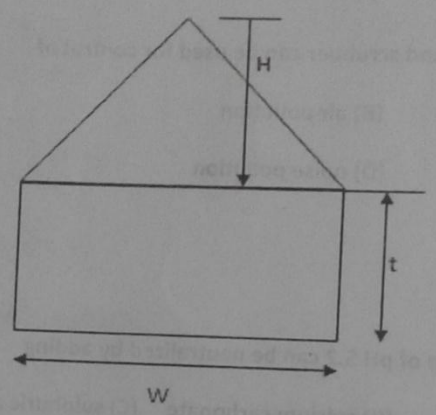


Solution.

Given that,

Coal thickness (t) = 3m

Bulking factor of root rock = 1.2



Bulking factor of rock = $\frac{Volume\ of\ rock\ after\ blasting}{Volume\ of\ rock\ before\ blasting}$

Total area $= w \times t + \frac{1}{2} \times w \times H$

Now,

$$1.2 = \frac{\left(w \times t + \frac{1}{2} \times w \times H\right) \times 1}{\frac{1}{2} \times w \times H \times 1}$$

$$1.2 \times \frac{1}{2} \times w \times H = \left(t + \frac{1}{2} \times H\right).w$$

$$H\left(\frac{1.2}{2} - \frac{1}{2}\right) = 3$$

$$\therefore \quad H = \frac{3}{0.1} = 30\ m$$

Q.22 **A piece of coal sample weighs 10 kg in air and 2 kg when immersed in water. The specific**

gravity of the coal sample is _____

Answer : 1.25 to 125.

Solution.

Specific gravity = $\frac{W_1}{W_1 - W_2}$

Where,

W_1 – weight of solid in air =10 kg

W_2 – weight of solid in water = 2 kg

Hence, specific gravity of coal sample is = $\frac{10}{10-2}$

= 1.25

Q.23 **In a borehole log of 1.2 m in length, recovery of rock cores in cm is given below**

20, 8, 15, 8, 8, 4, 3, 9, 10, 1, 5, 10

The RQD in percentage is

(A) 29.2 **(B) 31.8** **(C) 45.8** **(D) 50.0**

Answer (C)

Solution.

We know,

$$RQD = \frac{\sum Length\ (L) of\ core\ pieces \geq 10\ cm\ length}{Total\ length\ of\ core\ run} \times 100$$

$$RQD = \frac{(20+15+10+10)\ cm}{1.2\ m} \times 100$$

$$RQD = \frac{(0.2 + 0.15 + 0.1 + 0.1)\ m}{1.2\ m} \times 100$$

RQD = 45.8%

Q.24 **An underground coal mine panel produces 520 tonnes per day deploying 220, 200 and 192 persons in three shifts. As per CMR 1957, the minimum quantity of air in m^3/min to be delivered at the last ventilation connection of the panel is _____**

Answer : 1320 to 1320.

Solution.

Production per day = 520 tonnes

Total employee per day = 220 + 200 + 192 = 612

Here,

Total employee per day > Production per day

So,

Minimum quantity of air to be delivered shall be according to employees per day.

Hence,

Minimum quantity of air in m^3 / min to be delivered at the last ventilation connection of the panel is = number of workers in largest shift x 6 , m^3/min

= 220 x 6

= 1320 m^3/min

Q.25 **In a PERT network, the activities on the critical path are a, b and c. The standard deviations of the durations of these activities are 2, 2 and 1 respectively. The variance of the project duration is**

(A) 3 **(B) 5** **(C) 9** **(D) 12**

Answer (C)

Solution.

Given ,

$$\sigma_a = 2 \ , \quad \sigma_b = 2 \ , \quad \sigma_c = 1$$

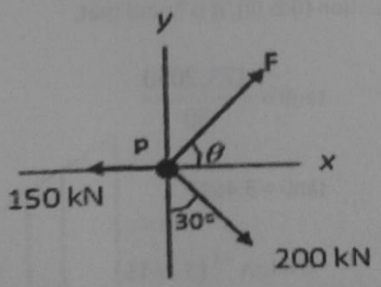
In PERT network,

$$(variance)_{abc} = (variance)_a + (variance)_b + (variance)_c$$

$$(variance)_{abc} = (\sigma^2)_a + (\sigma^2)_b + (\sigma^2)_c$$

$$(variance)_{abc} = 2^2 + 2^2 + 1^2 = 9$$

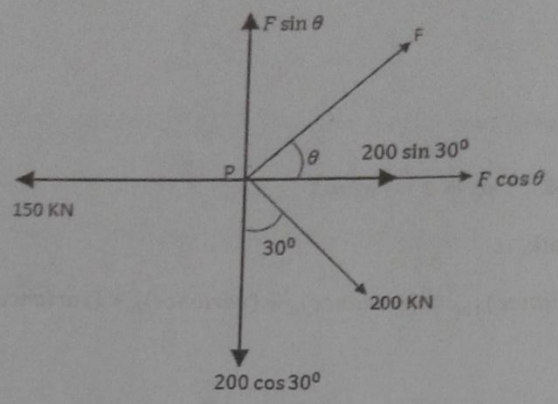
Q.26 **A particle P is in equilibrium as shown in the figure. The magnitude in kN and the orientation θ in degrees of the force F respectively are**



(A) 52.1, 16.1 **(B) 221.2, 23.2** **(C) 102.3, 53.4** **(D) 180.3, 73.9**

Answer (D)

Solution.



Now , $\sum H = 0$

$$-150 + F\cos\theta + 200\sin 30^0 = 0$$

$$F\cos\theta = 50 \text{ .....(i)}$$

And , $\sum V = 0$

$$F\sin\theta - 200\cos 30^0 = 0$$

$$F\sin\theta = 173.2050 \text{ .....(ii)}$$

From equation (i) & (ii), it is found that,

$$\tan\theta = \frac{173.2050}{50}$$

$$\tan\theta = 3.4641$$

$$\theta = \tan^{-1}(3.4641)$$

$$\theta = 73.9^0$$

From equation (i),

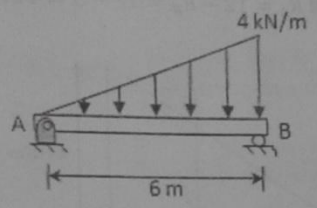
$$F\cos\theta = 50$$

$$F\cos 73.9^0 = 50$$

$$F = \frac{50}{\cos 73.9^0}$$

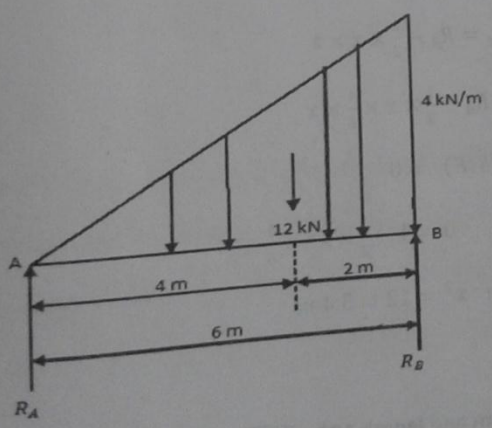
F = 180.3KN

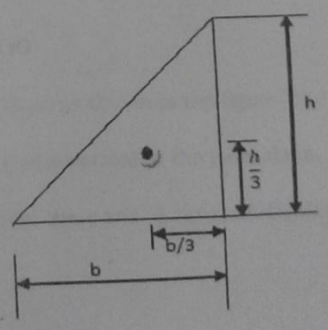
Q.27 A distributed load of 4 kN/m acts on a beam of 6 m length supported by a hinge and a roller as shown in the figure. The distance in m of the point of zero shear in the beam from the point A is ____.



Answer : 3.4 to 3.5.

Solution.





Now , $\Sigma V = 0$

$$R_A + R_B - \frac{1}{2} \times 6 \times 4 = 0$$

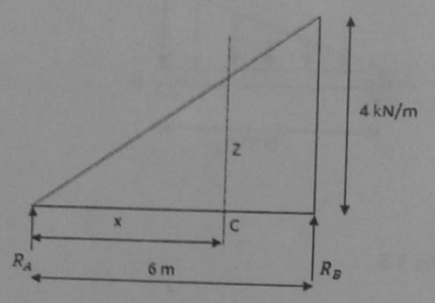
$$R_A + R_B = 12\ kN \text{ .....(i)}$$

Taking moment about A,

$$R_B \times 6 - \frac{1}{2} \times 6 \times 4 \times 4 = 0$$

$$R_B = \frac{48}{6} = 8\ kN$$

And $R_A = 12 - R_B = 12 - 8 = 4\ kN$



Here, $\frac{z}{x} = \frac{4}{6}$

$$z = \frac{4}{6}\ x$$

Now, $(S.F)_c = R_A - \frac{1}{2} \times x \times z$

Or $(S.F)_c = R_A - \frac{1}{2} \times x \times \frac{4}{6} \times x$

But $(S.F)_c = 0$

$$0 = 4 - \frac{1}{2} \times x^2 \times \frac{4}{6}$$

Or $x^2 = 12 = 3.4\ m$

Q.28 **A dry rock sample of diameter 50 mm and length 100 mm weighs 300 g. After saturating**

in brine solution of specific gravity 1.05, its weight increased to 330 g. The porosity of the rock sample in percentage is _____

Answer : 14.25 to 14.65.

Solution.

$$\text{Porosity} = \frac{Volume\ of\ void/liquid}{total\ volume\ of\ sample}$$

$$\text{Total volume of sample} = \pi r^2 l = 3.14 \times (25)^2 \times 100$$

$$= 196250\ mm^3$$

$$\text{Volume of void (liquid)} = \frac{mass\ of\ liquid}{density\ of\ liquid}$$

$$= \frac{mass\ of\ liquid}{specific\ gravity\ of\ liquid \times density\ of\ water}$$

$$= \frac{(330-300)\ g}{1.05 \times 1000\ kg/m^3}$$

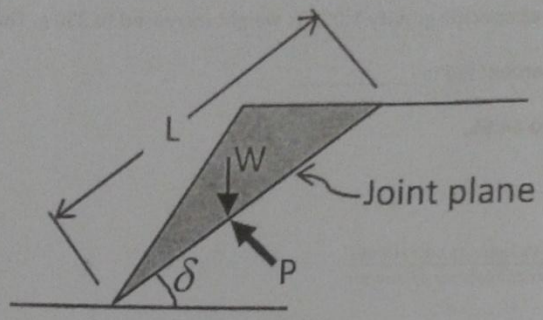
$$= \frac{30\ g \times m^3}{1.05 \times 1000\ kg}$$

$$\text{Or} \quad = \frac{30 \times 1000^3}{1.05 \times 1000 \times 1000}\ mm^3$$

$$\text{Hence,} \quad \text{Porosity} = \frac{30 \times 1000^3\ mm^3}{196250 \times 1.05 \times 1000 \times 1000\ mm^3} \times 100$$

$$= 14.55\ \%$$

Q.29 A joint plane of length L and dip δ intersects the toe of a slope as shown in the figure. The weight of the shaded block is W. Uniform water pressure P acts normal to the joint plane. If the cohesion and angle of internal friction of the joint surface are c and ϕ respectively, then the expression for 'safety factor' of the shaded block is



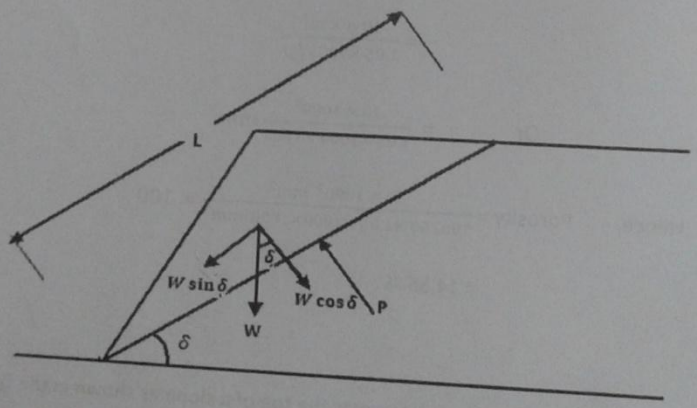
(A) $\frac{Lc+(W\sin\delta-LP)\tan\emptyset}{W\cos\delta}$ (B) $\frac{Lc+(W\cos\delta+LP)\tan\emptyset}{W\sin\delta}$

(C) $\frac{Lc+(W\cos\delta-LP)\tan\emptyset}{W\sin\delta}$ (D) $\frac{Lc+(W\sin\delta+LP)\tan\emptyset}{W\cos\delta}$

Answer (C)

solution .

Factor of safety = $\frac{Resisting\ force\ or\ shear\ force}{Driving\ force}$



From Mohr Coulomb failure criteria ,

Shear strength $= \tau = c + \sigma_n \tan\emptyset$

$[c - cohesion, \sigma_n - normal\ stress, \emptyset - Angle\ of\ internal\ friction]$

Therefore,

shear force $= \tau A = (c + \sigma_n \tan\emptyset).A = (c + N/A \tan\emptyset)A$

So, as per given condition :

Resisting force = shear force = $\left[c + \left(\frac{W \cos\delta}{L \times 1} - P\right) \tan\phi\right] L \times 1$

= Lc + (W.cosδ - PL) tanϕ

And driving force = w.sinδ

Hence, Factor of safety = $\frac{Lc + (W\cos\delta - LP)\tan\emptyset}{W\sin\delta}$

Q.30 The lengths and standard errors of three sections AB, BC, and CD of a straight line AD are given below AB = 125.85 ± 0.021 m; BC= 205.72±0.029 m; CD = 246.21 ± 0.025 m.

The standard error in total length AD in m is

(A) ±0.0436 (B) ±0.0350 (C) ±0.0250 (D) ±0.0019

Answer (A)

Solution.

$e_{AB} = \pm 0.021$ m

$e_{BC} = \pm 0.029$ m

$e_{CD} = \pm 0.025$ m

The standard error in total length AD –

$$\pm e_s = \sqrt{(0.021)^2 + (0.029)^2 + (0.025)^2}$$

$$\pm e_s = 0.0436$$

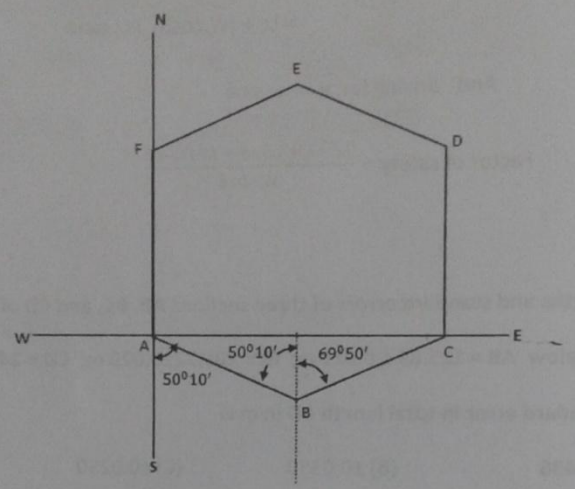
Or $e_s = \pm 0.0436$

Q.31 The bearing of side AB of a regular hexagon ABCDEF is $S50^{\circ}10'E$. If the station C is easterly from the station B, the whole circle bearing of the side BC is

(A) $65^{\circ}15'25''$ (B) $69^{\circ}50'25''$ (C) $69^{\circ}15'25''$ (D) $69^{\circ}50'0''$

Answer (D)

Solution.



Hence, whole circle bearing of BC is $69^{0}50'0''$.

Note – In hexagonal ABCDEF

$\angle A = \angle B = \angle C = \angle D = \angle E = \angle F = 120^{0}$

Q.32 In a room-and-pillar stope, bench blasting is conducted using ANFO having density of 800 kg/m^3.The specific gravity of rock is 2.5, hole diameter is 100 mm and spacing to burden ratio is 1.3. The charge length of each blast hole is 80% of the hole length. For a desired powder factor of 0.48 kg/tonne, the spacing and burden of the blast pattern in m respectively are

(A) 2.0, 2.6 (B) 2.3, 1.8 (C) 5.2, 4.0 (D) 1.3,

Answer (B)

Solution.

Given that

ANFO density = 800 kg/m^3

Specific gravity of rock = 2.5

Hole dia. = 100 mm

$$\frac{Spacing\ (S)}{Burden\ (B)} = 1.3$$

Power factor = 0.48 kg/tone, and

Charge length of hole = 80% of hole length

Now,

$$\text{Powder factor} = \frac{Amount\ of\ explosive\ \ (Kg)}{Blasted\ material\ (tonne)}$$

$$0.48 = \frac{800 \times \pi \times (0.05)^2 \times charge\ length}{S \times B \times hole\ length \times 2.5}$$

$$0.48 = \frac{800 \times \pi \times (0.05)^2 \times charge\ length}{S \times B \times \frac{charge\ length}{0.8} \times 2.5}$$

$$0.48 = \frac{800 \times 3.14 \times (0.05)^2 \times 0.8}{1.3 \times B \times B \times 2.5}$$

$$B^2 = \frac{800 \times 3.14 \times (0.05)^2 \times 0.8}{0.48 \times 1.3 \times 2.5}$$

$\therefore$ B = 1.8m

and spacing = 1.3 x 1.6 = 2.3m

Q.33 Match the following for ore handling operations in an underground metal mine

Arrangement	Description
(P) Drawpoint	(I) arrangement that prevents oversized rock to pass
(Q) Ore pass	(II) a system of vertical or near vertical openings for transferring ore from a stope to a single delivery point
(R) Grizzly	(III) a place where ore can be loaded and removed
(S) Finger raise	(IV) a vertical or inclined opening used for transferring ore

(A) P-IV, Q-III, R-II, S-I

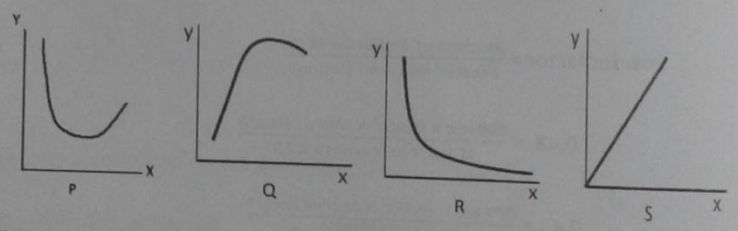
(B) P-III, Q-IV, R-I, S-II

(C) P-II, Q-IV, R-I, S-III

(D) P-III, Q-I, R-II, S-IV

Answer (B)

Q.34 The following characteristic curves (P, Q, R, S) pertain to rotary drilling in rock.



Title of the curve

I: Torque versus RPM

II: Rate of penetration versus uniaxial compressive strength of rock

III: Rate of penetration versus weight on bit

IV: Specific energy versus weight on bit

Match the curves with their titles

(A) P-III, Q-IV, R-II, S-I

(B) P-II, Q-IV, R-I, S-III

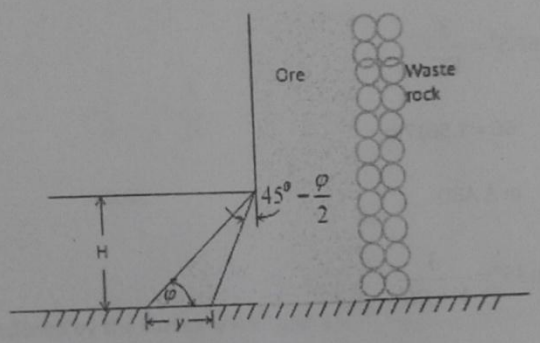
(C) P-IV, Q-III, R-II, S-I

(D) P-I, Q-III, R-II, S-IV

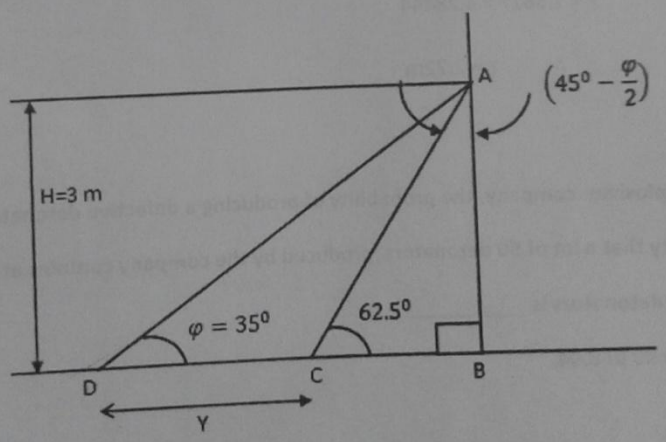
Answer (C)

Q.35 The height H of a drawpoint in a sublevel caving stope is 3.0 m. If the angle of repose (φ) of broken ore is 35^0, the digging depth y of the loader as shown in the figure in m is _____

Answer : 2.70 to 2.75.



Solution.



Given that, $\psi = 35^0$

Now,

$$\angle ACB = 90^0 - \left(45^o - \frac{\psi}{2}\right)$$

$$\angle ACB = 90^0 - \left(45^o - \frac{35^o}{2}\right)$$

$$\angle ACB = 62.5^0$$

In Δ ABC,

$$\tan 62.5^0 = \frac{3}{BC}$$

$\therefore$ BC = 1.5617m

Now, In Δ ABD

$$\tan 35^o = \frac{3}{Y + BC}$$

$$\therefore \quad Y + BC = \frac{3}{\tan 35^0}$$

Y + 1.5617 = 4.28444

$\therefore$ Y = 2.72m

Q.36 **For an explosives company, the probability of producing a defective detonator is 0.02. The probability that a lot of 50 detonators produced by the company contains at most 2 defective detonators is _____.**

Answer : 0.90 to 0.94.

Solution.

From Poisson distribution , Probability of observing x events in given interval is:-

$$P_x = \frac{e^{-m} m^x}{x!}, \qquad x = 0, 1, 2, 3, 4....$$

mean = m = np = 50 x 0.02 = 1

The probability that at most 2 defective detonators is

$$= \frac{e^{-m}.m^0}{0!} + \frac{m^1.e^{-m}}{1!} + \frac{m^2.e^{-m}}{2!}$$

$$= \frac{e^{-1}}{1} + \frac{1.e^{-1}}{1} + \frac{1^2.e^{-1}}{2!}$$

$$= \frac{1}{e} + \frac{1}{e} + \frac{1}{2e}$$

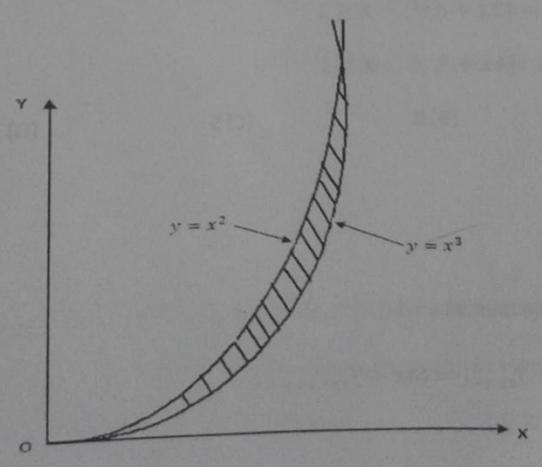
= 0.92

Q.37 **The area enclosed by the curves $y = x^2$ and $y = x^3$ for $x \in [0, \infty]$ is**

(A) 1/12 **(B) 1/6** **(C) 1/2** **(D) 1**

Answer (A)

Solution.



$$y = x^2 \quad \text{.....(i)}$$

$$y = x^3 \quad \text{.....(ii)}$$

from (i) & (ii)

$$x^3 - x^2 = 0$$

$$x^2.(x-1) = 0$$

Curves interest at (0, 0) and (1, 1) and we see that $x^3 < x^2$ in this interval.

Therefore, area is given by

$$\int_0^1 (x^2 - x^3)dx = \left(\frac{1}{3}x^3 - \frac{1}{4}x^4\right)_0^1$$

$$= \frac{1}{3} - \frac{1}{4} = \frac{1}{12}$$

Q.38 **The value of a, for which the function below is continuous at x = 1 is**

$$f(x) = \{2x + ax^2, \quad x \leq 1$$

$$\{4x + 3, \quad x > 1$$

(A) -5 **(B) 0** **(C) 5** **(D) 10**

Answer (C)

Solution.

Function is continuous at x = 1

if, $(2x + ax^2)_{at\ x=1} = (4x + 3)_{at\ x=1}$

$$\therefore \quad 2\times 1 + a\times 1^2 = 4\times 1 + 3$$

$$2 + a = 4 + 3$$

$$\therefore \quad a = 7 - 2 = 5$$

Q.39 **The sum of the infinite series $a + ar + ar^2 + ar^3 + \ldots\ldots + ar^{n-1} + \ldots\ldots$ for $|r| < 1$ is**

(A) a(1+r) **(B) a(1−r)** **(C) a/(1+r)** **(D) a/(1−r)**

Answer (D)

Solution.

The sum of n terms of a G.P is

$$S_n = \frac{a\left(1-r^n\right)}{1-r} \qquad \text{when } |r| < 1$$

$$S_n = \frac{a}{1-r} - \frac{ar^n}{1-r}$$

Since, numerical value of r is less than 1. When value of n increases, then value of r^n decreases. When n tends to ∞, then value of r^n tends to 0. So sum of infinites series will be

$$S_\infty = \frac{a}{1-r}$$

Q.40 **A centrifugal pump has a discharge rate of 2000 L of water per min against a total head of 200 m. If the pump efficiency is 75%, the input power to the pump in kW is**

(A) 87.20 **(B) 49.05** **(C) 13.33** **(D) 7.50**

Answer (A)

Solution.

Given that,

Discharge rate = 2000 L/min

Total head = 200m

Pump efficiency = 75%

Input power to the pump = $\frac{P.Q \times 10^{-3}}{Pump\ efficiency}$ Kw

P = Pump pressure = ρgh = 1000 × 9.81 × 200 = 1962000 Pa

Q = 2000 l/min = $\frac{2000 \times 10^{-3}}{60}\ m^3/sec$

Now,

Input power (P) to pump = $\frac{1962000 \times 2000 \times 10^{-3} \times 10^{-3}}{60 \times 0.75}$ Kw

∴ P = 87.2 KW

Q.41 A dragline is required to remove 3,00,000 m³ of rock per month on the bank volume basis. Consider the following data for the dragline operation.

Effective working hours per month = 450

Bucket fill factor = 0.8

Cycle time = 65 s

Swell factor of the rock = 1.25

The minimum bucket capacity of the dragline in m³ is

(A) 7.70 (B) 9.63 (C) 12.04 (D) 18.80

Answer (D)

Solution.

Given that,

Dragline productivity per month = 3,00,000 m^3

effective working hour per month = 450 hour

Bucket fill factor = 0.8

Cycle time = 65 seconds

Swell factor of rock = 1.25

Here, dragline productivity per hour = $\frac{300000}{450}$

= 666.67 m^3

Now, dragline productivity in m^3/h is given by

$$= \frac{3600 \times fill\ factor \times bucket\ capacity}{cycle\ time \times swell\ factor}$$

$$666.67 = \frac{3600 \times 0.8 \times bucket\ capacity}{65 \times 1.25}$$

Bucket capacity = $\frac{666.67 \times 65 \times 1.25}{3600 \times 0.8}$

∴ Bucket capacity = 18.80 m^3

Q.42 A direct rope haulage pulls 8 tubs loaded with coal through an incline of length 500 m having an inclination of 1 in 6. Consider the following additional data.

Capacity of tub = 1.0 tonne ,

Tare weight of tub = 500 kg

Hauling speed = 9 km per hour,

Coefficient of friction between wheel and rail = 1/60

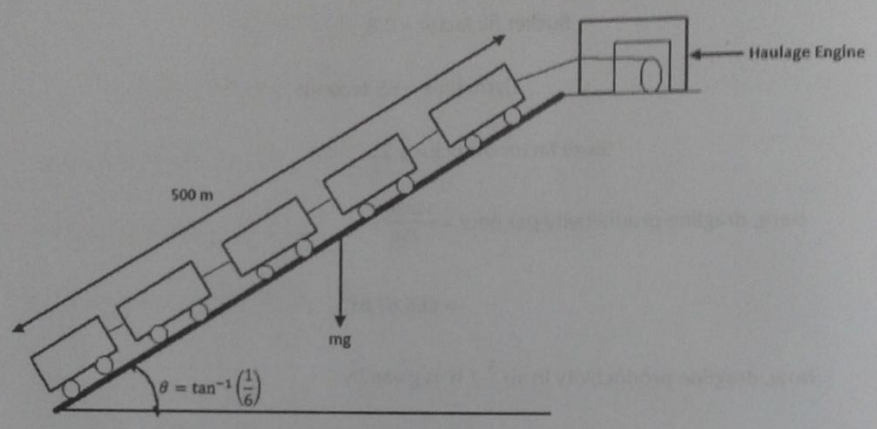
Coefficient of friction between rope and drum = 1/10 ,

Mass of rope per meter = 1.5 kg .

The minimum power required to haul the tubs in kW is

(A) 345.50 (B) 348.60 (C) 350.10 (D) 365.50

Solution.



Tractive force required = $G+g_1+F+F_1$

G = Gravitational resistance of full tubes

G = (Weight of gross load per set) x g x inclination

G = 1500 x 8 x 9.81 x $\frac{1}{6}$ = 19620 N

g_1 = Gradient Resistance of rope

g_1 = Rope length x rope mass per kg x g x inclination

g_1 = 500 x 1.5 x 9.81 x $\frac{1}{6}$ = 1226.25 N

F = Friction of full tubs

F = (Weight of dross load per set) x g x coefficient of fiction between wheel and rail

$$F = 1500 \times 9.61 \times \frac{1}{6} = 1962 \text{ N}$$

F_1 = Friction of rope

F_1 = Rope length x rope mass per kg x g x coefficient of friction between rope and drum

$$F_1 = 500 \times 1.5 \times 9.81 \times \frac{1}{10} = 735.75\text{N}$$

Therefore,

Tractive force to overcome = 19620 + 1226.25 + 1962 + 735.75

= 23544 N

Hauling speed = 9 km/h = 2.5 m/sec

Minimum power (P) required to haul the tubs = Tractive force x speed

= 23544 x 2.5

= 58860 W

P = 58.86 KW

Q.43 A coal mine receives two bids for purchase of a new dragline. The first bid quotes Rs. 150 crore as a price to be paid in full on delivery. The second bid quotes Rs. 180 crore as a price payable at the end of the third year after delivery. If the discount rate is 12%, the difference in NPV between the first and second bids in crore of rupees is _____

Answer : 21.80 to 21.95.

Solution.

NPV is given by

$$NPV = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

where, t – The time of cash flow

i – Discount rate

$R_t = the\ net\ cash\ flow$

For first bids –

t = 0, R = 150 Crore , i = 12% = 0.12

Here, $(NPV)_1 = \frac{150}{(1+0.12)^0} = 150$ Crore

for second bids

t = 3, R = 180 Crore, i = 12% = 0.12

Here, $(NPV)_2 = \frac{180}{(1+0.12)^3} = 128.12$ Crore

Therefore,

The difference in NPV between the first and second bids in Crore of rupees is =

150 – 128.2 = 21.8 Crores

Q.44 Match the following in the context of underground mine environment

Instrument	Measuring parameter
P. Haldane apparatus	I. Humidity
Q. Godbert-Greenwald apparatus	II. Air velocity
R. Hygrometer	III. Mine air composition
S. Anemometer	IV. Ignition point temperature

(A) P-II, Q-I, R-III, S-IV

(B) P-III, Q-IV, R-I, S-II

(C) P-IV, Q-II, R-III, S-I

(D) P-I, Q-III, R-IV, S-II

Answer (B)

Q.45 A mine airway having cross-section of 2.2 m × 2.2 m and length 500 m contains a bend. Given that the airway friction factor is 0.01 Ns^2m^{-4}, shock loss factor for the bend is 0.07 and density of air is 1.2 kg/m^3, the equivalent length of the airway in m is _____

Answer: 502 to 503.

Solution.

We have,

Pressure drop in mine airways:-

$$P = \frac{K\,S\,Q^2}{A^3} = \frac{K\,S\,V^2}{A}$$

When this equation is applied for bend then, becomes

$$\Delta P_s = \frac{K_b.S_b.V^2}{A}$$

where ΔP_s = Shock loss

K_b = Friction factor for bend

S_b = Surface area of bend

V = Velocity of air through bend

A = Cross seasonal area of bend

but $\Delta P_s = X.P_v$

$X \rightarrow$ Shock factor , P_v – Velocity pressure

Hence,

$$XP_V = \frac{K_b.S_b.V^2}{A}$$

$$X.\frac{1}{2}.\rho.v^2 = \frac{k_b S_b.V^2}{A}$$

Putting all values then,

$$0.07 \times \frac{1}{2} \times 1.2 = \frac{0.01 \times [2\,(2.2 + 2.2\,) \times l_b]}{2.2 \times 2.2} \quad \lfloor \ell_b - \text{length of bend} \rfloor$$

$$l_b = \frac{0.07 \times 1.2 \times 2.2 \times 2.2}{0.01 \times 8.8 \times 2}$$

$$\ell_b = 2.31\text{m}$$

Equivalent length of airways = 500 + 2.31 = 502.31m

Q.46 **In order to estimate the NVP in a mine, measurements are made at the main fan as shown below.**

Fan speed (RPM)	Fan drift pressure (Pa)	Fan quantity (m^3/s)
800	655	82.2
950	730	85.5

The NVP in Pa is _____

Answer : 258 to 263.

Solution.

We have

$$P = RQ^2$$

When, fan speed = 800 rpm, fan drift pressure = 655 Pa

Fan quantity = 82.2 m^3/S

$\therefore \quad N + 655 = R_1 \times (82.2)^2$

$$R_1 = \frac{N+655}{82.2^2} \quad \text{.....(i)}$$

Where, N = N.V.P

when, Fan speed = 950 rpm, Fan drift pressure = 730 Pa

Fan quantity = 85.5 m^3/S

$N + 730 = R_2 \times (85.5)^2$

$$R_2 = \frac{N+730}{(85.5)^2} \quad \text{.....(ii)}$$

In both, conditions resistance of mine will be same.

Hence, $R_1 = R_2$

$$\therefore \quad \frac{N+655}{82.2^2} = \frac{N+730}{85.5^2}$$

On solving , it is found that ,

N = 260.42 Pa.

Q.47 The resistances of two splits A and B are 0.35 Ns^2m^{-8} and 0.05 Ns^2m^{-8} respectively. The combined resistance of the shafts and trunk airways is 0.4 Ns^2m^{-8}. A booster fan is planned to be installed in split A to increase the quantity flowing through it. Assuming that the surface fan continues to operate at a constant pressure of 1000 Pa, the critical pressure of the booster fan in Pa is _____

Answer : 874 to 876.

Solution.

Given that,

Resistance of split A = $0.35\,Ns^2m^{-8}$

Resistance of split B = $0.05\,Ns^2m^{-8}$

Combined resistance of shaft and trunk airways = $0.4\,NS^2m^{-8}$

Surface fan pressure =1000 Pa

Now, critical pressure of booster fan is given by

$$P_c = \frac{P_f \times R_s}{R_t}$$

where P_f – surface fan pressure

R_s – Resistance of split in which booster fan installed

R_t – Resistance of shaft and trunk airways

$\therefore \quad P_c = \frac{100 \times 0.35}{0.4}$

$\therefore \quad P_c = 875$ Pa

Q.48 **A pitot tube is inserted in a ventilation duct with the nose facing the air flow. A vertical U-tube manometer filled with alcohol (specific gravity 0.8) has been used for pressure measurements such that 10.2 mm is read as the total pressure and 8.8 mm as the static pressure. Given the density of air to be 1.2 kg/m^3, the air velocity at the nose of the pilot tube in m/s is _____**

Answer : 4.20 to 4.35.

Solution.

We know,

$P = \rho gh;$

P – Pressure (Pa)

ρ – Density of fluid kg/m^3

g – Acceleration due to gravity (m/sec^2)

h – Head (height) (m)

Total pressure = $0.8 \times 1000 \times 9.81 \times \frac{10.2}{1000}$ Pa

= 80 Pa

Static pressure = $0.8 \times 1000 \times 9.81 \times \frac{8.8}{1000}$ Pa

= 69 Pa

∵ Total pressure = Static pressure + dynamic pressure

∴ Dynamic pressure = 80 – 69, Pa

= 11 Pa

Dynamic pressure $= \frac{1}{2}.\rho.v^2$

Where,

ρ – density of air

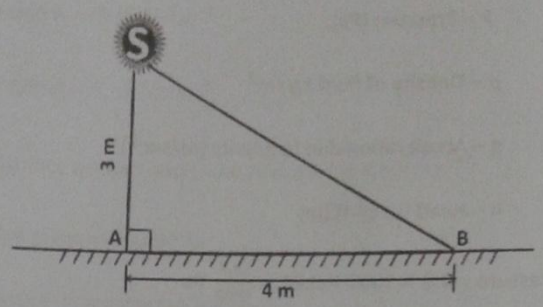
V – Velocity of air

∴ $11 = \frac{1}{2} \times 1.2 \times v^2$

Or $v = \sqrt{\frac{11 \times 2}{1.2}}$

v = 4.28 m/sec

Q.49

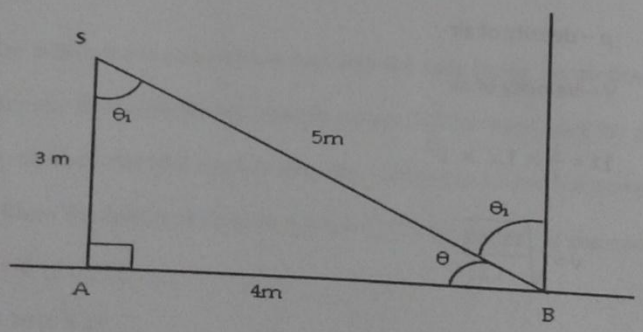


An illumination source S shown in the figure emits light equally in all directions. At a point A on the floor, the illuminance is 5.0 lux. The illuminance at point B on the floor in lux is _____

Answer : 1.0 to 1.2.

Solution.

Given figure



Now, $\theta = \tan^{-1}\frac{3}{4} = 36^0 52' 11.63''$

Hence $\theta_1 = 180^0 - \theta - 90^0 = 180^0 - 36^0\ 52' 11.63'' - 90^0$

$= 53^0 7' 48.37''$

We have,

illumination of a surface (Meter candle) = (Candle of source) $\times \frac{\cos\theta_1}{(distance\ in\ m)^2}$

Here,

Candle of source = 5 x 3 x 3 = 45 lumens

$\cos\theta_1 = \cos 53^0 7' 48.37'' = 0.6$

Hence, illumination at point B will be-

$= 45 \times \frac{0.6}{5^2}$

= 1.08 lux.

Q. 50 **Two machines A and B while operating simultaneously produce a sound pressure level of 85 dBA at a point. When the machine A stops, the sound pressure level at that point reduces to 80 dBA. The sound pressure level at the same point due to machine A operating alone in dBA is**

(A) 70.0 **(B) 75.0** **(C) 80.0** **(D) 83.3**

Answer (D)

Solution.

We know,

$$L_{eq} = 10\log_{10}[\sum_{i=0}^{n} t_i \cdot 10^{L_i/10}]$$

$$85 = 10\log_{10}\left[1\times10^{\frac{80}{10}} + 1\times10^{\frac{A}{10}}\right]$$

or $8.5 = \log_{10}\left[10^8 + 10^{A/10}\right]$

or $10^{8.5} = 10^8 + 10^{A/10}$

or $10^{8.5} = 10^{8} + 10^{A/10}$

$$\ln\left(10^{8.5} - 10^{8}\right) = \frac{A}{10}\ln(10)$$

A = 83.3 dB

Q. 51 **A waste water effluent has BOD_5 of 80 mg/L and the reaction rate constant is 0.16 per day. The ultimate BOD in mg/L is**

(A) 85 **(B) 100** **(C) 120** **(D) 145**

Answer (D)

Solution.

We have,

$$BOD_t = BOD_L \times \left(1 - e^{-Kt}\right)$$

where, BOD_t = BOD at any time t, mg/L = 80 mg/L

BOD_L = Ultimate BOD, mg/L

K = constant, reaction rate = 0.16

t = Time, day = 5 day

Hence, given BOD_t = 80 mg/L, k = 0.16, t = 5

$$80 = BOD_L \times \left(1 - e^{-5 \times 0.16}\right)$$

$$BOD_L = \frac{80}{1 - e^{-5 \times 0.16}} = 145 \text{ mg/L}$$

Q.52 **A series of tri-axial compression tests conducted on sandstone samples reveal the following relationship between major and minor principal stresses**

$\sigma_1 = 50 + 3\,\sigma_3$ [stresses are in MPa]

The cohesion in MPa and angle of internal friction in degrees of sandstone respectively are

(A) 14.43, 30.0 (B) 14.43, 60.0 (C) 0.21,73.9 (D) 0.21, 16.1

Answer (A)

Solution.

Given that

$$\sigma_1 = 50 + 3\,\sigma_3 \quad \text{.....(i)}$$

and we have

$$\sigma_1 = C_o + \tan\beta \,.\, \sigma_3 \quad \text{.....(ii)}$$

where, C_o – Uniaxial compressive strength

and angle β is constant

Comparing (i) and (ii), we found that,

C_o = 50 MPa and $\tan\beta = 3$

$$\tan\beta = \frac{1 + \sin\emptyset}{1 - \sin\emptyset}$$

where, ϕ – Angle of internal friction

so, $3 = \dfrac{1+\sin\phi}{1-\sin\phi}$

$\therefore \quad \phi = 30^0$,

and also we have,

Uniaxial compressive strength $(\sigma_c) = \dfrac{2\,c\,\cos\emptyset}{1 - \sin\emptyset}$

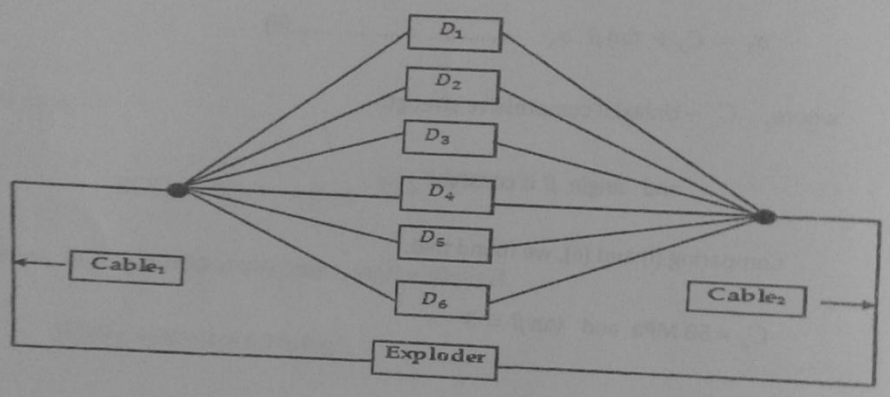
$$50 = \frac{2\,C\,\cos 30^0}{1 - \sin 30^0}$$

∴ C = 14.43 MPa

Q.53 Six detonators each having resistance of 1.5 ohm are connected in parallel. A 15 V exploder is connected to the detonators by two single-core cables of resistance 3 ohm each. The current in the circuit in Ampere is _____

Answer : 2.2 to 2.4.

Solution.



Given that, $D_1 = D_2 = D_3 = D_4 = D_5 = D_6 = 1.5\,\text{Ohm}$

and $Cable_1$, = $Cable_2$, = 3 Ohm

Now,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \frac{1}{R_6}$$

$$\frac{1}{R}=\frac{1}{1.5}+\frac{1}{1.5}+\frac{1}{1.5}+\frac{1}{1.5}+\frac{1}{1.5}+\frac{1}{1.5}$$

$$R=\frac{1.5}{6}=0.25\text{Ohm}$$

Total resistance = 0.25 + 3 + 3 = 6.25 Ohm

Hence current in the circuit = $\frac{15}{6.25}$ = 2.4 Ampere

Q.54 **The failure and the repair rates of a shovel are 0.06 per hr and 0.04 per hr respectively. The availability of the shovel in percentage is _____**

Answer : 40 to 40.

Solution.

$$\text{Availability} = \frac{Up\ time}{total\ time} = \frac{Up\ time}{Up\ time + down\ time}$$

$$= \frac{MTTF}{MTTF+MTTR}$$

Where,

MTTF → Mean time to failure

MTTR → Mean time to repair

Given that,

Failure rate = 0.06 hr^{-1}

Therefore , MTTF = $\frac{1}{0.06}=16.67\,\text{hr}$

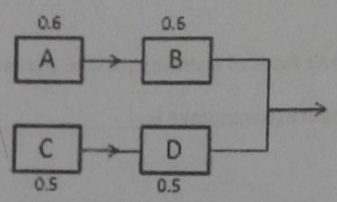
and Repair rate = 0.04 hr^{-1}

Therefore, MTTR = $\frac{1}{0.04}=25\,\text{hr}$

Hence shovel availability = $\frac{16.67}{16.67+25} = 0.40$

= 40%

Q.55 **The individual reliability values of four sub-systems are given in the figure below. The reliability of the system is _____**



Answer : 0.50 to 0.55.

Solution.

Given,

Reliability values of sub systems A & B

$R_{AB} = 0.6 \times 0.6 = 0.36$

Reliability values of sub systems C & D

$R_{CD} = 0.5 \times 0.5 = 0.25$

Now, Reliability of the system is

$= 1 - (1 - 0.36) \times (1 - 0.25)$

$= 0.52$

Q.56 **Choose the most appropriate word from the options given below to complete the following**

sentence.

A person suffering from Alzheimer's disease _____ short-term memory loss.

(A) experienced (B) has experienced

(C) is experiencing (D) experiences

Answer (D)

Q.57 Choose the most appropriate word from the options given below to complete the following sentence.

_____ is the key to their happiness; they are satisfied with what they have.

(A) Contentment (B) Ambition (C) Perseverance (D) Hunger

Answer (A)

Q.58 Which of the following options is the closest in meaning to the sentence below?

"As a woman, I have no country."

(A) Women have no country.

(B) Women are not citizens of any country.

(C) Women's solidarity knows no national boundaries.

(D) Women of all countries have equal legal rights.

Answer (C)

Q.59 In any given year, the probability of an earthquake greater than Magnitude 6 occurring in the Garhwal Himalayas is 0.04. The average time between successive occurrences of such earthquakes is ____ years.

Answer : 25 to 25.

Solution.

$$P = 0.04 = \frac{4}{100}$$

for 1 earthquake

$$\frac{100}{4} p = 1 \text{ earthquake}$$

Reverse probability

= 25 years

Q.60 The population of a new city is 5 million and is growing at 20% annually. How many years would it take to double at this growth rate?

(A) 3-4 years (B) 4-5 years (C) 5-6 years (D) 6-7 years

Answer (A)

Solution.

We know, from compound interest

$$S = P(1+i)^n$$

Where, S – value of n periods

P – Initial investments

i – Annual interest rate

n – Number of years

Here, we can apply such that,

S = 5 x 2 = 10, P = 5, i = 20% = 0.2

$$10 = 5(1+0.2)^n$$

$$\frac{10}{5} = 1.2^n$$

$$2 = 1.2^n$$

or $\log 2 = n \log 1.2$

$$\therefore \quad n = \frac{\log 2}{\log 1.2} = 3 - 4 \text{ years}$$

Q.61 In a group of four children, Som is younger to Riaz. Shiv is elder to Ansu. Ansu is youngest in the group. Which of the following statements is/are required to find the eldest child in the group?

Statements

1. Shiv is younger to Riaz.
2. Shiv is elder to Som.

(A) Statement 1by itself determines the eldest child.

(B) Statement 2 by itself determines the eldest child.

(C) Statements 1 and 2 are both required to determine the eldest child.

(D) Statements 1 and 2 are not sufficient to determine the eldest child.

Answer (A)

Q.62 Moving into a world of big data will require us to change our thinking about the merits of exactitude. To apply the conventional mindset of measurement to the digital, connected world of the twenty-first century is to miss a crucial point. As mentioned earlier, the obsession with exactness is an artefact of the information-deprived analog era. When data was sparse, every data point was critical, and thus great care was taken to avoid letting any point bias the analysis.

From "BIG DATA" Viktor Mayer-Schonberger and Kenneth Cukier

The main point of the paragraph is:

(A) The twenty-first century is a digital world

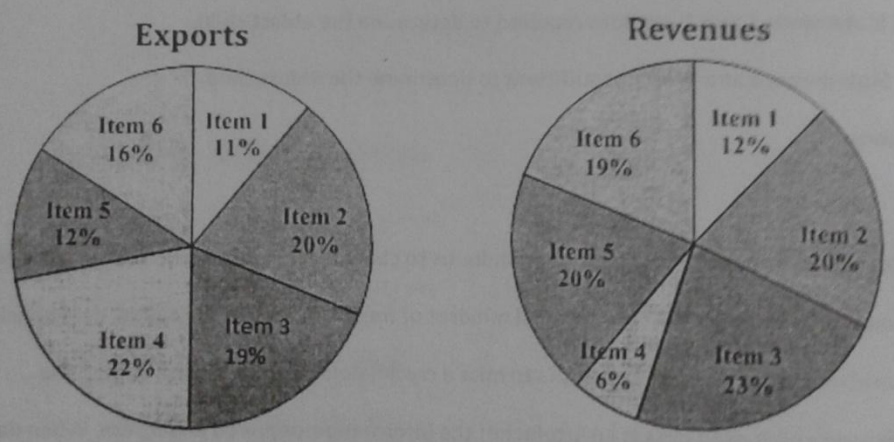
(B) Big data is obsessed with exactness

(C) Exactitude is not critical in dealing with big data

(D) Sparse data leads to a bias in the analysis

Answer (C)

Q.63 The total exports and revenues from the exports of a country are given in the two pie charts below. The pie chart for exports shows the quantity of each item as a percentage of the total quantity of exports. The pie chart for the revenues shows the percentage of the total revenue generated through export of each item. The total quantity of exports of all the items is 5 lakh tonnes and the total revenues are 250 crore rupees. What is the ratio of the revenue generated through export of Item 1 per kilogram to the revenue generated through export of Item 4 per kilogram?



(A) 1:2 (B) 2:1 (C) 1:4 (D) 4:1

Answer (D)

Solution.

For Item I,

$$\text{Revenue} = \frac{12}{100} \times 250 = 30 \text{ Crore rupees}$$

$$\text{Exports} = \frac{11}{100} \times 5{,}00000 \times 1000 = 55000000 \text{ Kg}$$

Therefore,

$$\text{Revenue generated through export of Item I, Per Kilograms} = \frac{30}{55000000}$$

For Item IV,

$$\text{Revenue} = \frac{6}{100} \times 250 = 15 \text{ Crore rupees}$$

$$\text{Exports} = \frac{22}{100} \times 5000000 \times 1000 = 110000000 \text{ kg}$$

Therefore,

$$\text{Revenue generated through export of Item IV per kilogram} = \frac{15}{110000000}$$

Hence,

$$\text{Required ratio} = \frac{\frac{30}{55000000}}{\frac{15}{110000000}}$$

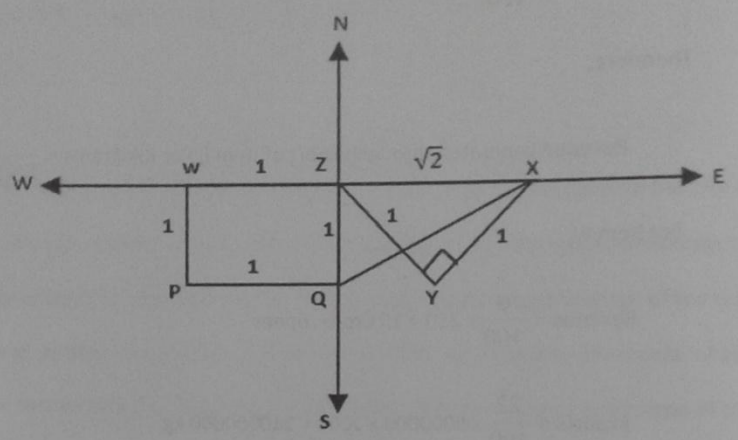
$$\text{Required ratio} = \frac{4}{1} = 4:1$$

Q.64 **X is 1 km northeast of Y. Y is 1 km southeast of Z. W is 1 km west of Z. P is 1 km south of W. Q is 1 km east of P. What is the distance between X and Q in km?**

(A) 1 **(B) √2** **(C) √3** **(D) 2**

Answer (C)

Solution.



In ΔXYZ, [applying Pythagoras theorem]

We found that,

$$ZX = \sqrt{2}$$

Again in ΔXZQ [applying Pythagoras theorem]

$$XQ = \sqrt{(ZQ)^2 + (XZ)^2}$$

$$XQ = \sqrt{1^2 + (\sqrt{2})^2}$$

$$XQ = \sqrt{3} \text{ Km}$$

Q.65 **10% of the population in a town is HIV^+. A new diagnostic kit for HIV detection is available; this kit correctly identifies HIV^+ individuals 95% of the time, and HIV^- individuals 89% of**

the time. A particular patient is tested using this kit and is found to be positive. The probability that the individual is actually positive is _____

Answer : 0.48 to 0.49.

Solution.

Let total population = 100

$$\text{HIV + patient} = 100 \times \frac{10}{100} = 10$$

$$\text{HIV − patient} = 100 \times \frac{90}{100} = 90$$

For patient to be +ve = 10 x 0.95

and to be –ve = 10 x 0.5

For patient to be –ve = 90 x 0.89

and to be +ve = 90 x 0.11

Hence, probability that the individual is

$$\text{Actually positive} = \frac{10 \times 0.95}{10 \times 0.95 + 90 \times 0.11}$$

$$= 0.48$$

Gate Solution-2013

Q.1 In the Coward flammability diagram, the respective percentages of methane and oxygen at the nose limit are

(A) 14.2, 0.0 (B) 14.1, 18.2 (C) 5.8, 12.1 (D) 5.0, 19.2

Answer (C)

Q.2 If the transpose of a matrix is equal to its inverse, then the matrix is

(A) symmetric (B) orthogonal (C) skew symmetric (D) singular

Answer (B)

Solution .

As per given condition-

$$\Rightarrow A' = A^{-1}$$

$$\Rightarrow A'A = 1$$

Hence , matrix is orthogonal.

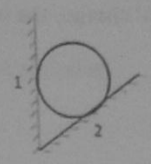
Q.3 In the Moh's scale of hardness, the minerals in increasing sequence of hardness are

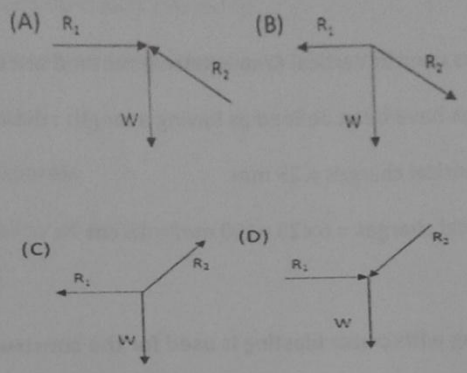
(A) calcite, gypsum, topaz, diamond (B) topaz, gypsum, calcite, diamond

(C) calcite, gypsum, diamond, topaz (D) gypsum, calcite, topaz, diamond

Answer (D)

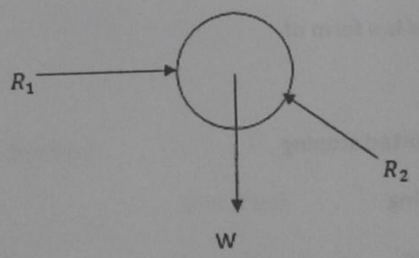
Q.4 A ball of weight W is supported on smooth walls as shown in the following figure. R_1 and R_2 are reactions from the walls 1 and 2. The free body diagram of the ball is represented by

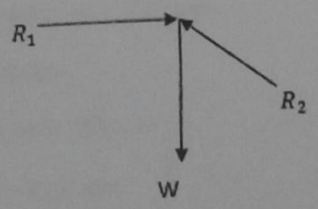




Answer (A)

Solution .





Q.5 For a 25 mm diameter spherical charge, the maximum allowable charge length in cm is

(A) 15.0 (B) 25.0 (C) 30.0 (D) 150.0

Answer (A)

Solution .

Explosive charges used in Vertical Crater Retreat method are normally spherical.

Spherical charges have been defined as having a length : diameter (L:D) ratio of 6:1.

$\because$ diameter of spherical charges = 25 mm

$\therefore$ length of spherical charges = 6×25 =150 mm = 15 cm

Q.6 Long-hole drilling with crater blasting is used for the construction of

(A) winze (B) shaft (C) raise (D) decline

Answer (C)

Q.7 Rill stoping method is a form of

(A) block caving

(B) artificially supported stoping

(C) underhand stoping

(D) overhand stoping

Answer (D)

Q.8 Transit theodolite is a

(A) micro-optic theodolite

(B) theodolite with face left and face right reading facilities

(C) theodolite with stadia hairs

(D) theodolite with two vertical circles

Answer (B)

Q.9 Incubation period is NOT related to

(A) crossing point temperature of coal

(B) panel size

(C) seam thickness

(D) explosibility of coal dust

Answer (D)

Q.10 The rotational speed and cutting velocity of a drill are 350 rpm and 71.50 m/min respectively. The diameter of the rotary drill bit in mm is

(A) 65 (B) 67 (C) 68 (D) 70

Answer (A)

Solution.

Radial speed is given by-

$$v = 2\pi\omega r$$

Where,

ω = rotational speed = 350 rpm

r = radial distance

$\therefore$ 71.50 = 2 × 3.14 × 350 × r

$\therefore$ r = 0.0325 m = 32.5 mm

$\therefore$ diameter =2× 0.0325 mm= 65 mm

Q.11 The pressure on a phreatic surface is

(A) less than atmospheric pressure

(B) greater than atmospheric pressure

(C) equal to atmospheric pressure

(D) independent of atmospheric pressure

Answer (C)

Q.12 Events A and B are independent but NOT mutually exclusive. If the probabilities P(A) and P(B) are 0.5 and 0.4 respectively, then $P(A \cup B)$ is

(A) 0.6 (B) 0.7 (C) 0.8 (D) 0.9

Answer (B)

Solution .

$P(A) = 0.5$

$P(B) = 0.4$

$\because$ Events A & B NOT mutually exclusive, then

$P(A \cap B) \neq 0$

$P(A \cup B) = P(A) + P(B) - P(A \cap B)$

Or $P(A \cup B) = P(A) + P(B) - P(A).P(B)$

$P(A \cup B) = 0.5 + 0.4 - 0.5 \times 0.4$

$\therefore P(A \cup B) = 0.7$

Q.13 Among the following options, the specific energy for rock-drilling is lowest in

(A) rotary diamond drilling (B) rotary roller drilling

(C) percussive drilling (D) jet piercing

Answer (C)

Q.14 Identify the correct statement for a 'normal distribution'.

(A) Mean is greater than mode but less than median

(B) Mean is less than mode but greater than median

(C) Mean is greater than mode and median

(D) Mean, median and mode are equal

Answer (D)

Q.15 An emulsion explosive of specific gravity 1.25 is used for blasting in an iron ore formation having P-wave velocity of 3000 m/s and specific gravity of 3.20. For an explosive impedance to rock impedance ratio of 0.5, the desired velocity of detonation of the explosive in m/s is

(A) 3840 (B) 4000 (C) 4200 (D) 7680

Answer (A)

Solution .

$$\because \quad \frac{explosive\ impedance}{rock\ impedance} = 0.5$$

$$\Rightarrow \quad \frac{(VOD)_e \times specific\ gravity\ of\ explosive}{(VOD)_r \times specific\ gravity\ of\ iron\ ore} = 0.5$$

$$\Rightarrow \quad \frac{(VOD)_e \times 1.25}{3000 \times 3.20} = 0.5$$

$$\Rightarrow (VOD)_e = \frac{0.5 \times 3000 \times 3.20}{1.25}$$

$$\Rightarrow (VOD)_e = 3840 \text{ m/s}$$

Q.16 **The number of ways in which the letters in the word MINING can be arranged is**

(A) 90 **(B) 180** **(C) 360** **(D) 720**

Answer (B)

Solution .

MINING = 6

N =2 & I =2

$\therefore$ Required number of ways $= \frac{6!}{2!\,2!} = \frac{720}{4} = 180$

Q.17 **Under standard temperature and pressure conditions the theoretical maximum height in m to which water can be lifted using an air-lift pump is**

(A) 10.33 **(B) 9.61** **(C) 7.45** **(D) 6.05**

Answer (A)

Q.18 **In a belt conveyor system, function of the snub pulley is to**

(A) clean the inner surface of the belt

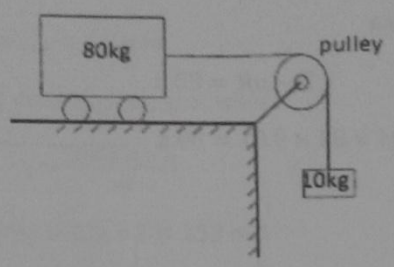
(B) clean the outer surface of the belt

(C) increase the angle of contact of belt with drive drum

(D) decrease the belt tension

Answer (C)

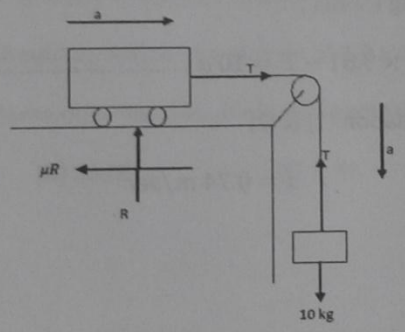
Q.19 In the following figure, the coefficient of kinetic friction between the trolley and the surface is 0.04. When the block is released from rest, the acceleration of the trolley in m/s^2 becomes

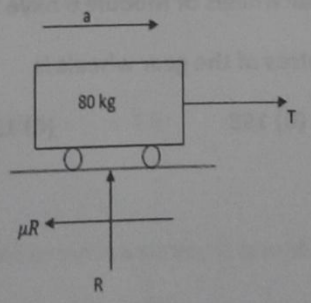


(A) 9.65 (B) 1.23 (C) 1.09 (D) 0.74

Answer (D).

Solution .





$$\sum V = 0$$

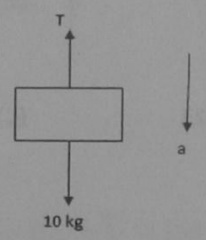
$$R - 80 = 0$$

$$R = 80 \times 9.81 \ N$$

Applying F = ma

$$T - \mu R = 80\, a$$

$$T - 0.04 \times 80 \times 9.81 = 80\, a \quad \text{.....(1)}$$



again applying F = ma ,

$$10 \times 9.81 - T = 10\, a \quad \text{.....(2)}$$

Solving equation (1) & (2)

$$\therefore\ a = 0.74\, m/sec$$

Q.20 **Two meshing spur gear wheels of Module 6 have 24 and 42 teeth. The distance in mm between the centres of the gear wheels is**

(A) 1000 **(B) 198** **(C) 126** **(D) 72**

Answer (B)

Solution.

We have,

$$\text{Module} = \frac{diameter}{teeth}$$

⇒For first meshing spur gear wheel

$$6 = \frac{(diameter)_1}{24}$$

$\therefore (diameter)_1 = 6 \times 24 = 144$ mm

Or $(radius)_1 = 72$ mm

⇒For second meshing spur gear wheel

$$6 = \frac{(diameter)_2}{42}$$

$\therefore (diameter)_2 = 6 \times 42 = 252$ mm

Or $(radius)_2 = 126$ mm

Therefore, distance between the centers of gear wheels = 72 + 126 = 198 mm

Q.21 **In an experiment to study coal dust explosibility, it is found that at least 3.0 g of limestone dust should be added to a sample of 2.0 g of coal dust to ensure that propagation of flame does not take place. The explosibility factor of coal dust is**

(A) 60.00 **(B) 20.00** **(C) 6.70** **(D) 1.50**

Answer (D)

Solution .

Explosibilty factor is the ratio between inert and combustible content.

Therefore,

Explosibility factor= $\frac{3}{2} = 1.5$

Q.22 **A 20 m steel tape used in a mine survey is found to be 20 cm short when compared with a standard tape. If the measured volume of a dump using the tape is 4000 m^3 , its actual volume in m^3 is**

(A) 3881 (B) 3902 (C) 3920 (D) 4121

Answer (A)

Solution.

We have,

$$\text{Actual volume} = \text{incorrect volume} \times \left(\frac{L'}{L}\right)^3$$

Where, L' = incorrect length of chain = 20 – 0.2 = 19.8 m

L = correct length of chain = 20 m

$$\text{Now, actual volume} = 4000 \times \left(\frac{19.8}{20}\right)^3 = 3881\ m^3$$

Q.23 **A mine worker inhales normal air; whereas, the exhaled air contains 16.65% O_2 and 3.83% CO_2. The respiratory quotient of breathing for the worker is**

(A) 0.23 (B) 0.89 (C) 0.99 (D) 1.13

Answer (B)

Solution .

$$\text{Respiratory quotient} = \frac{exhaled\ CO_2}{O_2\ consumed}$$

$$= \frac{3.83}{20.93 - 16.65} = 0.89$$

Q.24 **Block economic values in Lakhs of Rupees for a section of a block economic model are shown below.**

-1	-1	1	-1	0	-1
-1	0	0	0	-1	-2
-5	-3	-2	5	-2	-3

At a permissible slope angle of 1:1, the optimum pit value of the section in Lakhs of Rupees is

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

Answer (C)

Solution .

The following steps are used-

(1) The cone is floated from left to right along the top row of the blocks in the section, if there is a positive block it is removed.

-1	-1		-1	0	-1	+1
-1	0	0	0	-1	-2	
-5	-3	-2	5	-2	-3	

(2) After traversing the first row the apex of the cone is moved to the second row,starting floats from left to right stopping when it encounters the first positive blocks. If the sum of all blocks falling within the cone is positive (or zero), these blocks are removed . if the sum is negative the blocks are left and thee cone floats to the next positive blocks on this row. The summing and mining or leaving process is repeated.

-1					-1-1+0-1-1+0+0+5=+1
-1	0			-2	
-5	-3	-2	-2	-3	

(3) This floating cone process moving from left to right and top to bottom of the section continues until no more blocks can be removed.

(4) The profitability of the section is found by summing the value of the blocks removed.

$\therefore$The optimum pit value of section $= +1 + 1 = +2$

$= 2$ lakh of rupees

Optimum pit limit

-1	-1	1	-1	0	-1
-1	0	0	0	-1	-2
-5	-3	-2	5	-2	-3

Q.25 **The boundary of a mine is plotted on a scale of 1:2000. If a planimeter measures the plotted area as 58 cm^2, the actual mine area in m^2 is**

(A) 5800 **(B) 11600** **(C) 23200** **(D) 29000**

Answer (C).

Solution.

$$R.F = \frac{Dimension\ of\ object\ in\ drawing}{actual\ dimension\ of\ object}$$

Given , plotted area =58 cm^2

So, plotted length or width = $\sqrt{58}$ cm

$$\therefore \frac{1}{2000} = \frac{\sqrt{58}cm}{actual\ length\ or\ width\ of\ object}$$

∴ actual length or width of object = 2000 × $\sqrt{58}$ cm

So, actual area of object = 232000000 cm^2 =23200 m^2

Q.26 **For a shrinkage stope the following data values are given**

Insitu tonnage	:	**9000 tonne**
Insitu grade	:	**5.2 g/tonne**
Average grade of waste	:	**1.4 g/tonne**

Loss of ore in the stope : 10%

Dilution : 20%

The grade at the mill-head in g/tonne is _____

Answer : 4.5 to 4.518.

Solution .

	Tons	Grade (g/ton)	Tons×Grade (gram)
Ore in place	9000	5.2	9000×5.2=46800
Dilution (20 %)	$(+)\frac{20}{100}\times 9000=(+)1800$	1.4	(+) 1800×1.4=(+) 2520
Ore loss (10%)	$(-)\frac{10}{100}\times 9000=(-)900$	5.2	(−)900×5.2=(−)4680
Total	9900		44640

$$\therefore \text{Mill grade} = \frac{44640}{9900}\ \text{g/m} = 4.5\ \text{g/tone}$$

Q.27 In an experiment to determine specific gravity of a soil sample, the following data is obtained:

Mass of empty pycnometer : 20.4 g

Mass of pycnometer with soil sample : 51.6 g

Mass of pycnometer with soil sample filled with water : 88.6 g

Mass of pycnometer filled with water : 70.4 g

The specific gravity of the sample is _____

Answer : 2.35 to 2.45

Solution .

$$\text{Specific gravity} = \frac{W_1}{W_1 - W_2}$$

Where, W_1= weight of solid in air = 51.6−20.4=31.2 g

W_2 = weight of solid in water = 88.6 − 70.4 = 18.2 g

∴ Specific gravity of sample = $\frac{31.2}{31.2 - 18.2}$ = 2.40

Q.28 **A cylindrical rock specimen of diameter 54 mm has Young's modulus of 68.97 GPa and Poisson's ratio of 0.35. The rock specimen fails in uniaxial compression at a lateral strain of 0.01%. The axial load at failure in kN is _____**

Answer : 44.8 to 45.5

Solution.

$$\text{Poisson ratio} = \frac{lateral\ strain}{longitudinal\ strain}$$

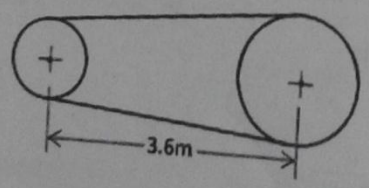
$$0.35 = \frac{0.01\ \%}{\varepsilon} = \frac{10^{-4}}{P/AE}$$ [from Hook's law , $\varepsilon = P/AE$]

$$\therefore P = \frac{10^{-4}}{0.35} \times 3.14 \times 27^2 \times 10^{-6} \times 68.97 \times 10^9$$

$$\therefore P = 45.107\ kN$$

Q.29 **An open belt drive connects two pulleys on parallel shafts that are 3.6 m apart as shown in the figure. The diameters of the pulleys are 2.4 m and 1.6 m. The angle of contact on the smaller pulley in degrees is _____**

Answer : 166 to 169



Solution .

$$\sin\theta = \frac{r_1 - r_2}{d}$$

Where,

r_1 = radius of larger pulley = $\frac{2.4}{2}$ =1.2 m

r_2 = radius of smaller pulley = $\frac{1.6}{2}$ = 0.8 m

D = distance between centres of both pulley = 3.6 m

$$\therefore \sin\theta = \frac{1.2 - 0.8}{3.6} = 0.11$$

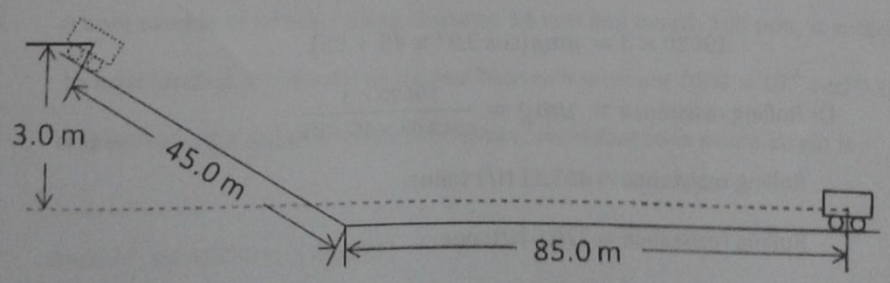
$$\therefore \theta = 6.3^0$$

$\therefore$ Angle of contact for smaller pulley = $180^0 - 2 \times \theta$

$= 180^0 - 2 \times 6.3^0$

$= 167^0 24' 0''$

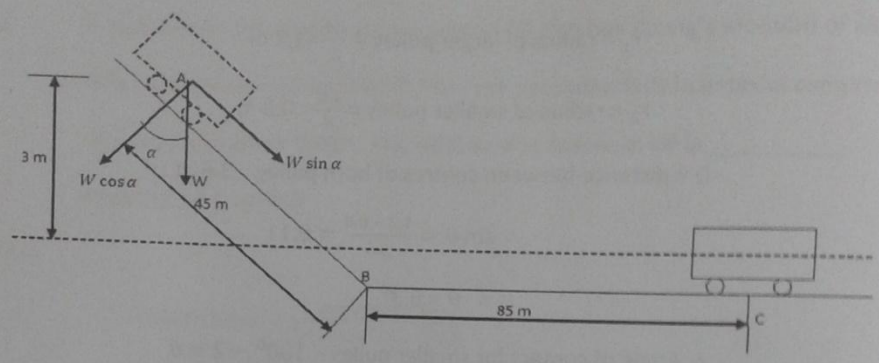
Q.30 **A two tonne mine car is released from the top of an incline at a height of 3 m as shown in the figure. The mine car travels 45 m along the inclined track and another 85 m along the horizontal track before coming to rest.**



The specific rolling resistance of the car in N/tonne is _____

Answer : 225 to 231.

Solution .



$$W = mg = 2000 \times 9.81 = 19620\ N$$

$$\alpha = \sin^{-1}\left(\frac{3}{45}\right) = 3.8^0$$

Rolling resistance $= \mu R$

Here,

Potential energy=(rolling resistance from A to B)×(distance from A to B)+ (rolling resistance from B to C)×(distance from B to C)

$$\text{m.g.h} = \mu mg \cos 3.8^0 \times 45 + \mu mg \times 85$$

$$19620 \times 3 = \mu mg[\cos 3.8^0 \times 45 + 85]$$

Or Rolling resistance $= \mu mg = \dfrac{19620 \times 3}{\cos 3.8^0 \times 45 + 85}$

Rolling resistance = 453.11 N/2 tonne

Rolling resistance = 226.6 N/tonne

Q.31 **A surface miner with 2.0 m cutting drum width excavates coal in windrowing**

mode from a bench with effective face length 200 m. The cutting speed of the surface miner is 10 m/min and the cutting depth 25 cm. The density of coal is 1.4 tonne/m^3. If the average turning time of the machine at the face end is 5 min, the rate of production in tonne/hour becomes _____

Answer : 335 to 337.

Solution.

$$\text{speed} = \frac{distance}{time}$$

$$\text{speed} = \frac{fece\ length}{time}$$

$$\text{time} = \frac{200}{10} = 20 \text{ minutes}$$

Now, total time taken in one cut = 20 + 5 = 25 minutes

production by shovel =2 × 200 × 0.25= 100 m^3

= 100×1.4= 140 tonne

Now, In 25 minutes = 140 tonnes

$\therefore$ In 1 hour = $\frac{140 \times 60}{25}$ = 336 tonnes

Hence, rate of production in tonne/hour = 336 tonne /hour

Q.32 **A core sample of a rock, having diameter 54 mm and length 108 mm, is subjected to axial loading. If the axial strain and Poisson's ratio are 2000 × 10^{-6} and 0.28 respectively, the value of volumetric strain, represented in micro-strain is**

_____

Answer : 0.000875 to 0.000885.

Solution.

$$\text{Volumetric strain} = \frac{\Delta V}{V} = \epsilon\,(1 - 2\vartheta)$$

Where, ϵ = axial strain = 2000×10^{-6}

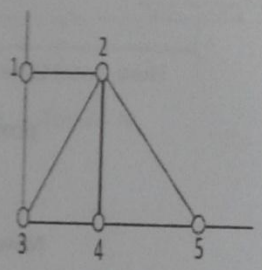
ϑ = poisson ratio = 0.28

$\therefore$ Volumetric strain = $2000 \times 10^{-6}(1 - 2 \times 0.28)$

$\therefore$ Volumetric strain = 0.00088

Q.33 A flat bauxite deposit has thickness of 10 m with an average density of 2200 kg/m3. The grade values and the sample coordinates are as shown in the table. To carry out reserve estimation using triangular method, the triangles are constructed as shown in the figure.

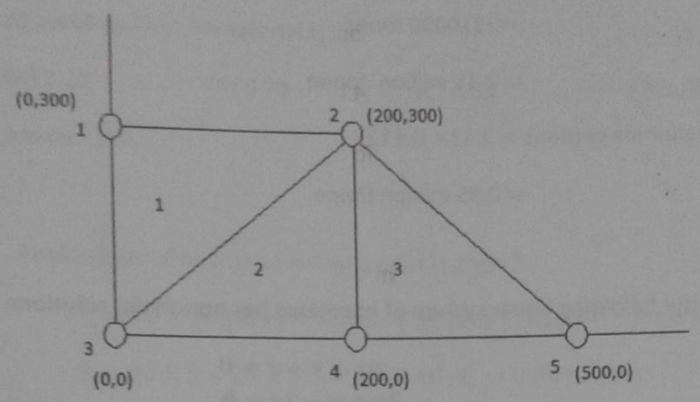
Sample No	1	2	3	4	5
Alumina%	35	40	39	47	42
x coordinate_m	0	200	0	200	500
y coordinate_m	300	300	0	0	0



The alumina content in million tonnes, in the region comprising the three triangles is _____

Answer : 0.9 to 1.

Solution.



$$g_{\Delta_1} = \frac{35 + 40 + 39}{3} = 38\%$$

$$g_{\Delta_2} = \frac{47 + 40 + 39}{3} = 42\%$$

$$g_{\Delta_3} = \frac{47 + 40 + 42}{3} = 43\%$$

And

$$A_1 = \frac{1}{2} \times 200 \times 300 = 30{,}000\ m^2$$

$$A_2 = \frac{1}{2} \times 200 \times 300 = 30{,}000\ m^2$$

$$A_3 = \frac{1}{2} \times 300 \times 300 = 45{,}000\ m^2$$

Grade of deposit (g)= $\frac{A_1 g_{\Delta_1} + A_2\, g_{\Delta_2} + A_3\, g_{\Delta_3}}{A_1 + A_2 + A_3}$

$$g = 41.29\ \%$$

Volume of deposit (V)= ($A_1 + A_2 + A_3$) × thickness

= (30000 + 30000 + 45000) ×10

$= 1050000\ m^3$

Tonnage of deposit = $\frac{density\ (\rho) \times V}{1000}$, tonne

$= \frac{2200 \times 1050000}{1000}$, tonne

$= 2310000$ tonne

$= 2.31$ million tonne

$\therefore$ alumina content $= 2.31 \times 0.4129$

$= 0.95$ million tonne

Q.34 If the following linear system of equations has non-trivial solutions

$$px + y + z = 0$$
$$2x + y - 2z = 0$$
$$x + 2y - 3z = 0$$

the value of p is

(A) 1 (B) 0 (C) -1 (D) -7

Answer (D)

Solution.

In case of Non-trival solution

$$\Delta = 0$$

$$\begin{vmatrix} P & 1 & 1 \\ 2 & 1 & -2 \\ 1 & 2 & -3 \end{vmatrix} = 0$$

$$P\begin{vmatrix} 1 & -2 \\ 2 & -3 \end{vmatrix} - 1\begin{vmatrix} 2 & -2 \\ 1 & -3 \end{vmatrix} + 1\begin{vmatrix} 2 & 1 \\ 1 & 2 \end{vmatrix} = 0$$

$$\therefore P + 4 + 3 = 0$$

$$\therefore P = -7$$

Q.35 A bucket wheel excavator with 20 buckets of capacity 0.5 m^3 each, rotates at 5 rev/min. The bucket fill factor is 80%. The excavator loads on to 1200 mm wide belt conveyor. The cross-section area (m^2) of the material on the belt is $0.1B^2$, where B is the belt width in m. The minimum speed of the belt in m/s

to avoid spillage of material is

(A) 7.23 (B) 5.79 (C) 4.63 (D) 3.70

Answer (C)

Solution.

Productivity of bucket wheel excavator is given by:

$$Q = 60 \times wheel\ rpm \times No.of\ bucket \times bucket\ capacity, m^3/h$$

$$Q = 60 \times 5 \times 20 \times 0.5 = 3000\ m^3/h\ = 0.84\ m^3/sec$$

$$\therefore Q = 0.84 \times 0.80 = 0.7\ m^3/sec$$

And productivity of belt conveyor is given by:

$$T = abv\ m^3/sec$$

$$\therefore\ T = 0.1 \times 1.2^2 \times 1 \times v\ \ m^3/sec$$

And now, $T = Q$

$$0.1 \times 1.2^2 \times 1 \times v = 0.7$$

$$\therefore v = 4.63\ m/sec$$

Q.36 **A simplex table shown below is generated during the maximization of a linear programming problem using simplex method**

Variable	Z	X1	X2	X3	X4	RHS
Z	1	-1	0	1	0	6
X2	0	1/3	1	1/3	0	2
X4	0	7/3	0	- 2/3	1	2

After one iteration, the value of the objective function becomes

(A) 48/7 **(B) 11/3** **(C) 22/7** **(D) 2/3**

Answer (A)

Solution .

Iteration procedure-

Step 01. Select a most negative coefficient in row (0). Put a box around the column below this coefficient and call this the pivot column

Step 02. Determine the minimum ratio test-

a) Pick out each coefficient in pivot column that is strictly positive (> 0)
b) Divide each of these coefficient in to the right side for same row.
c) Identify the same row that the smallest of these ratio.

variable	eq.	coefficient of					R,H.S	Ratio
		z	X_1	X_2	X_3	X_4		
Z	0	1	-1	0	1	0	6	
X_2	1	0	$\boxed{1/3}$	1	1/3	0	2	$\frac{2 \times 3}{1} = 6$
X_4	2	0	$\boxed{7/3}$	0	-2/3	1	2	$\frac{2 \times 3}{7} = \frac{6}{7}$ (minimum) ←

d) Put a box around this row and call it pivot and also call the number that is in both boxes the pivot number.

Z	0	1	-1	0	1	0	6
X_2	1	0	$\boxed{1/3}$	1	1/3	0	2
X_4	2	0	$\boxed{7/3}$	0	-2/3	1	2

Step 03. Divide the pivot row by pivot number and obtained row called new pivot row.

Step 04. Performing operation – Row (0)→ Row (0) + Row (2)

Performing operation – Row (1)→ Row (1) $-\frac{1}{3}$ Row (2)

	Iteration variable	eq.	coefficient of					R.H.S
			z	X_1	X_2	X_3	X_4	
0	Z	0	1	-1	0	1	0	6
	X_2	1	0	1/3	1	1/3	0	2
	X_4	2	0	7/3	0	-2/3	1	2
1	Z	0	1	0	0	15/21	3/7	48/7
	X_2	1	0	0	1	3/7	-3/21	12/7
	X_1	2	0	1	0	-6/21	3/7	6/7

After one iteration , the value of the objective function becomes = 48/7

Q.37 **The value of $\int_0^{\pi} \log(cosx)\, dx$ is**

(A) $-\pi/2$ log2 **(B) $-\pi/4$ log2** **(C) $\pi/2$ log2** **(D) $\pi/4$ log2**

Answer (A)

Solution.

Let, $I = \int_0^{\pi/2} \log_e \cos x\, dx$ .....(1)

$$I = \int_0^{\pi/2} \log_e \cos\left(\frac{\pi}{2} - x\right) dx$$

$I = \int_0^{\pi/2} \log_e \sin x\, dx$ .....(2)

[$\because$ properties $\int_0^a f(x)dx = \int_0^a f(a-x)dx$]

Adding (1) & (2)

$$2I = \int_0^{\pi/2} \log_e \cos x \, dx + \int_0^{\pi/2} \log_e \sin x \, dx$$

$$2I = \int_0^{\pi/2} [\log_e \cos x + \log_e \sin x + \log_e 2 - \log_e 2] dx$$

$$2I = \int_0^{\pi/2} [\log_e (2 \sin x \cos x) - \log_e 2] dx$$

$$2I = \int_0^{\pi/2} \log_e \sin 2x \, dx - \int_0^{\pi/2} \log_e 2 \, dx$$

$$2I = \int_0^{\pi/2} \log_e \sin 2x \, dx - \frac{\pi}{2} \log_e 2$$

In first integral, putting $2x = \theta$

Then $dx = \frac{d\theta}{2}$

When $x = 0, \theta = 0$ *and when* $x = \frac{\pi}{2}, \theta = \pi$

$$\therefore 2I = \int_0^{\pi} \log_e \sin \theta \, d\theta - \frac{\pi}{2} \log_e 2$$

$$2I = 2.\frac{1}{2} \int_0^{\pi/2} \log_e \sin \theta \, d\theta - \frac{\pi}{2} \log_e 2$$

$$2I = I - \frac{\pi}{2} \log_e 2$$

$$\therefore I = -\frac{\pi}{2} \log_e 2$$

Q.38 **Given the following,**

Machine	Component
P. Dint header	1. Cowl
Q. Coal plough	2. Cutting chain
R. Road header	3. Loading apron
S. Shearer	4. Static set of bits

the correct match is

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

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

Answer (D)

Q.39 Given the following,

Rescue apparatus	Characteristic
P. Draeger BG-4	1. Open circuit chemical oxygen self-rescuer
Q. MSA IW-65	2. Filter type self-rescuer
R. Draeger Pulmotor	3. Self-contained breathing apparatus
S. Oxyboks	4. Resuscitation apparatus

the correct match is

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

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

Answer (C)

Q.40 Given the following,

Equation/formula/law	Application
P. Bernoulli equation	1. Pressure loss in laminar flow of fluid
Q. Poiseuille equation	2. Drag loss due to regular obstructions in fluid flow
R. Bromilow's formula	3. Energy conservation in ideal fluid flow
S. Stokes law	4. Terminal settling velocity of fine particles in fluid

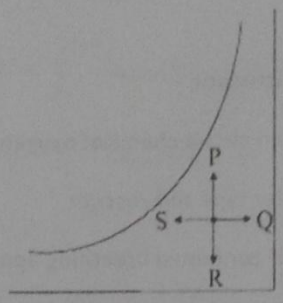
the correct match is

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

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

Answer (A)

Q.41 Four psychrometric processes P, Q, R and S are shown in the psychrometric chart below.



These processes respectively represent

(A) dehumidification, humidification, sensible heating, sensible cooling

(B) sensible heating, humidification, dehumidification, sensible cooling

(C) dehumidification, sensible heating, sensible cooling, humidification

(D) humidification, sensible heating, dehumidification, sensible cooling

Answer (D)

Q.42 Given the following differential equation

$$\frac{d^2y}{dx^2} + 7\frac{dy}{dx} + 12y = 0$$

the general solution is

(A) $y = Ae^{4x} + Be^{-3x}$ (B) $y = Ae^{-4x} + Be^{-3x}$

(C) $y = Ae^{3x} + Be^{-4x}$ (D) $y = Ae^{4x} + Be^{3x}$

Answer (B)

Solution.

We have

$$\frac{d^2y}{dx^2} + 7\frac{dy}{dx} + 12y = 0$$

In the symbolic form-

$$D^2 y + 7D\, y + 12y = 0$$

$$(D^2 + 7D + 12)y = 0$$

Its auxiliary equation will be -

$$D^2 + 7D + 12 = 0$$

$$\therefore D = -3, -4$$

Hence, general solution will be-

$$y = Ae^{-4x} + Be^{-3x}$$

Q.43 **Given the following,**

Mining method	Technique
P. Thick seam extraction	1. Double unit face
Q. Bord and pillar extraction	2. Jet cutting
R. Longwall face development	3. Inclined slicing
S. Hydraulic mining	4. Half moon method

the correct match is

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

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

Answer (D)

Q.44 **Given the following,**

Excavating/loading machine	Transportation scheme

P. Bucket Wheel Excavator — 1. Mine tub

Q. Continuous Miner — 2. Armoured flexible chain conveyor

R. Shearer — 3. Shiftable Conveyor

S. Load Haul Dumper — 4. Shuttle car

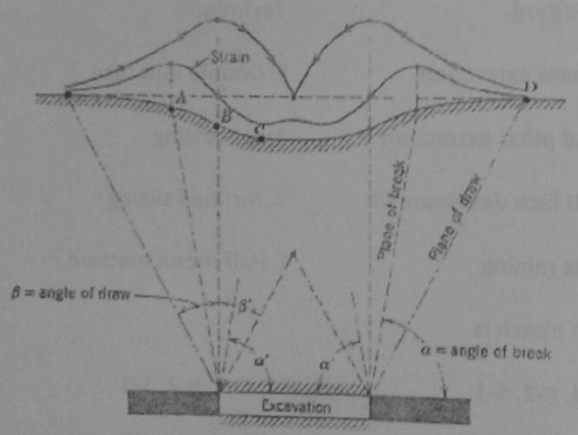
the correct match is

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

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

Answer (B)

Q.45 A sub-critical subsidence profile is shown in the figure below. The points A, B, C, and D represent respectively the points of



(A) zero vertical displacement, maximum tension, inflexion, maximum compression

(B) inflexion, maximum tension, maximum compression, zero vertical displacement

(C) maximum tension, inflexion, maximum compression, zero vertical displacement

(D) maximum compression, maximum tension, inflexion, zero vertical displacement

Answer (C)

Q.46 The uniaxial compressive strength of a limestone sample is 80 MPa. The sample is confined at a pressure of 20 MPa in a triaxial compressive strength test. Based on Hoek-Brown failure criteria the maximum principal stress at failure in MPa is (consider rock constants as m = 7.88, s = 1.0 and a = 0.5)

(A) 117.9 (B) 132.3 (C) 137.9 (D) 157.9

Answer (D)

Solution.

Hoek- Brown failure criteria by :-

$$\sigma_1 = \sigma_3 + \sigma_{ci}\left(m.\frac{\sigma_3}{\sigma_{ci}} + s\right)^a$$

Where,

σ_1, σ_3 are the major and minor effective principal stresses at failure

σ_{ci} is uniaxial compressive strength of the intact rock material

m, s and a are material constant

Therefore,

$$\sigma_1 = 20 + 80\left(7.88 \times \frac{20}{80} + 1\right)^{0.5}$$

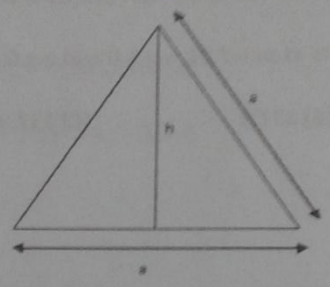
$$\sigma_1 = 157.9\ MPa$$

Q.47 A wire of length L is cut into two pieces to construct a circle and an equilateral triangle such that the combined area is minimum. The length of the wire used to construct the circle is

(A) $\frac{\sqrt{3}\pi L}{9+\sqrt{3}\pi}$ (B) $\frac{9L}{9+\sqrt{3}\pi}$ (C) $\frac{L}{2}$ (D) $\frac{18L}{9-\sqrt{3}\pi}$

Answer (A)

Solution.



$$h = \frac{a\sqrt{3}}{2}$$

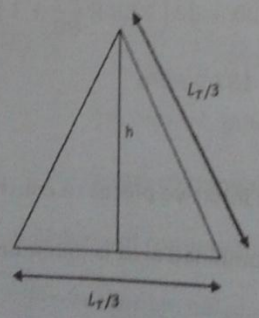
Area $= \frac{1}{2} \times base \times height$

Let total length of wire used to construct equilateral triangle and circle = L

Then, triangle length $= L_T$

And circle length $= L - L_T$

Now, calculation of equilateral triangle area –



$$h = \frac{L_T\sqrt{3}}{6}$$

$$\text{base} = \frac{L_T}{3}$$

$$\therefore A_T = \frac{1}{2} \times \frac{L_T}{3} \times \frac{L_T\sqrt{3}}{6}$$

$$\therefore A_T = \frac{L^2{}_T}{12\sqrt{3}}$$

Now, calculation of circle area –

$$\text{Circumference} = 2\pi r$$

$$\therefore L - L_T = 2\pi r$$

$$\text{Or } r = \frac{L-L_T}{2\pi}$$

$$\therefore \quad \text{Area of circle } (A_c) = \pi r^2$$

$$A_c = \frac{\pi\,(L-L_T)^2}{4\,\pi^2}$$

$$A_c = \frac{(L-L_T)^2}{4\,\pi}$$

Now, combined area –

$$A = \frac{L^2{}_T}{12\sqrt{3}} + \frac{(L-L_T)^2}{4\,\pi}$$

$$\frac{dA}{dL_T} = \frac{L_T}{6\sqrt{3}} - \frac{L-L_T}{2\,\pi}$$

For max. or min.

$$\frac{dA}{dL_T} = 0$$

$$\frac{L_T}{6\sqrt{3}} - \frac{L-L_T}{2\,\pi} = 0$$

$$\therefore L_T = \frac{3\sqrt{3}L}{\pi+3\sqrt{3}}$$

Now, length of the circle $= L - L_T$

$$= L - \frac{3\sqrt{3}L}{\pi+3\sqrt{3}} \quad \text{.....(1)}$$

Solving equation (1), length (L_c)of the wire used to construct circle is :-

$$L_c = \frac{\sqrt{3}.\pi.L}{9+\sqrt{3}.\pi}$$

<u>Common Data for Questions 48 and 49:</u>

Pressure characteristic of a mine fan is given by $P = -0.06Q^2 + 400$, where P is the pressure in Pa and Q^2 is the quantity in m^3/s. The resistance of the mine is 0.19 Ns^2/m^8.

Q.48 The mine quantity in m^3

(A) 160.0 (B) 53.5 (C) 45.9 (D) 40.0

Answer (D)

Solution.

We have,

$$P = RQ^2$$

$$-0.06Q^2 + 400 = 0.19 \times Q^2$$

$$\therefore Q = \sqrt{\frac{400}{0.25}} = 40\ m^3/sec$$

Q.49 An identical fan is installed in the mine to operate in series with the existing fan. The new mine quantity in m^3/s is

(A) 75.6 (B) 56.7 (C) 50.8 (D) 30.2

Answer (C)

Solution.

When identical fan is installed in series with the existing fan, then new pressure becomes

$$P' = 2P = -0.06 \times 2 \times Q^2 + 2 \times 400$$

$$P' = -0.12Q^2 + 800$$

Now, $P' = RQ^2$

$$-0.12Q^2 + 800 = 0.19Q^2$$

$$\therefore Q = \sqrt{\frac{800}{0.31}} = 50.8\ m^3/sec$$

Common Data for Questions 50 and 51:

The following observations are taken during a closed traverse.

Side	Length (m)	WCB
AB	100	90°
BC	173	180°
CA	200	330°

Q.50 The closing error of the traverse in mm is

(A) 205 (B) 20.5 (C) 2.05 (D) 0.205

Answer (A)

Solution.

Sum of the latitudes of the lines :-

$$\sum L \cos\theta = 100 \cos 90^0 + 173 \cos 180^0 + 200 \cos 330^0$$

$$\sum L \cos\theta = 0.2050\ m$$

Sum of the longitudes of the lines :-

$$\sum L \sin\theta = 100 \sin 90^0 + 173 \sin 180^0 + 200 \sin 330^0$$

$$\sum L \sin\theta = 0$$

Now,

Closing error of traverse $= \sqrt{(\sum L\cos\theta)^2 + (\sum L\sin\theta)^2}$

$$= \sqrt{(0.2050)^2 + (0)^2}$$

$$= 0.2050\ m$$

$$= 205\ mm$$

Q.51 The reduced bearing of the closing error in degrees is

(A) 87.21 (B) 64.03 (C) 14.04 (D) 0

Answer (D)

Solution.

Reduced bearing of closing error $= \tan^{-1}\left(\frac{\sum L\sin\theta}{\sum L\cos\theta}\right)$

$\therefore$ Reduced bearing of closing error $= \tan^{-1}\left(\frac{0}{0.205}\right)$

$$= 0^0$$

<u>Statement for Linked Answer Questions 52 and 53:</u>

Economic analysis of an iron ore deposit reveals that the net value of the ore is related to the grade mined as shown below:

Grade (%Fe)	Net value of ore (Rs/tonne)
64.5	3200
60.2	1800

Q.52 Assuming linear relationship between the net value and grade, the break-even cut-off grade in % Fe is

(A) 52.2 (B) 54.7 (C) 58.0 (D) 62.2

Answer (B)

Solution.

Assuming the net value (Rs/tonne) and grade (% Fe) relationship is linear then an equation of form $y = a + bx$ relating to net value (y) to grade (x)

So,

$$3200 = a + 64.5\,b \quad \text{.....(1)}$$

$$1800 = a + 60.2b \quad \text{.....(2)}$$

Solving both equations,

$$a = -17800$$

$$b = 325.58$$

Therefore, result is

$$Y = -17800 + 325.58\,x$$

But , at break even cutoff grade net value (Y) is zero, i.e

$$Y = 0$$

$$\therefore \quad 0 = -17800 + 325.58\,x$$

$$\therefore x = \frac{17800}{325.58} = 54.7\%$$

Q.53 Assuming that the grade follows normal distribution with mean 62.7%, and standard deviation 10.0% (A portion of the standard normal distribution table is given below),

z	0.00	0.01	0.02	0.03	0.04
0.6	0.72575	0.72907	0.73237	0.73565	0.73891
0.7	0.75803	0.76115	0.76424	0.76730	0.77035
0.8	0.78814	0.7 9103	0.79389	0.79673	0.79954
0.9	0.81594	0.81859	0.82121	0.82381	0.82639
1.0	0.84134	0.84375	0.84613	0.84849	0.85083

the percentage of waste in the deposit based on the break-even cut-off grade is

(A) 78.8 **(B) 71.2** **(C) 28.8** **(D) 21.2**

Answer (D)

Solution.

From normal distribution, we have

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

$\because x = 54.7\%$ $\mu = 62.7\%$, $\sigma = 10\ \%$

$$z = \frac{54.7 - 62.7}{10}$$

$$z = \frac{-8}{10} = -0.8$$

From normal distribution table , at $z = -0.8$

The percentage of ore in deposit based on cut off grade is = 78.814 %

Therefore,

The percentage of waste in deposit based on the cut off grade is = 100−78.814

= 21.2 %

<u>Statement for Linked Answer Questions 54 and 55:</u>

A 4.6 m wide vein dipping at 80^0 is mined by horizontal cut-and-fill stoping method. The fill is to be placed in the stope along the length of 46 m and to a height of 3.0 m. If the specific weight of the fill material is 15.86 kN/m^3 and the

porosity is 35%, under fully saturated conditions

Q.54 The volume of water in the fill in m^3 is

(A) 222.18 (B) 332.40 (C) 336.44 (D) 634.80

Answer (A)

Solution.

$$\text{Porosity} = \frac{volume\ of\ void(air/water)}{total\ volume\ of\ rock\ sample}$$

$$\frac{35}{100} = \frac{volume\ of\ water}{4.6 \times 46 \times 3}$$

$$\therefore \text{volume of water} = \frac{35 \times 4.6 \times 46 \times 3}{100}$$

$$\therefore \text{volume of water} = 222.18\ m^3$$

Q.55 The mass of solids in saturated fill in tonnes is

(A) 820.00 (B) 804.10 (C) 799.30 (D) 788.80

Answer (B)

Solution.

$$\text{Specific weight} = \frac{weight\ of\ solid}{volume\ of\ solid}$$

$$15.86 = \frac{weight\ of\ solid}{4.6 \times 46 \times 3}$$

$$\therefore \text{weight of solid} = 10076.928\ \text{kN}$$

$$= 10076928\ \text{N}$$

$$\text{mass of solid} = 1026292.355\ \text{kg}$$

$$\text{And mass of water} = 222.18 \times 1000 = 222180\ \text{kg}$$

$$\text{Hence mass of solids in saturated fill} = 1026292.355 - 222180$$

$$= 804112\ \text{kg}$$

≈ 804.1 tonnes

Q.56 If $3 \leq X \leq 5$ and $8 \leq Y \leq 11$ then which of the following options is TRUE?

(A) $\frac{3}{5} \leq \frac{X}{Y} \leq \frac{8}{5}$

(B) $\frac{3}{11} \leq \frac{X}{Y} \leq \frac{5}{8}$

(C) $\frac{3}{11} \leq \frac{X}{Y} \leq \frac{8}{5}$

(D) $\frac{3}{5} \leq \frac{X}{Y} \leq \frac{8}{11}$

Answer (B)

Solution.

Putting $X = 4$ and $Y = 9$, it is found that option (B) follows nearest values and correct order as compared to other given option and hence option (B) is correct.

Q.57 The Headmaster _____ to speak to you.

Which of the following options is incorrect to complete the above sentence?

(A) is wanting (B) wants (C) want (D) was wanting

Answer (C)

Q.58 Mahatama Gandhi was known for his humility as

(A) he played an important role in humiliating exit of British from India.

(B) he worked for humanitarian causes.

(C) he displayed modesty in his interactions.

(D) he was a fine human being.

Answer (C)

Q.59 All engineering student should learn mechanics, mathematics and how to do computation .

I II III IV

Which of the above underlined parts of the sentence is not appropriate?

(A) I (B) II (C) III (D) IV

Answer (D)

Q.60 Select the pair that best expresses a relationship similar to that expressed in the pair:

water: pipe::

(A) cart: road (B) electricity: wire

(C) sea: beach (D) music: instrument

Answer (B)

Q.61 Velocity of an object fired directly in upward direction is given by $V = 80 - 32t$, where t is time in seconds. When will the velocity be between 32 m/sec and 64 m/sec?

(A) (1, 3/2) (B) (1/2, 1) (C) (1/2, 3/2) (D) (1, 3)

Answer (C)

Solution.

$$V = 80 - 32t$$

When $V = 32$ m/sec

$$32 = 80 - 32t$$

$$\therefore t = 3/2 \text{ sec}$$

When $V = 64$ m/sec

$$64 = 80 - 32t$$

$$\therefore t = 1/2 \text{ sec}$$

$$\therefore (1/2, 3/2)$$

Q.62 **In a factory, two machines M1 and M2 manufacture 60% and 40% of the autocomponents respectively. Out of the total production, 2% of M1 and 3% of M2 are found to be defective. If a randomly drawn autocomponent from the combined lot is found defective, what is the probability that it was manufactured by M2?**

(A) 0.35 **(B) 0.45** **(C) 0.5** **(D) 0.4**

Answer (C)

Solution.

For machine M_1, given that

$$P(B) = 60\ \% = 0.60$$

$$P(A/B) = 2\% = 0.02$$

$$\therefore P(B).\ P(A/B) = 0.012$$

For machine M_2, given that

$$P(B) = 40\ \% = 0.40$$

$$P(A/B) = 3\% = 0.03$$

$\therefore P(B).\ P(A/B) = 0.012$

And $\sum P(B).\ P(A/B) = 0.024$

Hence , required probability by M_2 is given by:-

$$P(M_2) = \frac{\{P(B).P(A/B)\}_{M_2}}{\sum P(B).P(A/B)}$$

$$= \frac{0.012}{0.024} = 0.5$$

Q.63 **Following table gives data on tourists from different countries visiting India in the year 2011.**

Country	Number of tourists
USA	2000
England	3500
Germany	1200
Italy	1100
Japan	2400
Australia	2300
France	1000

Which two countries contributed to the one third of the total number of tourists who visited India in 2011?

(A) USA and Japan **(B) USA and Australia**

(C) England and France **(D) Japan and Australia**

Answer (C)

Solution.

Total number of tourists who visited India in 2011 = 13500

Now, one third of total number of tourists = 4500

Total number of tourists from Engliand and france = 4500

Hence, England and France both countries contributed to the one third of the total number of tourists who visited India in 2011.

Q.64 **If $|-2X+9|=3$ then the possible value of $|-X|-X^2$ would be:**

(A) 30 **(B) -30** **(C) - 42** **(D) 42**

Answer (B)

Solution.

$$|-2X+9|=3$$

Or $-2X+9=\pm 3$

Taking (+)

Then X = 3

Therefore ,

$|-X|-X^2=3-9=-6$, and

Taking $(-)$

Then X = 6

Therefore ,

$$|-X|-X^2=6-36=-30$$

$\therefore$ possible value $=-30$

Q.65 **All professors are researchers**

Some scientists are professors

Which of the given conclusions is logically valid and is inferred from the above arguments:

(A) All scientists are researchers

(B) All professors are scientists

(C) Some researchers are scientists

(D) No conclusion follows

Answer (C)

Q.1 A 30 m steel tape having an area of cross-section of 5×10^{-6} m is standardized at 20^0 C, supported under a tension of 5.45 N. It is used to measure a horizontal distance of 81.15 m under an applied tension of 9.09 N. The error, due to incorrect pulling arrangement in this observation, in m is

(E_{steel} = 200 GPa)

(A) 0.148 (B) 0.295 (C) 1.820 (D) 3.640

Answer (B)

Solution.

The error due to incorrect pulling arrangement is given by

$$C_p = \frac{(P - P_s)L}{AE}$$

Given that,

$$P = 9.09\ N;\ P_s = 5.45\ N;\ L = 81.15m$$

$$A = 5 \times 10^{-6} m^2;\ E = 200 \times 10^9\ N/m^2$$

Now

$$C_p = \frac{(9.09 - 5.45) \times 81.15}{5 \times 10^{-6} \times 200 \times 10^9}$$

$$C_p = 2.95 \times 10^{-4} m$$

$C_p = 0.295$ m

Q.2 The coefficient of variation of a dataset is measured by

(A) $\frac{mean}{standard\ deviation}$ (B) $\frac{mean}{variance}$ (C) $\frac{standard\ deviation}{mean}$ (D) $\frac{variance}{mean}$

Answer (C)

Q.3 The value of $\int_0^1 sin^{-1}(\cos x)dx$ is

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

Answer (A)

Solution.

$$I = \int_0^1 \sin^{-1}(\cos x)dx$$

$$I = \int_0^1 \sin^{-1}\left\{\sin\left(\frac{\pi}{2} - x\right)\right\}dx \quad \because \left[\sin\left(\frac{\pi}{2} - x\right) = \cos x\right]$$

$$I = \frac{\pi}{2} - \left[\frac{x^2}{2}\right]_0^1$$

$$I = \frac{\pi}{2} - \frac{1}{2} = \frac{\pi - 1}{2}$$

Q.4 Assuming sin(1) = 0.841 and sin(3) = 0.141 , the Lagrangian linear interpolating polynomial, for the function f(x) = sin(x) defined on the interval [1, 3] and passing through the end points of the interval, is

(A) $-0.35x + 1.19$ (B) $-3.05x + 11.92$

(C) $-35.00x + 119.10$ (D) $-40.50x + 219.19$

Answer (A)

Solution .

Lagrangian Interpretation Formula

$$f(x)=\frac{(x-x_1)....(x-x_n)}{(x_0-x_1)....(x_0-x_n)}f_0+.....+\frac{(x-x_0)....(x-x_{n-1})}{(x_n-x_0)....(x_n-x_{n-1})}f_n$$

Given, f (x) = sinx ; f_0 = 0.841; f_1 = 0.141

x_o = 1; x_1 = 3

$$\sin x = \frac{(x-3)}{(1-3)}\times 0.841+\frac{(x-3)}{(1-3)}\times 0.141$$

$$\sin x = \frac{(x-3)}{-2}\times 0.841+\frac{(x-1)}{2}\times 0.141$$

sinx = – (x – 3) x 0.4205 + (x – 1) x 0.0705

sinx = – 0.4205x + 1.2615 + 0.0705x – 0.0705

sinx = – 0.3500x + 1.191

Q.5 If Poisson's ratio of a rock sample is 0.25, then the relationship among the modulus of Elasticity (E), modulus of rigidity (G) and bulk modulus (K) is

(A) E = K = G (B) E > G > K (C) E = G > K (D) E > K > G

Answer (D)

Solution.

Given, Poisson ratio = $\frac{1}{m} = 0.25$

Or $m = 4$

Now, $K = \frac{mE}{3(m-2)}$

Where, K – Bulk modulus

E – Modulus of Elasticity

$$K = \frac{4E}{3(4-2)}$$

$$K = \frac{4E}{3\times 2} = \frac{2}{3}E$$

Or $E = 1.5K$ .....(i)

Now $G = \frac{mE}{2(m+1)}$

where G – Modulus of rigidity

$$G = \frac{4E}{2(4+1)} = \frac{4E}{2\times 5} = \frac{2}{5}E$$

$E = 2.5\,G$ .....(ii)

From (i) & (ii)

$1.5K = 2.5G$

$\therefore \frac{K}{G} = \frac{2.5}{1.5}$

$\therefore K = 1.6\,G$ .....(iii)

Hence, from equation (i), (ii) & (iii) it is seen that,

E > K > G

Q.6 The 2nd order differential equation having a solution y = (A/x)+ B, where A and B are constants,is

(A) $\frac{d^2y}{dydx}+\frac{2\,dy}{xdx}=0$ (B) $\frac{d^2y}{dx^2}+\frac{2dy}{x\,dx}=0$

(C) $\left(\frac{d^2y}{dx^2}\right)^2+\frac{2dy}{x\,dx}=0$ (D) $\frac{d^2y}{dydx}+\frac{d^2y}{dx^2}+\frac{dy}{dx}=0$

Answer (B)

Solution.

Given differential equation

$$y=\frac{A}{x}+B$$

Now differentiate w.r.t, x, we get

$$\frac{dy}{dx}=\frac{-A}{x^2} \quad \text{.....(i)}$$

Now differentiate equation (i). w.r.t , x, we get

$$\frac{d^2y}{dx^2}=\frac{2A}{x^3} \quad \text{.....(ii)}$$

Now multiplying (i) by $\frac{2}{x}$ we get,

$$\frac{2}{x}\frac{dy}{dx}=\frac{-2A}{x^3} \quad \text{.....(iii)}$$

Now , adding (ii) & (iii) we get,

$$\frac{2}{x}\frac{dy}{dx}+\frac{d^2y}{dx^2}=\frac{2A}{x^3}-\frac{2A}{x^3}$$

$$\frac{2}{x}\frac{dy}{dx}+\frac{d^2y}{dx^2}=0$$

Q.7 **A cylindrical rock specimen is uniaxially loaded under compression and fails at 50 MPa. The fracture plane is inclined at an angle of 45^0 with the axial direction. The normal and shear stresses respectively on the failure plane in MPa are**

(A) 50, 50 **(B) 0, 50** **(C) 50, 0** **(D) 25, 25**

Answer (D)

Solution.

Shear stress is given by-

$$\tau = \frac{\sigma_1}{2} = \frac{50}{2} = 25\ MPa$$

Now, $\tau = \sigma_n \tan \emptyset + C$

When C= 0 ;

$\therefore \tau = \sigma_n \tan \emptyset$

Given that, $\emptyset = 45^0$

$\therefore 25 = \sigma_n \tan 45^0$

$\therefore \tau = \sigma_n \tan 45^0$

$\therefore \sigma_n = 25\ MPa$

Q.8 **In a surface mine, sound pressure level at a location generated by operation of a dozer and a drill respectively are 80 dBA and 60 dBA, when operated independently. The sound pressure generated by the dozer compared to the drill is higher by a factor of**

(A) 10 **(B) 20** **(C) 100** **(D) 200**

Answer (A)

Q.9 As per the Indian Electricity Rules 1956, the maximum permissible length of a flexible cable used with an electric rope shovel in m is

(A) 100 (B) 200 (C) 300 (D) 500

Answer (C)

Q.10 The equipment that is NOT used in hard rock metal mining drivage is

(A) road header (B) drill jumbo (C) jack hammer (D) dint header

Answer (D)

Q.11 The roof bolt that follows the principle of point anchorage is

(A) expansion shell bolt (B) full column grouted bolt

(C) split set bolt (D) swellex bolt

Answer (A)

Q.12 Equipment used in mining of placer deposits is

(A) auger (B) wagon drill (C) rope saw (D) riffle box

Answer (D)

Q.13 A dump truck powered by 350 kW engine is running at a speed of 35 km/h. Considering the transmission efficiency of the truck as 85%, the rim pull of the truck in kN is

(A) 21 (B) 31 (C) 41 (D) 51

Answer (B)

Solution.

$$\text{Power} = \frac{work\ done}{time}$$

Or $$\text{power} = \frac{rim\ pull \times distance}{time}$$

Or power = rim pull × speed

$$350 \times 10^3 = \text{Rim pull} \times \frac{35\times10^3}{60\times60}$$

$$\text{Rim pull} = \frac{350\times10^3\times60\times60}{35\times10^3}$$

Rim pull = 36000N

But given transmission efficiency is 85%

Rim pull = 36000 x 0.85

Rim pull = 30600 N

Or Rim pull = 30.6 KN or 31KN

Q.14 Nystagmus is a miner's disease associated with

(A) lever **(B) lung** **(C) eye** **(D) stomach**

Answer (C)

Q.15 Apart from mining of coal, the longwall mining method has been practiced for mining the deposits of

(A) copper **(B) lead and zinc**

(C) manganese **(D) pyrite and phosphate**

Answer (D)

Q.16 The three segments, whose synchronous functioning is essential for GPS operations, are

(A) space, control and user

(B) signal, control and user

(C) space, control and geo-registration

(D) signal, control and geo-registration

Answer (A)

Q.17 When a double ended ranging drum shearer cuts coal in a longwall face,

(A) both the drums rotate in the same direction keeping the front drum up and the rear drum down

(B) both the drums rotate in the opposite direction keeping the front drum up and the rear drum down

(C) both the drums rotate in the opposite direction keeping the front drum down and the rear drum up

(D) both the drums rotate in the same direction keeping the front drum down and the rear drum up

Answer (B)

Q.18 The match the following

Mine gas	Principal constituent
P. Stink damp	1. CO
Q. White damp	2. H_2S
R. Black damp	3. CH_4
S. Fire damp	4. CO_2

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

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

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

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

Answer (C)

Q.19 Continuous miner and shuttle car combination is NOT applicable in mining with

(A) rib pillar extraction technique (B) Wangawilli system

(C) room and pillar method (D) longwall method

Answer (D)

Q.20 Contours in a topographic map

(A) are not closed upon themselves although the earth is a continuous surface

(B) are not perpendicular to the direction of maximum slope

(C) provide an indication of presence of valley or ridge in the area

(D) are the lines joining the points of same declination at different elevations

Answer (C)

Q.21 A Dragger Gas Mask DOES NOT filter

(A) water vapour (B) nitrous fumes

(C) carbon monoxide (D) carbon dioxide

Answer (B)

Q.22 A system consists of four elements A, B, C and D which are connected functionally in a parallel configuration. The individual reliability of the elements is 0.80, 0.82, 0.85 and 0.90 respectively. The reliability of the system is

(A) 0.498 (B) 0.602 (C) 0.750 (D) 0.999

Answer (D)

Solution.

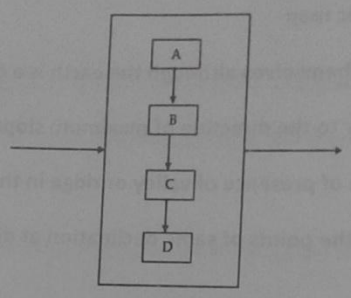
Given that,

Reliability of element A = 0.80

Reliability of element B = 0.82

Reliability of element C = 0.85

Reliability of element D = 0.90



The reliability of system will be

$$R = 1 - (1 - A).(1 - B).(1 - C).(1 - D)$$

$$R = 1 - (1 - 0.80).(1 - 0.82).(1 - 0.85).(1 - 0.90)$$

$$R = 0.999 \text{ Ans.}$$

Q.23 **The blasting technique used for controlled throw of overburden is known as**

(A) cast blasting **(B) coyote blasting**

(C) plaster shooting **(D) pop shooting**

Answer (A)

Q.24 **The stoping method, where a large part of blasted ore is allowed to accumulate in the stope to serve the purpose of providing working platform for stoping as well as to support the wall-rock, is known as**

(A) shrinkage stoping

(B) cut and fill stoping

(C) square-set stoping

(D) sublevel stoping

Answer (A)

Q.25 The injury rates of mine workers in an underground coal mine based on age group are given below:

Age of mine workers	Age specific injury rate per 1000 persons	Age specific population in the mine
18-32	1.8	1000
33-46	2.5	500
47-60	4.5	300

The injury rate per 1000 persons employed in the mine for the total population is

(A) 0.24 (B) 2.44 (C) 8.80 (D) 24.40

Answer (B)

Solution.

Injury rate per 1000 employed in the mine for the total population is –

$$= \frac{1.8\times1000+2.5\times500+4.5\times300}{1000+500+300}$$

$$= \frac{4400}{1800} = 2.44$$

Q.26 A shearer is deployed in a mine where the specific energy consumption for cutting coal is 800 kJ/m³. The specific gravity of coal is 1.2. If the machine produces 700 te/h, the electrical power consumption in kW of the shearer at 65% motor efficiency is

(A) 149.4 (B) 199.4 (C) 219.4 (D) 239.4

Answer (B)

Solution.

$\because$ 1 m^3 coal consume = 800 KJ

1×1.2 tonne of coal consume = 800KJ

1 tonne of coal consume = $\frac{800}{1.2}$ KJ

700 tonne of coal consume = $\frac{700 \times 800}{1.2}$ kJ

$700 \frac{tonne}{h}$ of coal consume = $\frac{700 \times 800}{1.2} \frac{kJ}{h}$

Or $700 \frac{tonne}{h}$ of coal consume = $\frac{700 \times 800}{1.2 \times 3600} \frac{kJ}{s}$

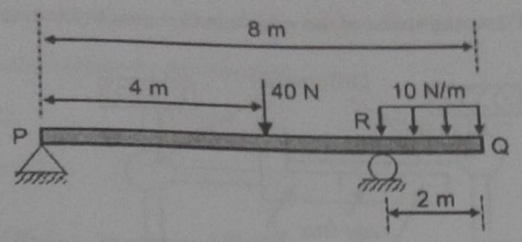
Or $700 \frac{tonne}{h}$ of coal consume = $\frac{700 \times 800}{1.2 \times 3600} \frac{kJ}{s}$

Or $700 \frac{tonne}{h}$ of coal consume = 129.63 kW

$\because$ Efficiency (%) = $\frac{output\ power}{input\ power}$

$\therefore$ Input power = $\frac{129.63}{0.65}$ = 199.4 kW

Q.27 **The figure shows a weightless beam PQ of length 8 m resting on a hinge support at P and on a roller support at R. A vertical force of 40 N is acting at a distance of 4 m from P. A uniformly distributed load of 10 N/m is acting on a length of 2 m of the beam from Q.**

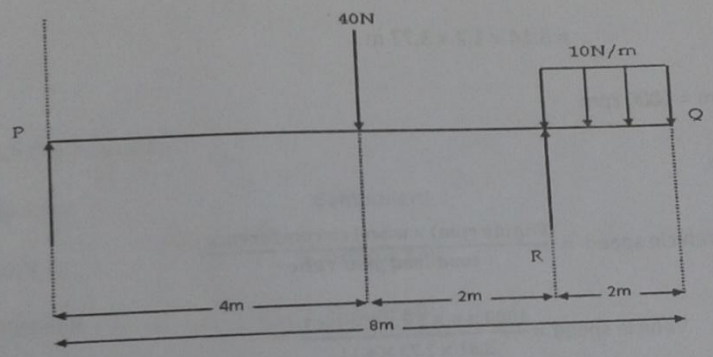


The magnitude of reaction force at R in N is

(A) 20 (B) 30 (C) 40 (D) 50

Answer (D)

Solution.



$$\sum Mp = 0$$

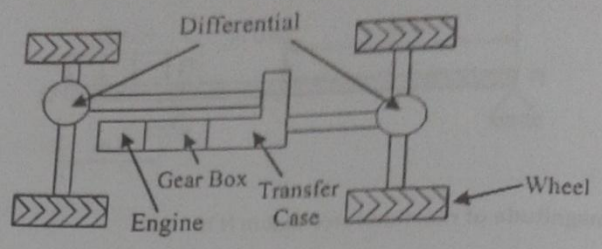
$$-40 \times 4 + R \times 6 - 10 \times 2 \times 7 = 0$$

$$\therefore \quad R = \frac{140 + 160}{6}$$

$$\therefore \quad R = 50 \text{ N}$$

Q.28 **The gear ratios of the first gear, transfer case and differential of a four wheel drive vehicle are 3.81:1, 2.72:1 and 4.11:1 respectively. If the engine is rotating at 1000 rpm and the**

wheel diameter is 1.2 m, the speed of the vehicle in first gear in km/h is



(A) 5.31 (B) 3.68 (C) 2.42 (D) 1.68

Answer (A)

Solution.

Circumstance of wheel = πD

$= 3.14 \times 1.2 = 3.77$ m

Engine rpm = 1000 rpm

We have,

$$\text{Vehicle speed} = \frac{(Engine\ rpm) \times wheel\ circumference}{combined\ gear\ ratio}$$

$$\text{Vehicle speed} = \frac{1000 \times \pi \times 1.2 \times 1 \times 1 \times 1}{3.81 \times 2.72 \times 4.11}$$

= 88.47 m/minute

$$= \frac{88.47 \times 60}{1000} \frac{km}{h}$$

= 5.31 Km/h

Hence, speed of vehicle in first gear is -

= 5.31 Km/h

Q.29 An iron ore mine recorded an average of 3 accidents per month. The number of

accidents is distributed according to Poisson distribution. The probability that there will be exactly 2 accidents per month is

(A) 0.22 (B) 0.30 (C) 0.43 (D) 0.67

Answer (A)

Solution.

Required probability = $\frac{e^{-m}(m)^r}{r!}$

Given that, m = 3, r = 2

Required probability = $\frac{e^{-3}(3)^2}{2!}$

= 0.22

Q.30 Match the following:

Equipment	Component
P. Scraper	1. Dribble belt
Q. Dragline	2. Dipper stick
R. Bucket wheel excavator	3. Fair lead
S. Rope shovel	4. Bowl

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

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

Answer (C)

Q.31 The torque in N-m of a winder motor is described by the relationship T = 1450 – 3.2ω, where, ω is the angular speed of the motor in rad/s. If the shaft is rotating at a speed of 1450 rpm, the power of the motor in kW is

(A) 112.4 (B) 146.4 (C) 184.4 (D) 212.4

Answer (B)

Solution.

Given, $T = 1450 - 3.2\,\omega$

$$\omega = \frac{2\pi N}{60}, \text{ rad/sec}$$

Where, N - rpm

$$\omega = \frac{2 \times 3.14 \times 1450}{60} = 151.77 \text{ rad/second}$$

Now, $T = 1450 - 3.2 \times 151.77$

$T = 964.336$ Nm

Since $P = \omega T$

$P = 151.77 \times 964.336$

$P = 146.35$ KW

Q.32 **An investment of Rs. 10,000, compounded annually, is estimated to return Rs. 20,000 after 6 years from the date of investment. The expected rate of return on this investment in percentage is**

(A) 8.75 **(B) 10.50** **(C) 12.25** **(D) 16.6**

Answer (C)

Solution.

$$S = P(1+i)^n$$

Given , S = 20,000

P = 10,000

$n = 6$

$\therefore \quad 20{,}000 = 10{,}000\ P(1+i)^n$

$2 = (1+i)^6$

$\therefore \quad (2)^{1/6} = 1 + i$

Or $\quad i = (2)^{1/6} - 1$

$\therefore \quad i = 12.25\%$

Q.33 **A spherical droplet of water, with density 1000 kg/m^3 and diameter of 1 μm, is falling in air. The viscosity of air is 1.85 x 10^{-5} kg/m s. Neglecting air density and assuming that the settling of droplet in air follows Stokes' Law, the settling velocity in m/s is**

(A) 0.98 x 10^{-5} (B) 2.95 x 10^{-5} (C) 8.04 x 10^{-5} (D) 53.03 x 10^{-5}

Answer (B)

Solution.

According to Stoke's settling velocity is given by

$$v = \frac{g\, d^2(\rho_p - \rho_f)}{18\,\eta} \quad [\because \rho_f = 0]$$

$$v = \frac{9.81 \times (10^{-6})^2 \times 1000}{18 \times 1.85 \times 10^{-5}}$$

$$v = 2.95 \times 10^{-5}\ \text{m/s}$$

Q.34 **A mining company has three mines (M1, M2 and M3) that supply coal to three power plants (P1, P2 and P3). The three mines produce 900, 1000 and 1200 te of coal per day respectively. The power plant requirements from these three mines are 1200, 1000 and**

900 te per day respectively. The unit cost of transporting coal from the three mines to the three power plants in Rs. is given below

		Power plants		
		P 1	P2	P3
Mines	M1	8	10	12
	M2	12	13	12
	M3	14	10	11

Based on the initial basic feasible solution, using Vogel's approximation method, the total transportation cost in Rs. is

(A) 31200 (B) 31400 (C) 32800 (D) 40000

Answer (B)

Solution.

Given that,

		Power	Plants		Supply
		P_1	P_2	P_3	
Mines	M_1	8	10	12	900
	M_2	12	13	12	1000
	M_3	14	10	11	1200
Requirement		1200	1000	900	Total = 3100

Now, for easy in calculation, taking scale of 100 = 1, for supply row and requirement column, then

8 (9)	10	12	9/0 (2)
12	13	12	10 (1)
14	10	11	12 (1)
12/3	10	9	31
(4)	(3)	(1)	
↑			

12	13	12	10 (1)
14	10 (10)	11	12/2 (1)
3	10/0	9	22
(2)	(3)	(1)	
	↑		

12	12	10 (0)
14	(2) 11	2/0 (3) ←
3	9/7	12
(2)	(1)	

12 (3)	7 (12)	10 /7/0
3/0	7/0	10

Therefore ,

8(900)	10	12	900
12(300)	13	12(700)	1000
14	10(1000)	11(200)	1200
1200	1000	900	3100

Total transportation cost = $8 \times 900 + 12 \times 300 + 12 \times 700 + 10 \times 1000 + 11 \times 200$

$= 31400$

Hence total transportation cost is Rs. 31400

Q.35 **The angle between the tangents to the curve $\vec{R} = t^2\hat{i} + 2t\hat{j}$ at the point $t = \pm 1$ is**

(A) $\pi/2$ **(B) $\pi/3$** **(C) $\pi/4$** **(D) $\pi/6$**

Answer (A)

Solution.

Given, $R = t^2\hat{i} + 2t\hat{j}$ and $t = \pm 1$

Now $\nabla.R = \left(I\frac{\partial}{\partial t} + J\frac{\partial}{\partial t} + \frac{\partial}{\partial t}\right)\left(t^2\hat{i} + 2t\hat{j}\right)$

$\nabla.R = 2tI + 2J$

Now at, $t = 1$

$(\Delta.R)_1 = 2I + 2J$

Now at, $t = -1$

$$(\Delta.R)_2 = -2I + 2J$$

Since,

$$\cos\theta = \frac{(\nabla.R)_1.(\nabla.R)_2}{|\nabla.R|_1.|\nabla.R|_2}$$

$$\cos\theta = \frac{(2I+2J).(-2I+2J)}{\sqrt{2^2+2^2}.\sqrt{(-2)^2+2^2}}$$

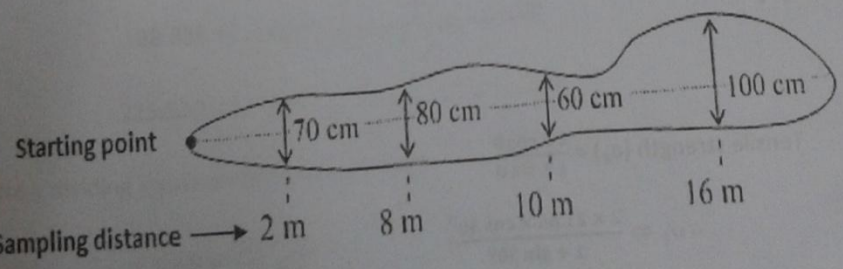
$$\cos\theta = \frac{-4+4}{\sqrt{8}.\sqrt{8}}$$

$$\cos\theta = \frac{0}{8} = 0$$

$$\theta = \frac{\pi}{2}$$

Q.36 **The chip sampling data, spaced irregularly for a gold vein deposit, are shown in figure. The sample points have equal influence on both the sides.**

Distance of sample from starting point (m)	**2**	**8**	**10**	**16**
Width (cm)	**70**	**80**	**60**	**100**
Assay (g/te)	**5**	**7**	**6**	**4**



The mean assay value in g/te is

(A) 6.52 **(B) 5.50** **(C) 5.19** **(D) 4.50**

Answer (C)

Solution

Position of sample	Width (m)	Assay (g/te)	Distance of influence	Area of influence	Area assay product
2	0.7	5	5	3.5	17.5
8	0.8	7	4	3.2	22.4
10	0.6	6	4	2.4	14.4
16	1	4	6	6	24
		Σ 22	Σ 19	Σ 15.1	Σ 78.3

$$\text{Mean assay value} = \frac{\sum area\ assay\ product}{\sum area\ of\ influence}$$

$$= \frac{78.3}{15.1}$$

Mean assay value = 5.19 g/tonnes

Q.37 A series of triaxial tests of sandstone samples reveal the cohesion and the angle of internal friction as 21.65 MPa and 30° respectively. Based on the assumption that the sandstone samples follow the Mohr-Coulomb's failure criteria, the tensile strength in MPa is

(A) 12.50 (B) 18.75 (C) 21.65 (D) 25.00

Answer (D)

Solution.

$$\text{Tensile strength } (\sigma_t) = \frac{2\,c\,\cos\emptyset}{1+\sin\emptyset}$$

$$\therefore \sigma_t = \frac{2 \times 21.65 \times \cos 30^0}{1+\sin 30^0}$$

$$\therefore \sigma_t = 25\ MPa$$

Q.38 The adjusted values of departure and latitude for a traverse line AB obtained in a field survey of a mine are 225.520 m and 388.835 m respectively. The length in m and azimuth of line AB are

(A) 449.50, 30.11° (B) 614.36, 30.11°

(C) 614.36, 45.11° (D) 449.50, 45.11°

Answer (A)

Solution 40.

Latitude = $l \times \cos\theta$

Departure = $l \times \sin\theta$

Where, l = Length of line

θ = Azimuth of line

Given,

Latitude of line AB = 388.835 m

Departure of line AB = 225.520m

Now,

$388.835 = l \times \cos\theta$ .....(i)

$225.520 = l \times \sin\theta$ .....(ii)

Now dividing equation (ii) by equation (i),

$$\tan\theta = \frac{225.520}{388.835}$$

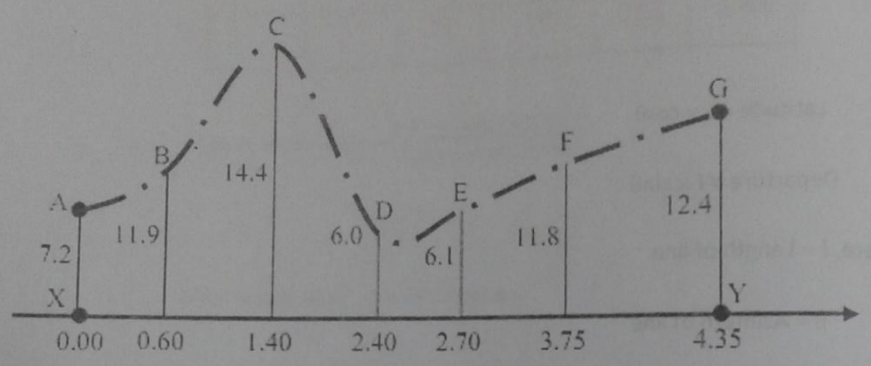
$$\theta = 30.11^0$$

Putting value of θ in equation (i), we get

$$388.835 = l \times \cos 30.11^0$$

$$\therefore \quad l = 449.50\ m$$

Q.39 **The figure shows the values of seven perpendicular offsets and the respective locations along the line XY as observed while carrying out a traverse survey. The area of the plot XABCDEFGY in m^2 is**



(All measurements are in meters)

(A) 26.10 **(B) 43.38** **(C) 44.92** **(D) 62.50**

Answer (C).

Solution.

The area of plot XABCDEFGY is $= \frac{1}{2} \times 0.6 \times (7.2 + 11.9) + \frac{1}{2} \times 0.8 \times (14.4 + 11.9) + \frac{1}{2} \times 1 \times$

$$(14.4 + 6) + \frac{1}{2} \times 0.3 \times (6 + 6.1) + \frac{1}{2} \times 1.05 \times (11.8 + 6.1) + \frac{1}{2} \times 0.6 \times (11.8 + 12.4)$$

$$= 5.73 + 10.52 + 10.2 + 1.813 + 9.3975 + 7.26$$

$$= 44.92\ m^2$$

Q 40. In a longwall panel, the main gate road is 1000 m long, 4.5 m wide and 2 m high. The gate road is to be used for airflow at the rate of 17 m^3/s. Considering a coefficient of resistance of airways of 0.01, the pressure in Pa required to maintain the airflow in the gate road is

(A) 51.83 (B) 463.84 (C) 875.98 (D) 7885.32

Solution.

Pressure is given by

$$P = \frac{KSQ^2}{A^3}, \text{Pa}$$

Given that,

K = 0.01, S = Length x Perimeter

S = 1000 x 2 x (4.5 +2)

S = 13000 m^2

Q = 17 m^3 / S

A = 4.5 × 2 = 9 m^2

$$\therefore \quad P = \frac{0.01 \times 13000 \times (17)^2}{(9)^3}$$

$\therefore$ P = 51.54 Pa

Q.41 The cofactor matrix of $P = \begin{bmatrix} 3 & 1 & 2 \\ 2 & 3 & 1 \\ 1 & 2 & 3 \end{bmatrix}$ **is**

(A) $\begin{bmatrix} 21 & -5 & 2 \\ 2 & 21 & -5 \\ -5 & 2 & 21 \end{bmatrix}$ (B) $\begin{bmatrix} 21 & 2 & -5 \\ 2 & 7 & 15 \\ -5 & 21 & 2 \end{bmatrix}$

(C) $\begin{bmatrix} -5 & 2 & 21 \\ 15 & 7 & 2 \\ -2 & 21 & -5 \end{bmatrix}$ (D) $\begin{bmatrix} 15 & 7 & 2 \\ -5 & 2 & 21 \\ -2 & 21 & -5 \end{bmatrix}$

Solution.

Cofactor of element 3 is $= (-1)^{1+1} \cdot \begin{vmatrix} 3 & 1 \\ 2 & 3 \end{vmatrix} = 7$

Cofactor of element 1 is $= (-1)^{1+2} \cdot \begin{vmatrix} 2 & 1 \\ 1 & 3 \end{vmatrix} = -5$

Cofactor of element 2 is $= (-1)^{1+3} \cdot \begin{vmatrix} 2 & 3 \\ 1 & 2 \end{vmatrix} = 1$

Cofactor of element 2 is $= (-1)^{2+1} \cdot \begin{vmatrix} 1 & 2 \\ 2 & 3 \end{vmatrix} = 1$

Cofactor of element 3 is $= (-1)^{2+2} \cdot \begin{vmatrix} 3 & 2 \\ 1 & 3 \end{vmatrix} = 7$

Cofactor of element 1 is $= (-1)^{2+3} \cdot \begin{vmatrix} 3 & 1 \\ 1 & 2 \end{vmatrix} = -5$

Cofactor of element 1 is $= (-1)^{3+1} \cdot \begin{vmatrix} 1 & 2 \\ 3 & 1 \end{vmatrix} = -5$

Cofactor of element 2 is $= (-1)^{3+2} \cdot \begin{vmatrix} 3 & 2 \\ 2 & 1 \end{vmatrix} = 1$

Cofactor of element 3 is $= (-1)^{3+3} \cdot \begin{vmatrix} 3 & 1 \\ 2 & 3 \end{vmatrix} = 7$

Hence, cofactor of Matrix P is $\begin{bmatrix} 7 & -5 & 1 \\ 1 & 7 & -5 \\ -5 & 1 & 7 \end{bmatrix}$

Q.42 **Match the following:**

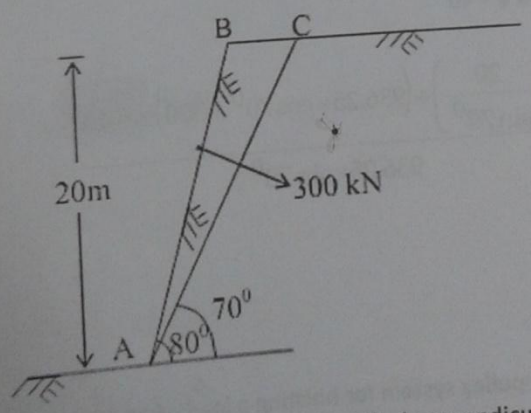
Mining system	Face supports
P. Mechanized longwall in flat seam	1. Cable bolting
Q. Blasting gallery method	2. Shield support
R. Mechanized longwall in steep seam	3. Alpine breaker line support
S. Wangawilli method for 3 m thick coal seam	4. Troika shield support

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

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

Answer (A)

Q.43 **An opencast mine bench has a potential failure plane AC as indicated in figure. Bolts are installed to stabilize the failure plane providing a resultant bolting force of 300 kN. The area of sliding block ABC is 37.45 m^2. The unit weight, cohesion and angle of internal friction of rock are 25 kN/m^2, 20 kPa and 40° respectively.**

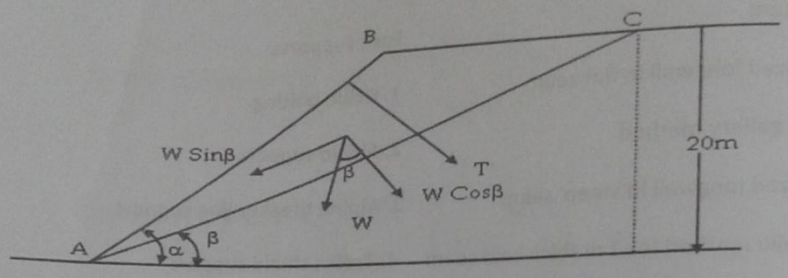


The factor of safety of slope when bolts are installed perpendicular to the failure plane is

(A) 0.79 (B) 1.08 (C) 1.78 (D) 3.46

Answer (B)

Solution.



$$\therefore \quad FOS = \frac{CA + (W\cos\beta + T)\tan\phi}{W\sin\beta}$$

where,

Cohesion = C = 20 KPa; $\alpha = 80^0$; $\beta = 70^0$

$$\text{Shear area} = A = \left(\frac{20}{\sin\beta}\right)\times 1 = \left(\frac{20}{\sin 70^0}\right)\times 1,\ m^2$$

W = 25 × 37.45 × 1 = 936.25KN

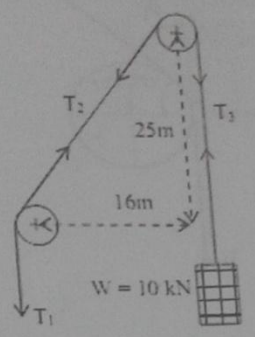
T = 300 KN & $\phi = 40^0$

$$\therefore \quad FOS = \frac{20\times\left(\frac{20}{\sin 70^0}\right) + \left(936.25\times\cos 70^0 + 300\right)\tan 40^0}{936.25\times\sin 70^0}$$

$\therefore$ FOS = 1.08

Q.44 Figure shows a two pulley system for hoisting a load of 10 kN. The coefficient of friction between each pulley and the rope is 0.2. The vertical and horizontal distances between

the centers of the pulleys are 25 m and 16 m respectively.

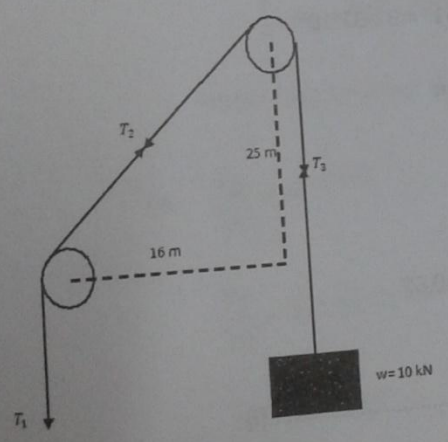


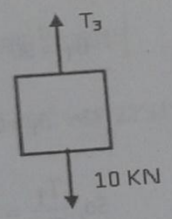
The tensions T_1 and T_2 respectively in kN are

(A) 6.00, 5.38 (B) 12.37, 11.06 (C) 18.74, 16.73 (D) 25.11, 22.41

Answer (C)

Solution.



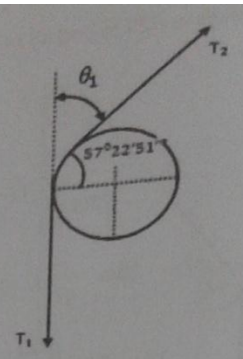


Here

Given , $\mu = 0.2$

$\therefore \quad T_3 - 10 = 0$

$T_3 = 10$ KN



Now , $\tan\theta = \dfrac{25}{16}$

$\theta = 57^0 22' 51''$

$\therefore$ Angle between T_1 & T_2 will be

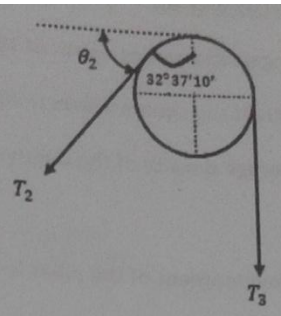
$\theta_1 = 90^0 - 57^0 22' 51'' = 32^0 37' 10''$

Or $\theta_1 = 0.57$ radian

So, $\dfrac{T_1}{T_2} = e^{\mu\theta_1}$

$\dfrac{T_1}{T_2} = 2.718^{0.2\times0.57}$

$T_1 = 1.1207\, T_2$ .....(i)



$$\tan\theta = \frac{16}{25}$$

$$\theta = 32^0 37' 10''$$

$\therefore$ Angle of lap between T_2 & T_3 is $= 90^0 + \theta_2$

$$\left[\because \theta_2 = 90^0 - 32^0 37' 10'' = 57^0 22' 51'\right]$$

$\therefore$ Angle of lap between T_2 & T_3 is $= 90^0 + 57^0 22' 51'' = 147^0 22' 51'' = 2.57$ radian

So, $$\frac{T_2}{T_3} = e^{\mu \times 2.57}$$

$$\frac{T_2}{10} = 2.718^{0.2 \times 2.57}$$

$$T_2 = 16.71 \text{ KN}$$

From equation (i),

$$T_1 = 1.1207 \times 16.71$$

$$T_1 = 18.73 \text{ KN}$$

Common Data for Questions 45 and 46:

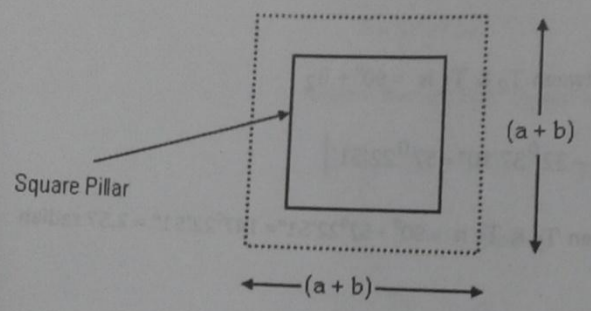
A 2.5 m thick coal seam lying at an average depth of 100 m has been developed by bord and pillar method. The width of the square pillars is 30 m (centre to centre) and the gallery width is 4 m. The average density of the overlying strata is 26 kN/m3 and the pillar strength is 4500 kN/m^2.

Q.45 Extraction ratio during the development of the pillar is

(A) 0.129 (B) 0.148 (C) 0.218 (D) 0.249

Answer (D)

Solution.



Given, a + b = 30m and b = gallery width = 4m

a + b = 30

∴ a = 30 – b = 30 – 4 = 26m

For square pillar extension ratio is given by-

$$R=1-\frac{a^2}{(a+b)^2}$$

$$R=1-\frac{(26)^2}{(26+4)^2}=0.249$$

Q.46 The safety factor of the pillar is

(A) 1.1 (B) 1.3 (C) 1.5 (D) 1.7

Answer (B)

Solution.

$$\text{Factor of safety} = \frac{strength\ of\ pillar}{Load\ acting\ on\ pillar}$$

Pillar strength is = 4500KN/m^2 = $4500 \times 10^3\ N/m^2$

Load acting on pillar is given by

$$P = Po \times \frac{1}{1-R}$$

or $$P = w.d \times \frac{1}{1-R}$$

$$w = 26kN/\ m^3 = 26 \times 10^3\ N/m^3$$

$$d = 100\ m$$

Here, $$P = 26 \times 10^3 \times 100 \times \frac{1}{1-0.249}$$

$$P = 3462050.599\ N/m^2$$

So, $$FOS = \frac{4500 \times 10^3}{3462050.599}$$

$$FOS = 1.3$$

Common Data for Questions 47 and 48:

The following data are provided for a surface mine to be excavated by a shovel:

Production target	: 10000 te/shift
Available hours per shift	: 6 hrs
Shovel loading cycles per hour	: 106
Bank density of the material mined	: 2400 kg/ m^3
Swing factor at 120 □swing	: 0.91
Bucket fill factor	: 0.64
Utilization of available time	: 83%
No. of working days in a year	: 300
No. of shifts per day	: 3

Q.47 The annual production target in Mte is

(A) 5.76 (B) 7.00 (C) 8.19 (D) 9.00

Answer (D)

Solution..

Annual production target will be = 10000 × 3 × 300

= 9000000 tonne

= 9 Mte

Q.48 The size of bucket of the shovel in m^3 is

(A) 5.55 (B) 9.33 (C) 11.22 (D) 13.55

Answer (D)

Solution.

Productivity of Shovel : -

$$A = \frac{3600 \times Cd \times \alpha \times F \times \eta}{t_s}, \ m^3/h$$

where,

Cd - Size of bucket, m^3

F - Fill factor

α - Swing factor

t_s - Cycle time, Sec

η - Percentage of utilization

Here,

$$A = 10000 \text{ t/shift} = \frac{10000}{6} \text{ t/hour}$$

$$= \frac{10000 \times 1000}{6} \text{ Kg/hour}$$

$$= \frac{10000 \times 1000}{6 \times 2400} \text{ m}^3\text{/hour}$$

$\because$ $t_s \rightarrow$ 1 hour = 106 cycle

106 cycle = 1 hour

$$1 \text{ cycle} = \frac{1}{106} \text{ hour} = \frac{3600}{106} \text{ seconds}$$

Putting all values,

$$\frac{10000 \times 1000}{6 \times 2400} = \frac{3600 \times Cd \times 0.64 \times 0.91 \times 1 \times 0.83}{\frac{3600}{106}}$$

$$Cd = \frac{10000 \times 1000}{6 \times 2400 \times 0.64 \times 0.91 \times 0.83 \times 10^6}$$

$$Cd = 13.55 \text{ m}^3$$

Statement for Linked Answer Questions 49 and 50:

A mining project is composed of five activities whose three time estimates in months are given below:

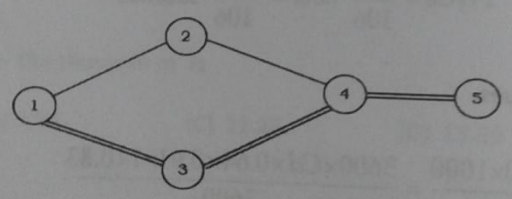
Activity	Esimated duration (months)		
	Optimistic time	Most likely time	Permissible time
1-2	1	1	7
1-3	2	5	8
2-4	1	1	7
3-4	2	5	14
4-5	3	6	15

Q.49 The expected duration of the mining project in months is

(A) 5 (B) 16 (C) 18 (D) 29

Answer (C)

Solution.



Activity	t_0	t_m	t_p	$t_e = \frac{t_0 + 4t_m + t_p}{6}$	$\sigma^2 = \left[\frac{t_p - t_0}{6}\right]^2$
1-2	1	1	7	2	1
1-3	2	5	8	5	1
2-4	1	1	7	2	1
3-4	2	5	14	6	4
4-5	3	6	15	7	4

Hence various path through the network and their length is given by-

$1-2-4-5 = 2+2+7 = 11$

$1-3-4-5 = 5+6+7 = 18$

Since path $1-3-4-5$ has longest duration, it is the critical path of network.

$\therefore$ Expected project length is = 18 months.

Q.50 **The standard deviation of the project length in months is**

(A) 2 **(B) 3** **(C) 6** **(D) 9**

Answer (B)

Solution.

Variance $= V_{1-3} + V_{3-4} + V_{4-5}$

$V = 1 + 4 + 4 = 9$

But $V = \sigma^2$

$\sigma^2 = 9$

$\sigma = 3$

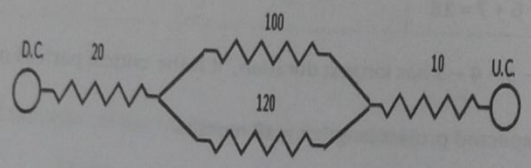
Statement for Linked Answer Questions 51 and 52:

In a mine between upcast shaft and downcast shaft, two airways are connected in parallel and their resistances are 100 $Ns^{-2}m^{-8}$ and 120 $Ns^{-2}m^{-8}$ respectively. The resistance of upcast shaft, downcast shaft and the fan drifts are 10, 20 and 5 $Ns^{-2}m^{-8}$respectively. The fan drift air pressure is 15 MN/m^2.

Q.51 The rate of airflow through the mine in m^3/s is

(A) 4.16 (B) 18.26 (C) 240.35 (D) 333.33

Solution.



$$\frac{1}{\sqrt{R}}=\frac{1}{\sqrt{R_1}}+\frac{1}{\sqrt{R_2}}$$

$$\frac{1}{\sqrt{R}}=\frac{1}{\sqrt{100}}+\frac{1}{\sqrt{120}}$$

$R = 27.33\ NS^{-2}m^{-8}$

Total resistance of mine = 27.33 + 20 + 10 + 5

$= 62.33\ NS^{-2}m^{-8}$

Now $P = RQ^2$

Given, $P = 15MN/m^2$

$\therefore \quad 15 \times 10^6 = 62.33 \times Q^2$

$$Q = \sqrt{\frac{15 \times 10^6}{62.33}}$$

$Q = 490.57 \ m^3/Sec$

Q.52 **The rate of airflow through the split airway having resistance of 100 $Ns^{-2}m^{-8}$ in m^3/s is**

(A) 0.42 **(B) 0.79** **(C) 2.19** **(D) 7.90**

Solution.

Rate of air flow through the split air way having resistance of 100 $NS^{-2}m^{-8}$ will be

$$Q_1 = Q \times \sqrt{\frac{R}{R_1}}$$

$$Q_1 = 490.57 \times \sqrt{\frac{27.33}{100}}$$

$Q_1 = 256.46 \ m^3/S$

Q.53 **Choose the most appropriate alternative from the options given below to complete the following sentence:**

I ___ to have bought a diamond ring.

(A) have a liking **(B) should have liked**

(C) would like **(D) may like**

Answer (C)

Q.54 **Choose the most appropriate alternative from the options given below to complete the**

following sentence:

Food prices ___ again this month.

(A) have raised (B) have been raising

(C) have been rising (D) have arose

Answer (C)

Q.55 Choose the most appropriate alternative from the options given below to complete the following sentence:

The administrators went on to implement yet another unreasonable measure, arguing that the measures were already ___ and one more would hardly make a difference.

(A) reflective (B) utopian

(C) luxuriant (D) unpopular

Answer (D)

Q.56 Choose the most appropriate alternative from the options given below to complete the following sentence:

To those of us who had always thought him timid, his ___ came as a surprise.

(A) intrepidity (B) inevitability

(C) inability (D) inertness

Answer (A)

Q.57 The arithmetic mean of five different natural numbers is 12. The largest possible value among the numbers is

(A) 12 (B) 40 (C) 50 (D) 60

Answer (C)

Solution.

Let five natural numbers are x_1, x_2, x_3, x_4, x_5, then

$$12 = \frac{x_1+x_2+x_3+x_4+x_5}{5}$$

$$\therefore \quad x_1 + x_2 + x_3 + x_4 + x_5 = 60$$

Take, $x_1 = 50, x_2 = 4, x_3 = 3, x_4 = 2, x_5 = 1$

Then, $50 + 4 + 3 + 2 + 1 = 60$

$$60 = 60$$

Hence, largest possible value among the numbers is-

$$x_1 = 50$$

Q.58 **Two policemen, A and B, fire once each at the same time at an escaping convict. The Probability that A hits the convict is three times the probability that B hits the convict. If the probability of the convict not getting injured is 0.5, the probability that B hits the convict is**

(A) 0.14 **(B) 0.22** **(C) 0.33** **(D) 0.40**

Answer (A)

Soltuion.

$P(A) = 3P(B)$ and $P(A \cup B) = 0.5$

Since $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

Here, $P(A \cap B) = 0$

$\therefore \quad P(A \cup B) = P(A) + P(B)$

$$0.5 = 3\,P(B) + P(B)$$

$$4P(B) = 0.5$$

$$P(B) = \frac{0.5}{4}$$

$$P(B) = 0.14$$

Q.59 **The total runs scored by four cricketers P, Q, R, and S in years 2009 and 2010 are given in the following table:**

Player	2009	2010
P	802	1008
Q	765	912
R	429	619
S	501	701

The player with the lowest percentage increase in total runs is

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

Answer (B)

Solution.

For player P percentage increases in total runs

$$= \frac{1008-802}{1008} \times 100 = 20.43\%$$

For player Q percentage increases in total runs

$$= \frac{912-765}{912} \times 100 = 16.12\%$$

For player R percentage increases in total runs

$$= \frac{619-429}{619} \times 100 = 30.70\%$$

For player S percentage increases in total runs

$$= \frac{701-501}{701} \times 100$$

$$= 28.53\%$$

Hence , the player with the lowest percentage is total runs is Q. Ans.

Q.60 If a prime number on division by 4 gives a remainder of 1, then that number can be expressed as

(A) sum of squares of two natural numbers

(B) sum of cubes of two natural numbers

(C) sum of square roots of two natural numbers

(D) sum of cube roots of two natural numbers

Answer (A)

Solution.

Let prime number is 5 and when this prime number is divided by 4 then gives remainder of 1.

Let two natural numbers are 2, 1 and hence prime number 5 can be expressed as sum of squares of these two natural numbers i.e

$$2^2 + 1^2 = 5$$

$$4 + 1 = 5$$

$$5 = 5$$

Q.61 Two points (4, p) and (0, q) lie on a straight line having a slope of 3/4. The value of (p – q) is

(A) -3 (B) 0 (C) 3 (D) 4

Answer (C)

Solution.

$y = mx + C$ .....(i)

Given two points (4, P) and (0, q) and slope of 3/4

Now, at point (4, P) and slope 3/4, equation (i) becomes

$$P = \frac{3}{4} \times 4 + C$$

$P = 3 + C$ .....(ii)

Now at point (0,q) and slope $\frac{3}{4}$, equation (i) becomes,

$q = 3/4 \times 0 + C$

$q = C$ .....(iii)

from equation (ii) and (iii) , it is found that

$p - q = 3 + C - C$

$P - q = 3$

Q.62 In the early nineteenth century, theories of social evolution were inspired less by Biology than by the conviction of social scientists that there was a growing improvement in social institutions. Progress was taken for granted and social scientists attempted to discover its laws and phases.

Which one of the following inferences may be drawn with the greatest accuracy from the

above passage?

Social scientists

(A) did not question that progress was a fact.

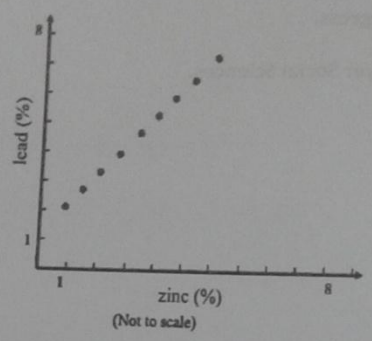
(B) did not approve of Biology.

(C) framed the laws of progress.

(D) emphasized Biology over Social Sciences.

Answer (A)

Q.1 A scatter plot prepared using a set of values of lead and zinc from a lead-zinc deposit is shown in figure below. The value of correlation coefficient is



(A) 1.0 (B) 0.7 (C) 0.5 (D) 0

Answer (A)

Solution .

By looking at the scatter points, it can be seen that all of the points are very close to being along a straight line . So there is a perfect positive correlation between lead and zinc from lead – zinc deposit.

Therefore,

Correlation coefficient (r) = + 1

Q.2 The value of $\lim_{x\to 0}\frac{1}{x}\{\sqrt{1+x}-\sqrt{1-x}\}$ is

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

Answer (B)

Solution .

$$f(x)=\lim_{x\to 0}\frac{1}{x}\{\sqrt{1+x}-\sqrt{1-x}\}$$

$$f(x) = \lim_{x\to 0} \frac{1}{x}\left\{\frac{\sqrt{1+x}-\sqrt{1-x}}{\sqrt{1+x}+\sqrt{1-x}} \times \sqrt{1+x}+\sqrt{1-x}\right\}$$

$$f(x) = \lim_{x\to 0} \frac{1}{x}\left\{\frac{\left(\sqrt{1+x}\right)^2-\left(\sqrt{1-x}\right)^2}{\sqrt{1+x}+\sqrt{1-x}}\right\}$$

$$\therefore \quad f(x) = \lim_{x\to 0} \frac{1}{x}\left\{\frac{2x}{\sqrt{1+x}+\sqrt{1-x}}\right\}$$

$$\therefore \quad f(x) = \lim_{x\to 0} \left\{\frac{2}{\sqrt{1+x}+\sqrt{1-x}}\right\}$$

$$\therefore \quad f(x) = \frac{2}{2} = 1$$

Q.3 **The infinite series** $1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+ \ldots\ldots$, **is**

(A) convergent **(B) divergent** **(C) oscillatory** **(D) semi-convergent**

Answer (A)

Solution .

Given infinite series , $1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\ldots\ldots\ldots\ldots\ldots\ldots\infty$

Or $\sum_{n=0}^{\infty}\frac{1}{2^n} = 1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\ldots\ldots\ldots\ldots\ldots\ldots\infty$

So, $r = \sum_{n=0}^{\infty}\frac{1}{2^n} = \frac{1}{2^\infty} = 0$

$\therefore r < 1$, the series is convergent.

Q.4 **The largest area of a rectangular shaft for a given constant perimeter is obtained when length is**

(A) 2.5 times of breadth **(B) 1.5 times of breadth**

(C) 2 times of breadth **(D) equal to breadth**

Answer (D)

Solution .

Perimeter for a rectangular shaft is given by:-

Perimeter = 2(length + breadth).....(1)

Let take perimeter is x

From equation (1)

length + breadth = 0.5 x .....(2)

Case -1. When length is 2.5 times of breadth

from equa. (2)

2.5 breadth + breadth = 0.5 x

$\therefore$ breadth = 0.14 x

$\therefore$ length = 0.36 x

$\therefore$ Area = 0.0504 x^2

Case -2. When length is 1.5 times of breadth

from equa. (2)

1.5 breadth + breadth = 0.5 x

$\therefore$ breadth = 0.2 x

$\therefore$ length = 0.3 x

$\therefore$ Area = 0.06 x^2

Case -3. When length is 2 times of breadth

from equa. (2)

2 breadth + breadth = 0.5 x

$\therefore$ breadth = 0.17 x

$\therefore$ length = 0.34 x

$\therefore$ Area = 0.0578 x^2

Case -4. When length is equal to the breadth

from equa. (2)

breadth + breadth = 0.5 x

$\therefore$ breadth = 0.25 x

$\therefore$ length = 0.25 x

$\therefore$ Area = 0.063 x^2

Hence , In case of 4, Area of rectangular will be largest.

Q.5 **A drive shaft of an engine develops torque of 500 N-m. It rotates at a constant speed of 50 rpm. The power transmitted by the shaft in kW is**

(A) 1.46 **(B) 2.05** **(C) 2.62** **(D) 4.32**

Answer (C)

Solution.

Relation of Power (P),Torque (T) and Rotational Speed (ω) are given by-

$$P = \omega . T$$

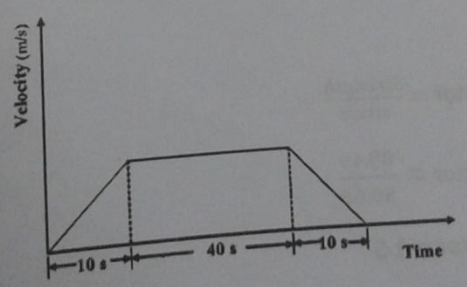
Or $P = \frac{2\pi N}{60} . T$

$$\therefore P = \frac{2\pi N}{60} . T = \frac{2 \times 3.14 \times 50}{60} \times 500$$

$$\therefore P = 2616.7 \text{ watt}$$

$$\therefore P = 2.62 \text{ kW}$$

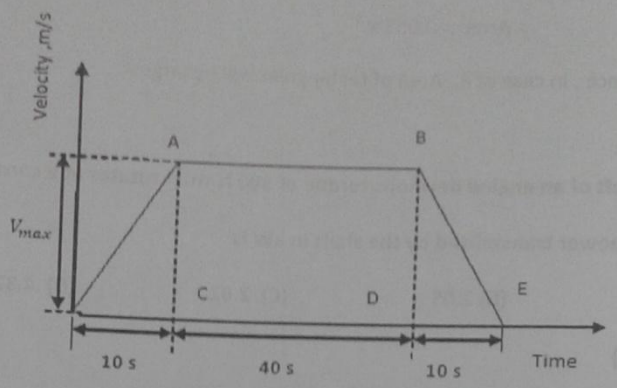
Q.6 **A mine winder cage traveling 450 m from pit bottom to pit top is following a three period duty cycle as shown in the figure below. The maximum velocity attained by the cage in m/s is**



(A) 7.5 **(B) 9.0** **(C) 11.0** **(D) 12.0**

Answer (B)

Solution .



Here, at point B , the cage will attain maximum velocity. Hence, maximum velocity attained by the cage is-

$$V_{max} = \frac{450}{50} = 9\ m/sec$$

Q.7 **Stress concentration at a point on the wall of a vertical shaft results in a compressive stress of 59.66 MPa. The wall rock mass has an unconfined compressive strength of 89.49 MPa. The safety factor of the shaft wall at the point is**

(A) 0.67 **(B) 0.86** **(C) 1.23** **(D) 1.50**

Answer (D)

Solution .

$$\text{Safety factor} = \frac{Strength}{stress}$$

$$\text{Safety factor} = \frac{89.49}{59.66}$$

$$\text{Safety factor} = 1.5$$

Q.8 A core sample of 54 mm diameter having Young's modulus of 68.97 GPa fails in uniaxial compression at 0.1% axial strain. The axial load at failure in kN is

(A) 158.00 (B) 68.97 (C) 58.00 (D) 15.80

Answer (A)

Solution .

We have,

Stress = young modulus×strain

Or $\frac{Axial\ load}{Area}$ = young modulus × axial strain

$\therefore \frac{Axial\ load}{3.14\times(27\times10^{-3})^2} = 68.97 \times 10^9 \times 1 \times 10^{-3}$ [$\because Axial\ strain = 0.1\% = 1 \times 10^{-3}$]

$\therefore$ Axial load $= 68.97 \times 10^9 \times 1 \times 10^{-3} \times 3.14 \times (27 \times 10^{-3})^2$ N

$\therefore$ Axial load $= 157876\ N$

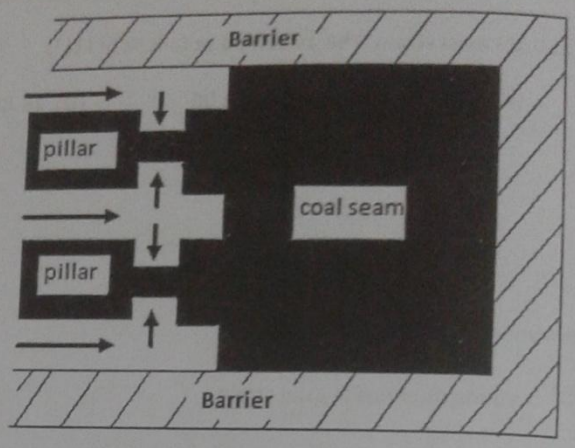
$\therefore$ Axial load $= 158\ kN$

Q.9 The maximum number of coal faces in an underground bord and pillar development district is 13. The number of headings in the district is

(A) 3 (B) 5 (C) 6 (D) 7

Answer (B)

Solution .



Arrow indicates Heading

From above figure, relation between number of face (m) and number of heading (n) are given by-

$$m = 3 \times n - 2$$

$$\therefore \; 13 = 3 \times n - 2$$

$$\therefore \; n = 5$$

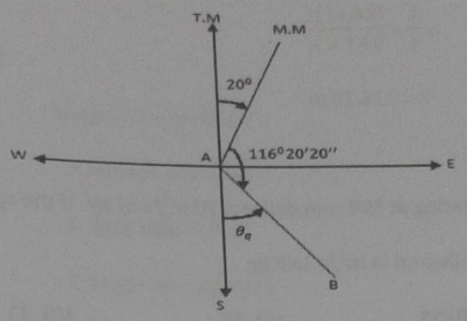
Q.10 **The whole circle bearing of the line AB is $116^\circ\, 20'\, 20''$. If there exists an east declination of 20°, the true quadrantal bearing of line AB is**

(A) $S41^0\, 59'40''E$ **(B)** $S43^0\, 39'40''E$

(C) $S45^0\, 59'40''W$ **(D)** $S47^0\, 59'40''W$

Answer (B)

Solution .



T.M. = True Meridian

M.M. = Magnetic Meridian

True bearing of line AB = $116^0 20' 20'' + 20^0 0' 0'' = 136^0 20' 20''$

∴ True quadrantal bearing of line AB = S $(180^0 0' 0'' - 136^0 20' 20'')$ E

∴ True quadrantal bearing of line AB = S $43^0 39' 40''$ E

Q.11 **It is proposed to connect two straights of a road by a simple circular curve. If the maximum speed of the vehicle is 60 km/h and the centrifugal ratio for the road is 1/4, the minimum radius of the curve in m is**

(A) 113.26 **(B) 98.18** **(C) 25.46** **(D) 15.50**

Answer (A)

Solution .

We have,

$$\text{Centrifugal ratio} = \frac{P}{W} = \frac{v^2}{gR}$$

Where, P – centrifugal force

W – weight of vehicle

$$\therefore \frac{1}{4} = \frac{(16.67)^2}{9.81 \times R}$$

$\therefore$ R = 113.26 m

Q.12 A centrifugal fan rotating at 500 rpm delivers 70 m^3/s of air. If the speed is reduced to 200 rpm, The quantity of air delivered in m^3/s will be

(A) 175 (B) 55 (C) 28 (D) 11

Answer (C)

Solution .

We know, Quantity of air (Q) delivered varies directly as fan-speed (N).

$$Q \propto N$$

Or $$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$$

$$\therefore \quad \frac{70}{Q_2} = \frac{500}{200}$$

$$\therefore \quad Q_2 = 28\ m^3/\text{sec}$$

Q 13. According to mine regulations, the value of the fleet angle α, in degree of a drum winder installation lies in the range of

(A) 1.5<α≤2.0 (B) 0<α ≤1.5 (C) 2.0< α ≤2.5 (D) 2.5<α ≤3.0

Answer (B)

Q.14 Water will not be delivered by a centrifugal pump due to

(A) lack of priming (B) too low discharge head

(C) wrong direction of rotation (D) partial obstruction at discharge outlet

Answer (A)

Q.15 Match the following

Mine car type	Mode of unloading
P. Granby	1. Bottom opening
Q. Gable bottom	2. Both side tilting
R. Drop bottom	3. Single side opening
S. Rocker dump	4. Both side opening

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

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

Answer (D)

Q.16 Mean air temperature of a 450 m deep downcast shaft is 29°C and that of the upcast shaft is 37°C. The height of the motive column in m is

(A) 8.2 (B) 9.5 (C) 11.6 (D) 12.8

Answer (C)

Solution .

We have,

$$\text{Motive column} = D \times \frac{T_u - T_d}{273 + T_u}, \text{m}$$

$$\therefore \text{Motive column} = 450 \times \frac{37-29}{273+37}, \text{m}$$

$$\therefore \text{Motive column} = 11.6 \text{ m}$$

Q.17 The total pressure and the static pressure measured at a point in a ventilation duct are 20 mm and 10 mm of water gauge respectively. If density of air is 1.2 kg/m3, the velocity of the air in m/s is

(A) 14.08 (B) 12.78 (C) 8.53 (D) 6.24

Answer (B)

Solution .

We know,

Total pressure = velocity pressure + static pressure

20 = 10 + velocity pressure

Velocity pressure = 10 mm of w.g

Or velocity pressure = 100 Pa

Or velocity pressure = $\frac{1}{2} \times \rho \times v^2$

Where, ρ - density of air in kg/m^3 = 1.2 kg/m^3

v- velocity of air in m/sec

$100 = \frac{1}{2} \times \rho \times v^2$

Or $v^2 = \frac{2 \times 100}{1.2}$

$\therefore$ v = 12.93 m/sec

Q.18 **The type of fire extinguisher that must NOT be used in case of fire in an electric substation located in an underground metal mine is**

(A) multi-purpose dry chemical extinguisher **(B) CO_2 snow extinguisher**

(C) dry chemical powder extinguisher **(D) foam extinguisher**

Answer (D)

Q.19 ***ISO 9000 Quality Systems DO NOT contain***

(A) legal provisions **(B) measurement** **(C) document control** **(D) standardization**

Answer (A)

Q.20 Air samples collected from the intake and the return gates of a retreating longwall face show methane concentration values of 0.1 % and 0.8 % respectively. The production from the longwall face is 2000 tonne/day and the air quantity circulating the face is 15 m^3/s. The rate of methane emission in m^3 per tonne of coal produced is

(A) 11.0 (B) 9.5 (C) 5.5 (D) 4.5

Answer (D)

Solution .

$$\text{Quantity of methane picked up by air} = \frac{15 \times (0.8 - 0.1)}{100}$$

$$= 0.105\ m^3/\text{sec}$$

$$= 9072\ m^3/\text{day}$$

$$\therefore \text{Emission of methane per tonne of coal} = \frac{9072}{2000} = 4.5\ m^3/\text{tone}$$

Q.21 The time study data of an equipment deployed in a mine during a calendar month is given below.

Total working hours = 400

Total maintenance hours = 100

Total hours of actual work = 240

The percentage of utilization of the equipment is

(A) 85 (B) 80 (C) 65 (D) 60

Answer (B)

Solution .

$$\text{Percentage of utilization of equipment} = \frac{240}{400-100} \times 100$$

$$= 80\ \%$$

Q.22 **100 ml of waste water is allowed to evaporate in a dish weighing 48.6232 g. The weight of the dish with dry solids is 48.6432 g. The concentration of dry solids in waste water in mg/l is**

(A) 200 **(B) 220** **(C) 260** **(D) 320**

Answer (A)

Solution

Weight of dry solids in 100 ml waste water = 48.6432−48.6232

= 0.02 g

So, 100 ml contains 0.02 g dry solids

1 ml contains $= \frac{0.02}{100}$ g dry solds

And 1 l waste water contains $= \frac{0.02\times1000}{100}$ g dry solids

Or 1 l waste water contains $= \frac{0.02\times1000\times1000}{100}$ mg dry solids

Or 1 l waste water contains = 200 mg dry solids

Hence, concentration of dry solids in waste water is 200 mg/L.

Q.23 **A longwall face cut by double back shuffle method can be only worked with**

(A) fixed drum shearer **(B) single ended ranging drum shearer**

(C) double ended ranging drum shearer **(D) plough**

Answer (C)

Q.24 **For an oil exploration drilling, chance of striking an oil reservoir is 1 out of 15. If an oil exploration company decides to explore 5 sites, the probability of striking at least one successful oil reservoir is**

(A) 0.292 (B) 0.250 (C) 0.034 (D) 0.0024

Answer (A)

Solution .

Let P(A) = 1/15; P(B) = 1/15; P(C) = 1/15; P(D) = 1/15; P(E) = 1/15;

The probability of striking at least one successful oil reservoir is-

$$P = 1 - P(\bar{A}).P(\bar{B}).P(\bar{C}).P(\bar{D}).P(\bar{E})$$

$$P = 1 - \{(1 - \mathrm{P(A)}\}\{(1 - \mathrm{P(B)}\}\{(1 - \mathrm{P(C)}\}\{(1 - \mathrm{P(D)}\}\{(1 - \mathrm{P(E)}\}$$

$$P = 1 - (1 - 1/15).(1 - 1/15).(1 - 1/15)(1 - 1/15).(1 - 1/15)$$

$$\therefore \quad P = 0.292$$

Q.25 Product of the eigen values of the matrix A = $\begin{bmatrix} 3 & 2 & 5 \\ 2 & 2 & 1 \\ 1 & 5 & 4 \end{bmatrix}$ is

(A) 6 (B) 8 (C) 10 (D) 35

Answer (D)

Solution .

We know,

The product of eigen value of a given matrix is equal to the determinant of given matrix.

$$A = \begin{bmatrix} 3 & 2 & 5 \\ 2 & 2 & 1 \\ 1 & 5 & 4 \end{bmatrix}$$

$$\text{Now, } |A| = \begin{vmatrix} 3 & 2 & 5 \\ 2 & 2 & 1 \\ 1 & 5 & 4 \end{vmatrix}$$

$$|A| = 3\begin{vmatrix} 2 & 1 \\ 5 & 4 \end{vmatrix} - 2\begin{vmatrix} 2 & 1 \\ 1 & 4 \end{vmatrix} + 5\begin{vmatrix} 2 & 2 \\ 1 & 5 \end{vmatrix}$$

$$|A| = 3\,(8 - 5) - 2(8 - 1) + 5(10 - 2)$$

$$|A| = 35$$

Q.26 For the equation $\frac{dy}{dx} = 2x + 3y$, the value of y at x = 0.1 in one step using Runge-Kutta Fourth order method for the condition y =1 when x = 0 , is

(A) 0.3608 (B) 1.2508 (C) 1.3608 (D) 1.4625

Answer (C)

Solution .

$$f(x, y) = 2x + 3y,\ x_0 = 0, y_0 = 1, h = 0.1 - 0 = 0.1$$

Now, $K_1 = h.f(x_0, y_0) = 0.1 \times (2x_0 + 3y_0)$

$= 0.3$

$K_2 = h.f\left(x_0 + \frac{h}{2}, y_0 + \frac{k_1}{2}\right) = 0.1\, f(0.05, 1.15)$

$= 0.355$

$K_3 = h.f\left(x_0 + \frac{h}{2}, y_0 + \frac{k_2}{2}\right) = 0.1\, f(0.05, 1.1775)$

$= 0.36325$

$K_4 = h.f(x_0 + h,\ y_0 + k_3) = 0.1\, f(0.1, 1.36325)$

$= 0.428975$

Now, $k = \frac{k_1 + 2k_2 + 2k_3 + k_4}{6}$

$\therefore k = 0.3609125$

Hence, Value of y =1+ 0.3609125 = 1.3609125

Q.27 The Value of the integral $\int_0^1 \sqrt{\frac{1+x}{1-x}}\, dx$ is

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

Answer (B)

Solution .

$$I = \int_0^1 \sqrt{\frac{1+x}{1-x}}\, dx$$

$$I = \int_0^1 \sqrt{\frac{1+x}{1-x} \times \frac{1+x}{1+x}}\ dx$$

$$I = \int_0^1 \frac{1+x}{\sqrt{1-x^2}}\ dx$$

$$I = \int_0^1 \frac{1}{\sqrt{1-x^2}}\ dx + \int_0^1 \frac{x}{\sqrt{1-x^2}}\ dx$$

$$I = [\sin^{-1} x]_0^1 + \int_0^1 \frac{x}{\sqrt{1-x^2}}\ dx$$

Let , $1 - x^2 = t$

$$\therefore dx = \frac{-dt}{2x}$$

When $x = 1$ then t = 0 & When $x = 0$ then t = 1 ,

$$I = [\sin^{-1} 1 - \sin^{-1} 0] - \int_1^0 \frac{x}{\sqrt{t}} \cdot \frac{dt}{2x}$$

$$\therefore \quad I = \frac{\pi}{2} - \frac{1}{2}\left[\frac{t^{1/2}}{1/2}\right]_1^0$$

$$\therefore \quad I = \frac{\pi}{2} + 1$$

Q.28 **A 1 tonne mine car traveling at a constant speed of 10 km/h collides with a stationary buffer and comes to rest. If the buffer spring stiffness is 200 kN/m, the maximum compression in the spring in mm is**

(A) 49 **(B) 98** **(C) 196** **(D) 247**

Answer (C)

Solution .

Kinetic energy (E_K)of mine car = $\frac{1}{2}mv^2$

Where, m = mass of mine car = 1 tonne = 10^3 kg

v = speed of mine car = 10 km/h = 2.78 m/sec

Potential energy (E_P) of spring = $\frac{1}{2}kx^2$

where, k = spring stiffness = 200 kN/m = 200×10^3 N/m

x = spring displacement or compression

$$\therefore \quad E_K = E_P$$

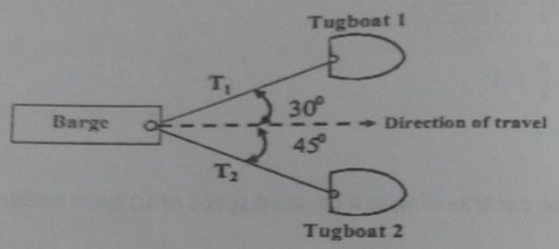
$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

$$x = \sqrt{\frac{mv^2}{k}}$$

$$\therefore \quad x = \sqrt{\frac{10^3 \times 2.78^2}{200 \times 10^3}}$$

$$\therefore \quad x = 0.196 \text{ m} = 196 \text{ mm}$$

Q.29 In an iron ore handling port, a barge is pulled by ropes using two tugboats as shown in the figure. In equilibrium, the resultant of the forces T_1 and T_2 along the axis of the barge in the direction of its travel is 5000 N. The tensions T_1 and T_2 in N respectively are

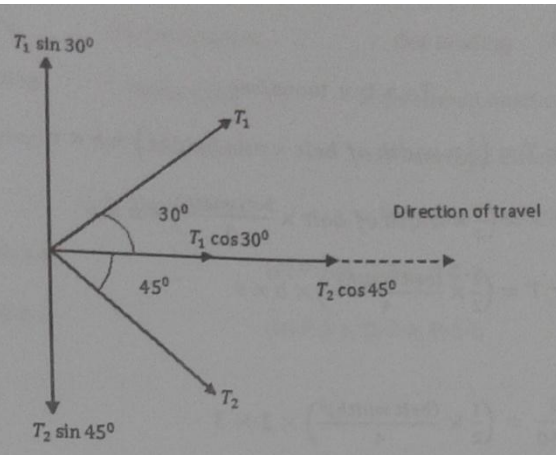


(A) 9700 and 6831 (B) 6831 and 9700

(C) 3660 and 2588 (D) 2588 and 3660

Answer (C)

solution .



$$\because \quad \sum V = 0$$

$$\therefore \quad T_1 \sin 30^0 - T_2 \sin 45^0 = 0 \text{ .....(1)}$$

$$\because \quad \sum H = 0$$

$$\therefore \quad T_1 \cos 30^0 + T_2 \cos 45^0 = 5000 \text{ .....(2)}$$

From equation (1) & (2), it is found that

$$\therefore \quad T_1 = 3660\ N \ \&\ T_2 = 2588\ N$$

Q.30 A flat belt conveyor is carrying coal of bulk density 1 tonne/m^3 at a rate of 400 tonne/h. The belt speed is 3 m/s. Coal is spread over the belt covering 80% of the belt width in a shape of a triangle. If the pile height is 1/4 of the belt width, the width of the belt in mm is

(A) 1109 **(B) 909** **(C) 709** **(D) 609**

Answer (D)

Solution .

Given that , pile height $= \dfrac{belt\ width}{4}$

Productivity of belt conveyor (T) = 400 tonne/hour

$$T = \frac{400}{60 \times 60} \text{ tonne/sec}$$

And we have,

$$T = a.b.v \text{ tonne/sec}$$

$$\text{Or } T = \left(\frac{1}{2} \times width\ of\ belt \times pile\ height\right) \times b \times v$$

$$\text{Or } T = \left(\frac{1}{2} \times width\ of\ belt \times \frac{belt\ width}{4}\right) \times b \times v$$

$$\text{Or } T = \left(\frac{1}{2} \times \frac{(belt\ width)^2}{4}\right) \times b \times v$$

Now,

$$\frac{400}{60 \times 60} = \left(\frac{1}{2} \times \frac{(belt\ width)^2}{4}\right) \times 1 \times 3$$

$\therefore$ belt width = 609 mm

Q.31 **Match the following.**

Hydraulic system components	Symbols
P. Fixed displacement unidirectional flow pump	1.
Q. Fixed displacement unidirectional flow motor	2.
R. Accumulator	3.
S. Filter	4.

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

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

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

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

Answer (B)

Q.32 **Match the following**

Method of mining	Stope support	Ore loading
P. Shrinkage stoping	1. Insitu pillar	a. Overhead mucker
Q. Blasthole stoping	2. Broken ore	b. Pneumatic autoloader
R. Top slicing	3. Timber mat	c. Load haul dumper

(A) P-2-a, Q-1-c, R-3-b

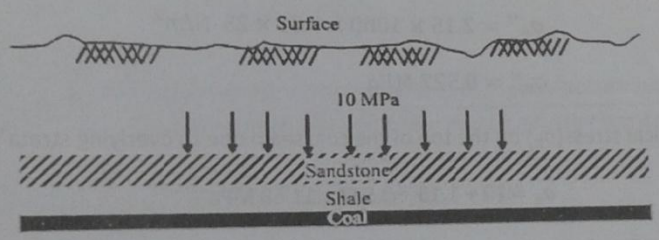
(B) P-2-a, Q-3-c, R-1-b

(C) P-2-b, Q-3-c, R-1-a

(D) P-3-c, Q-2-a, R-1-b

Answer (A)

Q.33 A typical case of gravity loading under complete lateral restraint in flat strata is shown in the figure below. The physico-mechanical parameters of the strata are given in the table. The in situ stresses (σ_z, σ_H) on the top of the coal seam in MPa are



Cross-section of the strata

Strata	Thickness (m)	Specific Gravity	Young's Modulus (GPa)	Shear Modulus(GPa)
Sandstone	50	2.35	26.40	12.5
Shale	25	2.15	20.50	8.25
Coal	20	1.52	2.41	0.95

(A) (10.17, 2.54) (B) (10.17, 3.69) (C) (11.68, 3.69) (D) (11.68, 2.54)

Answer (C)

Solution .

Vertical stress:-

$$\sigma_v = \gamma . z$$

$$\text{Or } \sigma_v = \rho . g . z$$

Where,

ρ- density of rock

g- acceleration due to gravity

z- depth below surface

γ- unit weight of rock

Now, vertical stress due to sandstone on the top of the shale:-

$$\sigma_v' = 2.35 \times 1000 \times 9.81 \times 50 \text{ N}/m^2$$

$$\sigma_v' = 1.15 \text{ MPa}$$

Vertical stress due to shale on the top o f coal:-

$$\sigma_v'' = 2.15 \times 1000 \times 9.81 \times 25 \text{ N}/m^2$$

$$\sigma_v'' = 0.527\ MPa$$

∴ vertical stress(σ_z) on the top of the coal seam due to overlying strata :-

$$\sigma_z = 10 + 1.15 + 0.527 = 11.68 \text{ MPa}$$

Given for shale :-

G = shear modulus = 8.25 GPa

E = young modulus = 20.50 GPa

And we know,

$$G = \frac{mE}{(m+1)}$$

Where, m - Poisson number ;

$$\therefore 8.25 = \frac{m \times 20.50}{2(m+1)}$$

∴ m = 4.125

$\therefore$ poisson ratio $= \vartheta = \frac{1}{m} = 0.24$

And $k = \frac{\vartheta}{1-\vartheta} = \frac{0.24}{1-0.24} = 0.315$

$\therefore$ Horizontal stress $(\sigma_H) = k.\sigma_z$

$$\sigma_H = 0.315 \times 11.68$$

$$\sigma_H = 3.69\ MPa$$

Q.34 **The sale value of chromite ore from an open pit mine is Rs. 6500 per tonne. Cost of mining, excluding stripping cost, is Rs. 2450 per tonne. If the cost of stripping is Rs. 1150 per m^3, the breakeven stripping ratio in m^3/tonne is**

(A) 2.18 **(B) 3.52** **(C) 3.65** **(D) 4.25**

Answer (B)

Solution .

$$Break\ even\ stripping\ ration$$

$$= \frac{Recoverable\ price\ per\ tonne\ of\ ore - O.C.production\ cost\ per\ tonne\ of\ ore}{cost\ of\ extraction\ per\ cubic\ meter\ of\ overburden\ material}$$

$$= \frac{(6500) - (2450)}{1150}\ m^3/tonne$$

$$= 3.52\ m^3/tonne$$

Q.35 **An investment at 10% yearly interest rate, compounded quarterly, accumulates to a sum of Rs. 120,000 in 5 years. The present value of the sum in rupees is**

(A) 73,233 **(B) 74,511** **(C) 88,232** **(D) 106,063**

Answer (A)

Solution.

Relation between Future Value (FV) and Present Value (PV) is given by-

$$FV = PV\left(1 + \frac{r}{n}\right)^{nt}$$

Where,

r- rate of interest

t- times in years

n - number of times per year, interest is compounded

Therefore,

$$120000 = PV\left(1+\frac{0.1}{4}\right)^{4\times5}$$

∴ PV = 73232 rupees

Q.36 **A toxic gas flows into a mine working place at the rate of 2.52 m^3/min. The concentration of the gas in the intake air is 0.25%. The minimum quantity of intake air in m^3/min required to dilute the gas to its threshold limit value of 1.0 % is**

(A) 123 **(B) 252** **(C) 295** **(D) 333**

Answer (D)

Solution .

$$Q = \frac{100\,q}{C_p - C_a} - q$$

$$Q = \frac{100\ \times 2.52}{1-0.25} - 2.52$$

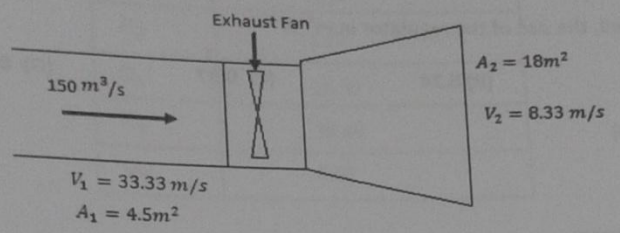
$$Q = 333\ m^3/min.$$

Q.37 **An exhaust fan attached to an evasee of 18 m^2 cross-sectional area at the outlet circulates 150 m^3/s of air at the pressure of 1000 Pa in a mine ventilation system. The ratio of the inlet to outlet area of the evasee is 1:4 and the density of air is 1.2 kg/ m^3. The quantity of air circulated in the mine in absence of evasee is 120 m^3/s. The evasee efficiency in % is**

(A) 57.6 **(B) 43.2** **(C) 39.06** **(D) 37.7**

Answer (A)

Solution .



$$\because \frac{A_1}{A_2} = \frac{1}{4}$$

$$\therefore A_1 = \frac{18}{4} = 4.5\ m^2$$

And $$V_1 = \frac{Q}{A_1} = \frac{150}{4.5} = 33.33\ m/sec$$

$$V_2 = \frac{Q}{A_2} = \frac{150}{18} = 8.33\ m/sec$$

Pressure recovery by evasee $= \frac{1}{2} \times \rho \times \left(V_1{}^2 - V_2{}^2\right) \times recovery\ efficiency(\eta)$, Pa

$$= \frac{1}{2} \times 1.2 \times (33.33^2 - 8.33^2) \times \eta$$

$$= 624.9 \times \eta \text{ Pa}$$

Now, In absence of evasee-

$$(1000 - 624.9 \times \eta) = \text{R} \times 120^2 \text{.....(1)}$$

In presence of evasee-

$$1000 = \text{R} \times 150^2 \text{.....(2)}$$

From equation (1) & (2),

$$\frac{(1000 - 624.9 \times \eta)}{120^2} = \frac{1000}{150^2}$$

$$\therefore \eta = \frac{1000-640}{624.9}$$

$$\therefore \eta = 57.6\ \%$$

Q.38 A fan circulates 24 m^3/s of air at a pressure of 1200 Pa in a ventilation district. It is intended to reduce the air quantity to 16 m^3/s by placing a regulator. Assuming the pressure remains unchanged, the size of the regulator in m^2 is

(A) 1.48 (B) 0.74 (C) 0.37 (D) 0.18

Answer (B)

Solution .

We know,

$$P = RQ^2$$

Before installation of regulator-

$$1200 = R \times 24^2$$

$$\therefore R = 2.08\ Ns^2m^{-8}$$

After installation of regulator-

$$P = (R + R_R)\ Q^2$$

Where , R_R – resistance of regulator

$$1200 = (2.08 + R_R) \times 16^2$$

$$R_R = \frac{1200}{256} - 2.08$$

$$R_R = 2.608\ Ns^2m^{-8}$$

Now, size of regulator $= \frac{1.2}{\sqrt{R_R}}$

$$= \frac{1.2}{\sqrt{2.608}}$$

$$= 0.74\ m^2$$

Q.39 An air sample taken from the return airway of a district contains the following gases. The Graham's ratio for the district is

Gas	Concentration (%)
CO_2	0.40
H_4	1.17
O_2	19.92
N_2	78.49
CO	0.02

(A) 5.6 (B) 4.8 (C) 3.0 (D) 2.3

Answer (D)

Solution .

Atmosphere air constituents following which goes down the mine (by volume %) : -

Oxygen - 20.93 %

Nitrogen (including Argon and other rare inert gas) - 79.04 %

Carbon dioxide – 0.03 %

Now, percentage of oxygen, when percentage of nitrogen is 78.49 % $= \frac{20.93}{79.04} \times 78.49$

$= 20.79\ \%$

$\therefore$ oxygen absorbed $= 20.79 - 19.92$

$= 0.87\ \%$

Now, Graham's ratio $= \frac{CO\ produced}{O_2\ consumed} \times 100$

$= \frac{0.02}{0.87} \times 100$

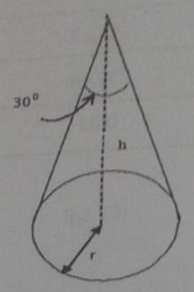
$= 2.3\ \%$

Q.40 An incandescent headlight of a mining vehicle is of spot beam type with a beam angle of 30^0.The spherical surface in m^2 subtended by the lighted beam at a distance of 5 m from the headlight is

(A) 7.5 (B) 15 (C) 21 (D) 25

Answer (C)

Solution .



Spot beam angle = 30^0

Spot area = πr^2

But in case, of sphere-

Spherical surface area = solid angle$\times r^2$

Solid angle = $2\pi(1-\cos 30^0)$

$\therefore$ solid angle = 0.841

Therefore, spherical surface area = $0.841\times 5^2 = 21\ m^2$

Q.41 The total cost C (lakh rupees) of a longwall face of length L in m is given by the equation $C = 0.1L + \frac{1562.5}{L} + 300$. Length of the face in m for the minimum total cost is

(A) 40 (B) 125 (C) 156 (D) 300

Answer (B)

Solution .

$$c = 0.1\,L + \frac{1562.5}{L} + 300 \text{ .....(1)}$$

Differentiating equation (1), w.r.t ,L

$$\frac{dc}{dL} = 0.1 - \frac{1562.5}{L^2}$$

But for minimum or maximum

$$\frac{dc}{dL} = 0$$

$$0.1 - \frac{1562.5}{L^2} = 0$$

$$\therefore \text{ L} = \sqrt{\frac{1562.5}{0.1}}$$

$$\therefore \text{ L} = 125\ m$$

Q.42 **20 plain detonators in series, each of 2Ω resistance, are fired by a DC exploder supplying a current of 1.25 A. If 250 mJ energy is spent to fire the detonators, the time required in millisecond after detonator initiation is**

(A) 4 **(B) 8** **(C) 12** **(D) 16**

Answer (A)

Solution .

Electric power (P) $= i^2 \times R$

$$\text{P} = 1.25^2 \times (2 \times 20)$$

$$\text{P} = 62.5\ W$$

And Power(P) $= \frac{work(w)}{time(t)}$

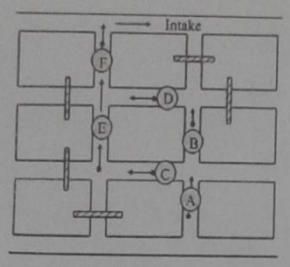
Or w = P.t

$$250 = 62.5 \times \text{t}$$

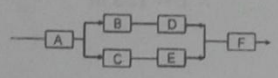
$$\therefore t = \frac{250}{62.5} = 4 \text{ ms}$$

Q.43 **A sudden increase of CO incidence has occurred in an underground mine section. A man at point A starts to run out to the main intake of the mine where he will be safe. Refer figure**

below for the mine section and the logic diagram. The probabilities that he will successfully cross the gallery sections A, B, C, D, E, and F are 0.9, 0.8, 0.7, 0.8, 0.7 and 0.9 respectively. The probability that he will successfully reach the main intake is



Section of the mine

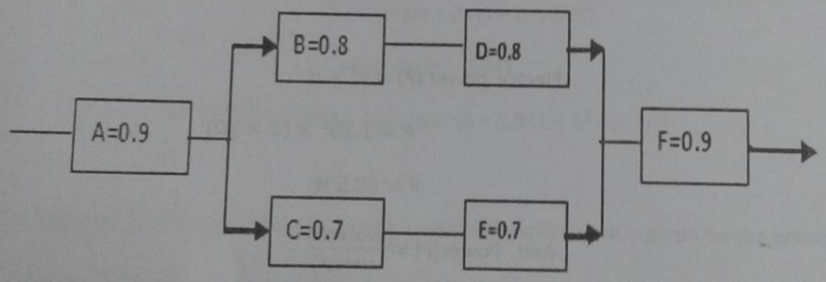


Series-parallel logic diagram

(A) 0.40 (B) 0.51 (C) 0.66 (D) 0.77

Answer (C)

Solution .



For sections B&D -

Reliability will be $= 0.8 \times 0.8 = 0.64$

For sections C&E-

Reliability will be $= 0.7 \times 0.7 = 0.49$

Now, Reliability for sections BD &CE will be-

$$= 1 - (1 - 0.64) \times (1 - 0.49)$$

$= 0.8164$

Hence,

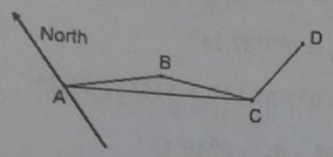
$$\text{Required probability} = 0.9 \times 0.9 \times 0.8164$$
$$= 0.66$$

Q.44 **In an underground correlation survey by the Weisbach triangle (figure below) the following data are obtained.**

AB = 3.50 m, BC = 2.75 m, CA = 6.20 m,

Angle $A\widehat{C}D = 179^\circ\ 14'33''$, Angle $B\widehat{C}D = 179^\circ\ 10'17''$ and

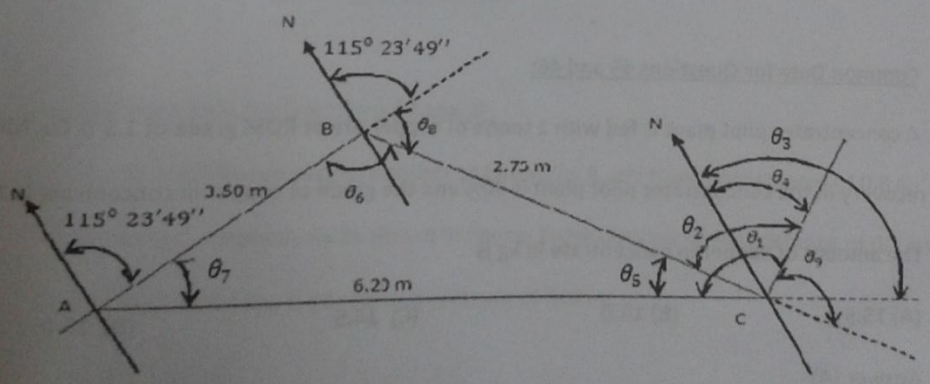
bearing of AB $= 115^\circ\ 23'49''$. The bearing of traverse CD is



(A) $102^\circ 27' 16''$ **(B) $114^\circ\ 41' 49''$** **(C) $115^\circ 27' 16''$** **(D) $179^\circ 14' 16''$**

Answer (B)

Solution .



$$\because \theta_1 = 179^0 14' 33''$$

$$\theta_2 = 179^0 10' 17''$$

$$\therefore \theta_5 = \theta_1 - \theta_2 = 0^0 4' 16''$$

Applying sine formula in ΔABC

$$\frac{3.50}{\sin \theta_5} = \frac{2.75}{\sin \theta_7}$$

$$\therefore \theta_7 = 0^0 3' 21.14''$$

So,

$$\theta_6 = 180^0 - \theta_5 - \theta_7$$

$$\therefore \theta_6 = 179^0 52' 86''$$

$$\theta_8 = 180^0 - \theta_6$$

$$\therefore \theta_8 = 0^0 7' 37.14''$$

$$\theta_3 = 115^0 23' 49'' + 0^0 7' 37.14'' = 115^0 31' 26.14''$$

$$\theta_9 = 180^0 - \theta_2 = 0^0 49' 43''$$

Therefore, bearing of CD-

$$\theta_4 = \theta_3 - \theta_9$$

$$\theta_4 = 114^0 41' 49''$$

Common Data for Questions 45 and 46:

A concentrator pilot plant is fed with 1 tonne of copper ore at ROM grade of 1.5 % Cu. Metal recovery in the concentrator pilot plant is 90% and the grade of copper in concentrate is 20%

Q 45. The amount of copper in concentrate in kg is

(A) 13.5 **(B) 14.0** **(C) 14.5** **(D) 15.0**

Answer (A)

Solution 48.

Grade of copper = 1.5 % (ROM)

Copper content per tonnne of ore $= \frac{1.5}{100} \times 1000 = 15\ kg$

Copper recovered by mill $= 15 \times \frac{90}{100} = 13.5\ kg$

Hence, amount of copper in concentrate $= 13.5\ kg\ of\ copper$

Q.46 **Amount of concentrate produced from 1 tonne of ore in kg is**

(A) 75.0 **(B) 72.0** **(C) 70.0** **(D) 67.5**

Answer (D)

Solution .

Grade of copper in concentrate = 20 %

It means that,

100 kg of concentrate has 20 kg of copper

Or 1 kg of copper produced from $\frac{100}{20}$ kg of concentrate.

Hence,

Amount of concentrate produced from 1 tonne of ore:-

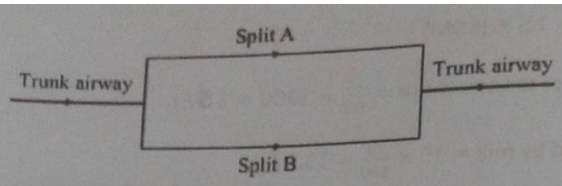
$$= 13.5 \times \frac{100}{20} \text{ kg of concentrate}$$

$$= 67.5 \text{ kg of concentrate}$$

<u>Common Data for Questions 47 and 48:</u>

A mine ventilation system consists of two splits A and B with resistances of 0.8 Ns^2m^{-8} and 3.2 Ns^2m^{-8}, respectively as shown in figure. Trunk airways have resistance of 0.2 Ns^2m^{-8}.

The main mine fan is generating pressure of 500 Pa.

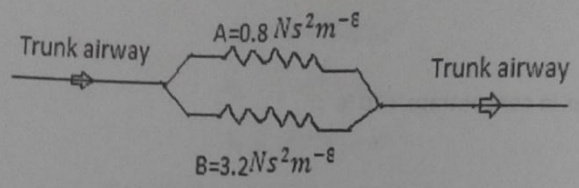


Q.47. The air quantities in m^3/s circulated in the splits A and B respectively are

(A) 20 and 30 (B) 30 and 20 (C) 20 and 10 (D) 40 and 10

Answer (C)

Solution .



$$\frac{1}{\sqrt{R_{AB}}} = \frac{1}{\sqrt{R_A}} + \frac{1}{\sqrt{R_B}}$$

$$\frac{1}{\sqrt{R_{AB}}} = \frac{1}{\sqrt{0.8}} + \frac{1}{\sqrt{3.2}}$$

$$\therefore R_{AB} = 0.36\ Ns^2m^{-8}$$

Total resistance = 0.20 + 0.36 = 0.56 Ns^2m^{-8}

$$\because P = R_T Q_T{}^2$$

$$500 = 0.56 \times Q_T{}^2$$

$$\therefore Q_T = 30\ m^3/sec$$

fan Pressure = pressure lost in trunk roadway + pressure lost in split A

$$500 = R_{T_r} Q_T{}^2 + R_A Q_A{}^2$$

$$500 = 0.2 \times 30^2 + 0.8 \times Q_A{}^2$$

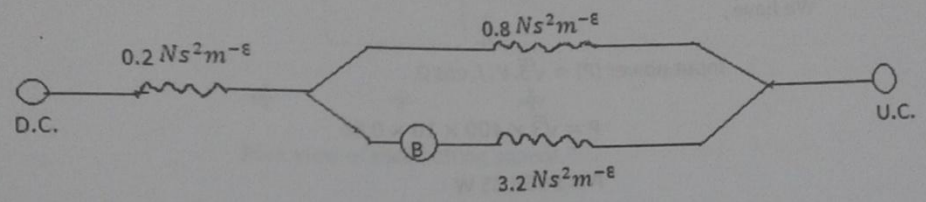
$$\therefore Q_A = 20\ m^3/sec$$

And , $Q_B = Q_T - Q_A = 30 - 20 = 10\ m^3/sec$

Q.48 The flows in the two splits are equalized by placing a booster fan in split B. Assume that the fan pressure does not change after installation of the booster fan. The size of the booster fan in Pa is

(A) 749.05 (B) 850.08 (C) 950.02 (D) 1000.50

Solution .



After installation of booster fan:-

Fan Pressure = pressure lost in trunk airways + pressure lost in split A

$$500 = R_{T_r}Q_T{}^2 + R_AQ_A{}^2$$

$$500 = 0.2 \times Q_T{}^2 + 0.8 \times (Q_T - Q_B)^2$$

$$500 = 0.2 \times Q_T{}^2 + 0.8 \times (Q_T - 20)^2 \quad [\because\ Q_B = 20\ m^3/sec]$$

$$\therefore Q_T = 36.88\ m^3/sec$$

Now, flow in split B

$$500 + P_B = R_{T_r}Q_T{}^2 + R_BQ_B{}^2$$

Where, P_B = booster fan pressure

$$500 + P_B = 0.2 \times 36.88^2 + 3.2 \times 20^2$$

$$\therefore P_B = 1052\ Pa$$

Statement for Linked Answer Questions 49 and 50:

A 400 V, 3 phase, star connected induction motor takes a line current of 10 A with 0.86 p.f. lagging. Total stator losses are 5 % of the input. Rotor copper losses are 4 % of the input to the rotor, and mechanical losses are 3 % of the input to the rotor.

Q.49 The input power to the rotor in Watts is

(A) 5958 (B) 5788 (C) 5660 (D) 5532

Answer (C)

Solution .

We have ,

Input power (P) $= \sqrt{3}.V.I.\cos\emptyset$

$$P = \sqrt{3} \times 400 \times 10 \times 0.86$$

$$P = 5958.25 \text{ W}$$

Given that , total stator losses = 5 % of input power

Hence, input power to the rotor is:-

$$P = 5958.25 - 5958.25 \times \frac{5}{100}$$

$$P = 5660.34 \text{ W}$$

Q.50 The shaft output power in Watts is

(A) 5562 (B) 5490 (C) 5434 (D) 5264

Answer (D)

Solution .

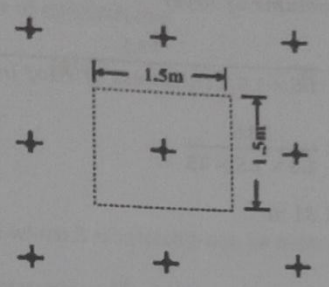
Given that total copper losses and mechanical losses are 4% and 3% of input power respectively.

So shaft power output $= 5660.34 - 5660.34 \times \frac{4}{100} - 5660.34 \times \frac{3}{100}$

$= 5264.118$ watt

Statement for Linked Answer Questions 51 and 52:

The bolts are spaced at 1.5 m centre-to-centre in a square pattern as shown in the figure below. The tensile stress in 22 mm diameter bolt rod is 193.35 MPa. The unit weight of the roof layer is 25 kN/m³.



Plan view of rock bolting pattern

Q.51 The axial load in the bolt rod in kN is

(A) 294.0 (B)173.5 (C) 147.0 (D) 73.5

Answer (D)

Solution .

$$stress = \frac{load}{area}$$

$$\text{Or tensile stress} = \frac{axial\ load}{area}$$

$$\text{Or axial load} = \text{area} \times \text{tensile stress}$$

$$\text{axial load} = 3.14 \times \frac{(22 \times 10^{-3})^2}{4} \times 193.35 \times 10^6$$

$$= 73461\ N$$

$$= 73.461K\ N$$

Q.52 At equilibrium, the thickness of the roof layer supported by the bolt in m is

(A) 1.31 (B) 2.4 (C) 2.62 (D) 3.08

Answer (A)

Solution .

We have,

$$\text{Unit weight of layer} = \frac{weight\ of\ layer}{volume\ of\ layer}$$

$$25 = \frac{73.5}{1.5 \times 1.5 \times thickness\ of\ roof\ layer}$$

$$\therefore \text{thickness of roof layer} = \frac{73.5}{1.5 \times 1.5 \times 25}$$

$$\therefore \text{thickness of roof layer} = 1.31\ m$$

Q.53 **Choose the word from the options given below that is most nearly opposite in meaning to the given word:**

Deference

(A) aversion **(B) resignation** **(C) suspicion** **(D) contempt**

Answer (D)

Q.54 **Choose the most appropriate word(s) from the options given below to complete the following sentence.**

We lost confidence in him because he never _____ the grandiose promises he had made.

(A) delivered **(B) delivered on** **(C) forgot** **(D) reneged on**

Answer (B)

Q.55 **Choose the word or phrase that best completes the sentence below.**

_____ in the frozen wastes of Arctic takes special equipment.

(A) To survive (B) Surviving (C) Survival (D) That survival

Answer (A)

Q.56 In how many ways 3 scholarships can be awarded to 4 applicants, when each applicant can receive any number of scholarships?

(A) 4 (B) 12 (C) 64 (D) 81

Answer (C)

Solution .

Number of ways in which 3 scholarship can be awarded to 4 applicant, when each receive any number of scholarship $= 4^3 = 64$

Q.57 Choose the most appropriate word from the options given below to complete the Following sentence.

The _____ of evidence was on the side of the plaintiff since all but one witness testified that his story was correct.

(A) paucity

(B) propensity

(C) preponderance

(D) accuracy

Answer (C)

Q.58 If (2y+1)/(y+2) < 1, then which of the following alternatives gives the CORRECT range of y?

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

Answer (B)

Solution .

$\frac{2y+1}{y+2} < 1$ .....(1)

Put , $y = -1$, to satisfy equation (1)

$$\frac{-2+1}{-1+2} < 1$$

$$-1 < 1$$

Now,

Case1→ $-2 < y < 2 \Rightarrow -2 < -1 < 2$

Case 2→ $-2 < y < 1 \Rightarrow -2 < -1 < 1$

Case 3→ $-3 < y < 1 \Rightarrow -3 < -1 < 1$

Case 4→ $-4 < y < 1 \Rightarrow -4 < -1 < 1$

Here, case 2 is more accurate.

Q.59 **A student attempted to solve a quadratic equation in x twice. However, in the first attempt, he incorrectly wrote the constant term and ended up with the roots as (4, 3). In the second attempt, he incorrectly wrote down the coefficient of x and got the roots as (3, 2). Based on the above information, the roots of the correct quadratic equation are**

(A) (-3, 4) **(B) (3, -4)** **(C) (6, 1)** **(D) (4, 2)**

Answer (C)

Solution .

In first attempt:-

$$\alpha + \beta = \frac{-b}{a}$$

And roots (4,3)

$$\therefore \quad 4 + 3 = \frac{-b}{a}$$

$$7 = \frac{-b}{a}$$

Or $b = -7a$

In second attempt:-

$$\alpha.\beta = \frac{c}{a}$$

And roots (3,2)

$$\therefore 3.2 = \frac{c}{a}$$

Or $c = 6a$

Now,

$$ax^2 + bx + c = 0$$

$$ax^2 - 7ax + 6a = 0$$

$$x^2 - 7x + 6 = 0$$

$$x^2 - 6x - x + 6 = 0$$

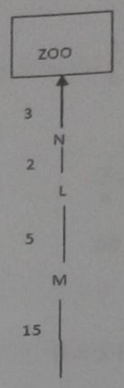
$$\therefore \ x = 1,\ 6$$

Q.60 **L, M and N are waiting in a queue meant for children to enter the zoo. There are 5 children between L and M, and 8 children between M and N. If there are 3 children ahead of N and 21 children behind L, then what is the minimum number of children in the queue?**

(A) 28 **(B) 27** **(C) 41** **(D) 40**

Answer (A)

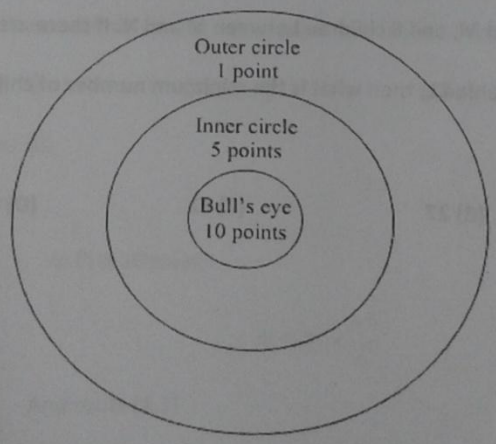
Solution .



∴ minimum number of children in the queue :-

$$3 + N + 2 + L + 5 + M + 15 = 28$$

Q.61 **Four archers P, Q, R and S try to hit a bull's eye during a tournament consisting of seven rounds. As illustrated in the figure below, a player receives 10 points for hitting the bulls' eye, 5 points for hitting within the inner circle and 1 point for hitting within the outer circle.**



The final scores received by the players during the tournament are listed in the table below.

Round	P	Q	R	S
1	1	5	1	10
2	5	10	10	1
3	1	1	1	5
4	10	10	1	1
5	1	5	5	10
6	10	5	1	1
7	5	10	1	1

The most accurate and the most consistent players during the tournament are respectively

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

Answer (B)

Solution .

	P	Q	R	S
E(X)	4.72	6.57	2.86	4.14
$[E(X)]^2$	22.29	43.17	8.18	17.14
$E(X^2)$	36.14	53.72	18.57	32.72
Var (X)	13.85	10.55	10.39	15.58

Most accurate = max. E(X) value

= Q is most accurate

Most consistent = min. Var (X)

= R is most consistent

Q.62 Nimbus clouds are dark and ragged, stratus clouds appear dull in colour and cover the entire sky. Cirrus clouds are thin and delicate, whereas cumulus clouds look like cotton balls.

It can be inferred from the passage that

(A) A cumulus cloud on the ground is called fog

(B) It is easy to predict the weather by studying clouds

(C) Clouds are generally of very different shapes, sizes and mass

(D) There are four basic cloud types: stratus, nimbus, cumulus and cirrus

Answer (D)

Q. 1 Ascensionally ventilated coal mine inclines ideally should have higher methane layering number when compared to descensionally ventilated inclines. The reason is

(A) in ascensionally ventilated inclines density of air is higher

(B) ascensionally ventilated inclines creates conditions for improved turbulent mixing of methane layer

(C) methane drainage is not practiced in ascensionally ventilated inclines

(D) descensionally ventilated inclines creates conditions for improved turbulent mixing of methane layer

Answer (D)

Q.2 A coolant is a desirable component in the design of a Self Contained Breathing apparatus since

(A) surrounding can be hot and humid during rescue
(B) a rescue worker generates large amount of metabolic heat
(C) exhaled air CO_2 absorption is an exothermic reaction
(D) exhaled air water vapour has to be condensed

Answer (C)

.3 determine the correctness or otherwise of the following Assertion [a] and the Reason [r]

<u>Assertion</u> : Both intake and return side stoppings must be closed simultaneously in the event of sealing off a coal mine panel with explosion hazard following a fire.

<u>Reason</u> : By continuously ventilating the area till simultaneous closure of the stopping, the possibility of an explosion hazard due to gas build up is avoided.

(A) [a] is true but [r] is false
(B) Both [a] and [r] are true and [r] is the correct reason for [a]
(C) Both [a] and [r] are true and [r] is not the correct reason for [a]
(D) Both [a] and [r] are false

Answer (C)

Q.4 In a Cartesian coordinate system the vertices of a triangular plate are given by $(-2, 1)$, $(3, 4)$ and $(-4, -8)$. The coordinates of the centre of gravity of the plate are

(A) 3, 4 (B) 7,12 (C) $-1, -1$ (D) $-3, -4$

Answer (C)

Solution .

The coordinates of center of gravity (O) of triangular plate ABC, having three vertices (x_1, y_1), (x_2, y_2), (x_3, y_3) are given by

$$O_x = \frac{x_1 + x_2 + x_3}{3}, \; O_y = \frac{y_1 + y_2 + y_3}{3}$$

$$\therefore O_x = \frac{-2+3-4}{3}, \; O_y = \frac{1+4-8}{3}$$

$$\therefore \; (-1, -1)$$

Q.5 An air quality parameter required to monitored under the Indian National Ambient Air Quality Standards is

(A) As (B) Pb (C) Hg (D) Silica

Answer (B)

Q.6 In an underground coal mine, a freshly exposed roof can be supported by a temporary support in the form of

(A) triangular chocks
(B) crew props
(C) safari support

(D) hydraulic prop

Answer (C)

Q.7 At a surface mine office the independent sound pressure level (SPL) measured in dB (A) on account of 3 drill machines are 85, 88 and 85. If all the three machines work simultaneously , the combined SPL, in dB (A), is

(A) 91 (B) 90 (C) 92 (D) 94

Answer (A)

Solution .

Combined SPL is given by :-

$$L_{com} = 10\log_{10}\left[\sum_{i=1}^{n} t_i\, 10^{\frac{L_i}{10}}\right]$$

$$L_{com} = 10\log_{10}\left[1\times 10^{\frac{85}{10}} + 1\times 10^{\frac{88}{10}} + 1\times 10^{\frac{85}{10}}\right]$$

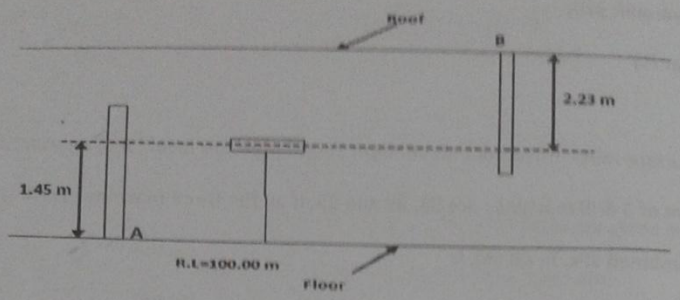
$$L_{com} = 91 \text{ dB}$$

Q.8 The backsight reading on a bench mark of RL 100.0 m is 1.45 m. if the inverse staff reading on a foresight is 2.23 m, the RL of the staff station in m is

(A) 105.13 (B)103.68 (C)100.78 (D)98.55

Answer (B)

Solution .



∴ R.L. of staff station B is = 100 + 1.45 + 2.23

= 103.68 m

Q.9 **For a mine of production t per year, the total cost of production is given by $at^2 + b$. The revenue from sale is given by ct. if a, b and c , are constant, the breakeven value of t is**

(A) $\left[c \pm \sqrt{\{c^2 - 4ab\}}\right]/(2a)$ **(B)** $\left[\sqrt{\{c^2 - 4ab\}}\right]/(2a)$

(C) $\left[-c \pm \sqrt{\{c^2 - 4ab\}}\right]/(2a)$ **(D)** $\left[c \pm \sqrt{\{c^2 + 4ab\}}\right]/(2a$

Answer (A)

Solution .

In case of breakeven condition -

Total cost of production = Revenue

$$at^2 + b = ct$$

Or $at^2 - ct + b = 0$

$$\therefore \quad t = \frac{c \pm \sqrt{c^2 - 4ab}}{2a}$$

Q.10 **The value of the limit $\lim_{x \to 1} \left[\frac{1-x^{-1/3}}{1-x^{-2/3}}\right]$ is**

(A) ∞ **(B)** 1 **(C)** 0 **(D)** ½

Answer (D)

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Solution .

$$f(x) = \lim_{x\to 1}\left[\frac{1-x^{-1/3}}{1-x^{-2/3}}\right]$$

$$f(x) = \lim_{x\to 1}\left[\frac{\frac{x^{1/3}-1}{x^{1/3}}}{\frac{x^{2/3}-1}{x^{2/3}}}\right]$$

$$f(x) = \lim_{x\to 1}\frac{x^{1/3}(x^{1/3}-1)}{x^{2/3}-1}$$

$$f(x) = (1)^{1/3}\lim_{x\to 1}\left\{\frac{x^{1/3}-1}{x-1}\cdot\frac{x-1}{x^{2/3}-1}\right\}$$

$$f(x) = \frac{\lim_{x\to 1}\frac{x^{1/3}-1}{x-1}}{\lim_{x\to 1}\frac{x^{2/3}-1}{x-1}}$$

$$\left[since\,,\lim_{x\to a}\frac{x^n-a^n}{x-a} = n\,a^{n-1}\right]$$

$$f(x) = \frac{\frac{1}{3}.(1)^{\frac{1}{3}-1}}{\frac{2}{3}.(1)^{\frac{2}{3}-1}}$$

$$\therefore\ f(x) = 1/2$$

Q.11 **Two determinants of order n are multiplied. The order of the resultant determinant is**

(A) n **(B) 2n** **(C) n^2** **(D) n/2**

Answer (A)

Solution .

Note - The product of two determinant of nth order is a determinant of the nth order.

Therefore, Two determinant of order n are multiplied then the order of resultant determinant is n.

Q.12 **The partial differential equation, $r\frac{\partial\theta}{\partial r}$ =constant , is a solution for**

(A) $\frac{\partial^2\theta}{\partial r^2} - \frac{1}{r}\frac{\partial\theta}{\partial r} = 0$ **(B)** $\frac{\partial^2\theta}{\partial r^2} + \frac{\partial\theta}{\partial r} = 0$

(C) $r^2\frac{\partial^2\theta}{\partial r^2}+\frac{1}{r}\frac{\partial\theta}{\partial r}=0$ (D) $\frac{\partial^2\theta}{\partial r^2}+\frac{1}{r}\frac{\partial\theta}{\partial r}=0$

Answer (D)

Solution .

We have,

$$r\frac{\partial\theta}{\partial r}=constant$$

Differentiating w.r.t, r, then

$$r\frac{\partial^2\theta}{\partial r^2}+\frac{\partial\theta}{\partial r}=0$$

Dividing both sides by 1/r, then

$$\frac{r}{r}\frac{\partial^2\theta}{\partial r^2}+\frac{1}{r}\frac{\partial\theta}{\partial r}=0$$

$$\frac{\partial^2\theta}{\partial r^2}+\frac{1}{r}\frac{\partial\theta}{\partial r}=0$$

Q.13 **In mohr-coulomb failure criteria , the ratio of the uniaxial compressive strength to the tensile strength is**

(A) $\frac{1+\sin\emptyset}{1-\sin\emptyset}$ (B) $\frac{1-\sin\emptyset}{1+\sin\emptyset}$

(C) $\frac{C\,(1+\sin\emptyset)}{(1-\sin\emptyset)}$ (D) $\frac{2C\,(1+\sin\emptyset)}{(1-\sin\emptyset)}$

Answer (A)

Solution .

Uniaxial compressive strength is given by

$$\sigma_c=\frac{2c\cos\emptyset}{1-\sin\emptyset}\quad\text{.....(1)}$$

And

Tensile strength is given by

$$\sigma_t = \frac{2\,c\,\cos\emptyset}{1+\sin\emptyset} \quad \text{.....(2)}$$

From equa. (1) & (2),

$$\frac{\sigma_c}{\sigma_t} = \frac{1+\sin\emptyset}{1-\sin\emptyset}$$

Q.14 The average young's modulus and poisson's ratio values of a limestone sample are 60×10^3 MPa and 0.3 respectively. The shear modulus in MPa is

(A) 23.07 **(B) 230.7** **(C) 2307.0** **(D) 23070.0**

Answer (D)

Solution .

Poisson ration = $\frac{1}{m}$ = 0.3

Or m = 3.33

And young modulus = E= $60 \times 10^3\ MPa$

We have,

Shear modulus = C = $\frac{m\,E}{2\,(m+1)}$

C = $\frac{3.33 \times 60 \times 10^3}{2 \times (3.33+1)}$

C = 23071 MPa

Q.15 The angle of draw in a trough subsidence helps in determining the

(A) Maximum subsidence
(B) Extent of surface subsidence
(C) Plane of failure
(D) Critical width of opening

Answer (B)

Q.16 Recapping a winding rope is done due to

(A) increase the strength flexural strength of rope
(B) increase the flexibility of the rope
(C) remove a portion of rope subjected to deterioration
(D) prevent the rope from excessive rusting

Answer (C)

Q.17 Match the following for standard diamond drill rods.

Specification	Outer diameter in mm
P. AW	p. 34.9
Q. BW	q. 44.4
R. EW	r. 54.0
S. NW	s. 66.7

(A) P-r, Q-q, R-s, S-p (B) P-r, Q-p, R-s, S-q
(C) P-q, Q-r, R-p, S-s (D) P-q, Q-r, R-s, S-p

Answer (C)

Q.18 Payback period is time required

(A) for the cash income from a project to get back the initial cash investment
(B) from the start of the project to the time to recover the total initial investment
(C) from the start of the project to the start of the production
(D) to the period during which internal rate of return is generated

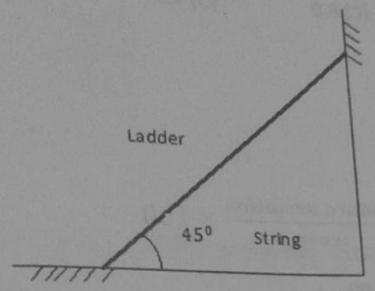
Answer (B)

Q.19 For electric signaling systems in underground coal mines, the statement that is NOT true is

(A) all signaling equipment must be instrinsically safe
(B) the signaling circuit must be connected to ground
(C) the source of current should be an approved dry battery
(D) DC bells or relay when connected in parallel should be supplied from a single source current

Answer (D)

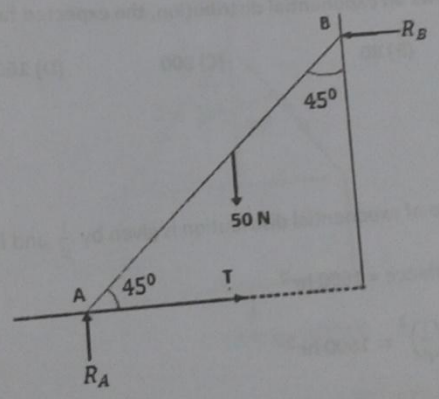
Q.20 A ladder of weight 50 N rests against a frictionless wall and floor as shown in figure. A horizontal string ties the base of the ladder to the wall. The tension in the string in N is



(A) 100 (B) 50 (C) 72 (D) 25

Answer (D)

Solution .



$$R_A = R_B = \frac{W}{2} = \frac{50}{2} = 25\ N$$

Now, $\sum H = 0$

$T - R_B = 0$ [where T is the tension in the string]

$\therefore T = R_B = 25\ N$

Q.21 The mean and standard deviation of the grade of ore in a deposit are 62% and 5% respectively. The coefficient of variation of the grade in % is

(A) 24.8 (B) 12.4 (C) 8.0 (D) 4.0

Answer (C)

Solution .

We have,

$$\text{Coefficient of variation} = \frac{standard\ deviation}{mean} \times 100$$

$$= \frac{5}{62} \times 100$$

$$= 8\ \%$$

Q.22 The variance of failure time (time to failure) of an electric motor in shovel is 1600 hr^2. If the failure time follows an exponential distribution, the expected failure time in hr is

(A) 40 (B) 80 (C) 800 (D) 1600

Answer (A)

Solution .

The expected value of exponential distribution is given by $\frac{1}{\mu}$ and its variance is given by $\frac{1}{\mu^2}$

$\because$ variance = 1600 hr^2

$\therefore \quad \left(\frac{1}{\mu}\right)^2 = 1600\ hr^2$

Or $\quad \frac{1}{\mu} = \sqrt{1600\ hr}$

$\therefore \quad \frac{1}{\mu} = 40\ hr$

Q.23 Match the following

Instrument	Purpose/Measurement
1. Abneys level	a. horizontal and vertical angles

2. Pantograph
3. Plannimeter
4. Box sextant

b. area of plotted figures 3
c. enlargement and reduction of plotted maps 2
d. angle of inclination 1

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

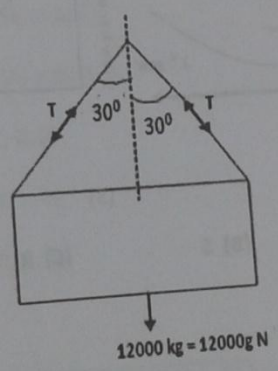
Answer (D)

Q.24 A cage of weighing 12000 kg is raised by four chains each making an angle of 30^0 with the vertical. The tension in each chain in KN is

(A) 41 (B)34 (C)25 (D)20

Answer (B)

Solution .



Since cage is raised by four chains and each making an angle of 30^0 with vertical. So vertical component of each chain will be $T\cos 30^0$.

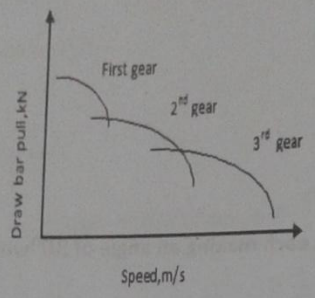
$$\therefore \quad \sum V = 0$$

$$T\cos 30^0 + T\cos 30^0 + T\cos 30^0 + T\cos 30^0 - 12000 \times 9.81 = 0$$

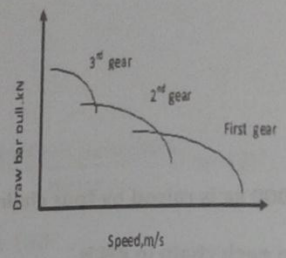
$$\therefore 4T\cos 30^0 = 12000 \times 9.81$$

$$T = 33982 \text{ N} = 34 \text{ kN}$$

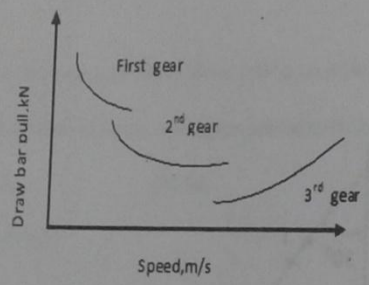
Q.25 The relationship between the drawbar pull and speed for different gears of a self propelling vehicle is represented by



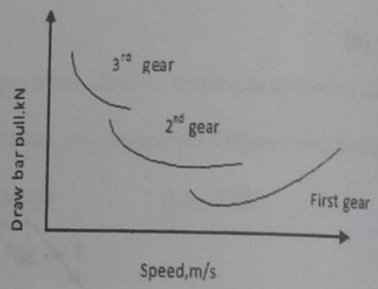
(P)



(Q)



(R)



(S)

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

Answer (D)

Q.26 A flammable mixture has 70% CH_4 and 30% CO. The lower flammability limit for these gases are 5% and 13% respectively. For the mixture, the lower flammability limit in % is

(A) 6.13 (B) 8.72 (C) 10.25 (D) 12.16

Answer (A)

Solution .

The lower flammability limit in (%) for mixture is given by:-

$$X = \left[\frac{100}{\frac{P_1}{N_1} + \frac{P_2}{N_2} + \frac{P_3}{N_3} + \cdots \frac{P_n}{N_n}}\right] percent$$

$$X = \left[\frac{100}{\frac{70}{5} + \frac{30}{13}}\right] \%$$

$$X = 6.13\ \%$$

Q.27 The volume of tetrahedron with vertices at (0,0,0),(1,0,0),(0,1,0) and (0,0,1) is

(A) 1/2 (B) 1/4 (C) 1/6 (D) 1/8

Answer (C)

Solution .

Volume of tetrahedron $= \frac{1}{3} \times A_0 \times h$

Where, A_0- area of base

h - height from base to apex

Assuming apex vertice, (A) = (0, 0, 0)

and base vertices ,B = (1, 0, 0)

C = (0, 1, 0)

D = (0, 0, 1)

Now,

$$a = BC = \sqrt{(1-0)^2 + (0-1)^2 + (0-0)^2} = \sqrt{2}$$

$$b = CD = \sqrt{(0-0)^2 + (1-0)^2 + (0-1)^2} = \sqrt{2}$$

$$c = DB = \sqrt{(0-1)^2 + (0-0)^2 + (1-0)^2} = \sqrt{2}$$

$$s = \frac{a+b+c}{3} = \frac{\sqrt{2}+\sqrt{2}+\sqrt{2}}{3} = 2.121$$

Area of base $= \sqrt{s\,(s-a)(s-b)(s-c)}$

$\therefore$ Area of base $= \sqrt{2.121(2.121-\sqrt{2})(2.121-\sqrt{2})(2.121-\sqrt{2})} = 0.8653$

Now coordinates of the centre of base are $= \frac{1+0+0}{3}, \frac{0+1+0}{3}, \frac{0+0+1}{3}$

$$= \frac{1}{3}, \frac{1}{3}, \frac{1}{3}$$

Now, height from base to apex (h) $= \sqrt{\left(0-\frac{1}{3}\right)^2 + \left(0-\frac{1}{3}\right)^2 + \left(0-\frac{1}{3}\right)^2}$

h = 0.5773

Hence, area of tetrahedron $= \frac{1}{3} \times 0.8653 \times 0.5773 = \frac{1}{6}$

Q.28 **A balanced winder raises 3000 tonnes per day from a depth of 500 m. The payload of the winding cage is 7 tonnes. The energy consumed per day in kWh at 70% winder efficiency is**

(A) 6030 **(B) 5840** **(C) 5750** **(D) 5630**

Answer (B)

Solution .

Material hoisting = 3000 tonnes per day

$$= \frac{3000\times1000\times9.81}{24\times60\times60} \frac{N}{s}$$

$$= \frac{3000\times1000\times9.81\times500}{24\times60\times60} \frac{Nm}{s}$$

= 170312.5 watt

= 170.3125 kW

$$= \frac{170.3125}{h} \text{ kwh}$$

$$= \frac{170.3135\times24}{day} \text{ kwh}$$

$$= 4087.5 \frac{kwh}{day}$$

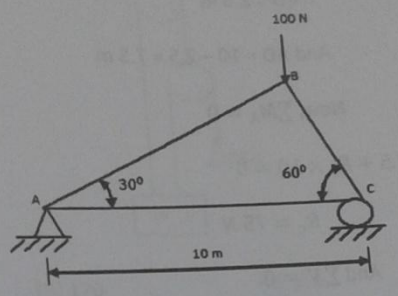
But winder efficiency is 70 %

$$= \frac{4087.5}{0.70} \frac{kwh}{day}$$

= 5839.2857 kwh/day

= 5840 kwh /day

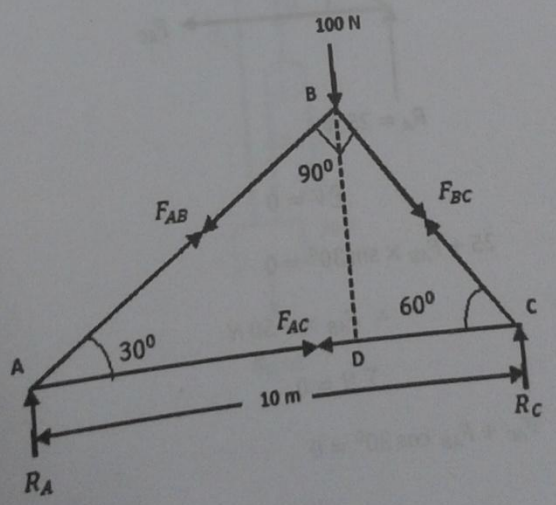
Q.29 **A truss is loaded as shown in the figure. The force in the member AC is**



(A) tension 75.9 N
(B) compression 43.3 N
(C) tension 43.4 N
(D) compression 75.9 N

Answer (C)

solution .



Applying sine formula

$$\frac{10}{\sin 90^0} = \frac{AB}{\sin 60^0} = \frac{BC}{\sin 30^0}$$

$\therefore$ AB = 8.66 m & BC = 5 m

Now , $\cos 60^0 = \frac{CD}{5}$

$\therefore$ CD = 2.5 m

And AD = 10 −2.5 = 7.5 m

Now, $\sum M_A = 0$

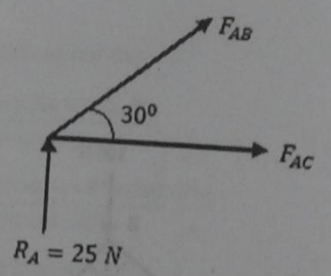
$$-100 \times 7.5 + R_c \times 10 = 0$$

$$R_c = 75\ N$$

And $\sum V = 0$

$$R_A + R_C - 100 = 0$$

$$R_A = 25\ N$$



$$\sum V = 0$$

$$25 + F_{AB} \times \sin 30^0 = 0$$

$$\therefore\ F_{AB} = -50\ N$$

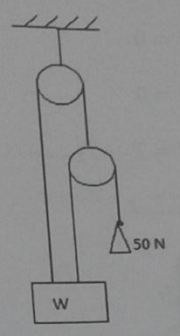
$$\sum H = 0$$

$$F_{AC} + F_{AB}\ \cos 30^0 = 0$$

$$F_{AC} = -F_{AB} \cos 30^0$$

$$\therefore F_{AC} = 43.3\ N \text{ (Tension)}$$

Q.30 In the frictionless pulley system shown in the figure, each pulley weighs 20 N. The weight W in N, that can be lifted by the system under the conditions shown is



(A) 200 (B) 170 (C) 150 (D) 100

Answer (B)

Solution .

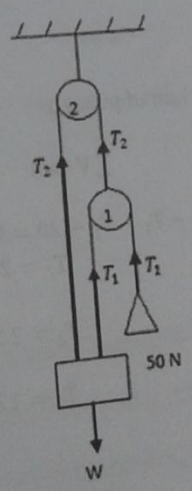


Fig-01

Here , $T_1 = 50N$

From figure 01.

Equilibrium of load W

$$\sum V = 0$$

$$T_1 + T_2 - W = 0$$

$$W = T_1 + T_2 \text{.....}(1)$$

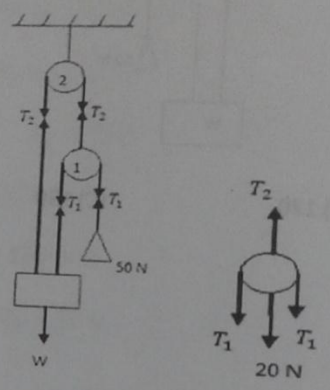


Fig.-02

From figure (2), equilibrium of pulley 1

$$\sum V = 0$$

$$T_2 - T_1 - T_1 - 20 = 0$$

$$T_2 = 2T_1 + 20$$

$$T_2 = 2 \times 50 + 20$$

$$T_2 = 120 \text{ N}$$

From equation (1)

$$W = 50 + 120$$

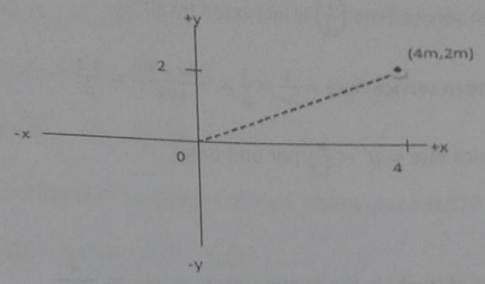
$$W = 170 \text{ N}$$

Q.31 A force of $50\hat{\imath} - 50\hat{\jmath}\,N$ is moved from the origin to a coordinate (4.0m, 2.0m). The work done in the process in J is

(A) 75.6 (B)85.5 (C) 90.2 (D) 100.0

Answer (D)

solution .



Displacement $= \vec{d} = 4\hat{\imath} - 2\hat{\jmath}$,m

Force $= \vec{F} = 50\hat{\imath} - 50\,\hat{\jmath}$,N

$\therefore$ Work done $= \vec{F}.\vec{d}$

$= (50\hat{\imath} - 50\,\hat{\jmath}).(4\hat{\imath} - 2\hat{\jmath})$

$= 200 - 100$

$=100$ J

Q.32 The queue of trucks at a crusher plant hopper is known to be M/M/1 queue. The probability that there is no truck to unload is 0.3. Due to rains the mean service time at the hopper is increased by 30%. As a consequence, the expected number of trucks in the queuing system (including the one possibly unloading) become

(A) 10 (B) 12 (C) 14 (D) 16

Answer (A)

Solution .

$$P_0 = (1-\rho) = 1 - \frac{\lambda}{\mu}$$

$$0.3 = 1 - \frac{\lambda}{\mu}$$

$\therefore \lambda = 0.7\,\mu =$ mean arrival rate (per unit time)

Since mean service time $\left(\frac{1}{\mu}\right)$ is increased by 30 %,

So, new mean service time $= \frac{1}{\mu'} = \frac{1}{\mu} \times \frac{(100+30)}{100} = \frac{1.3}{\mu}$

Mean service rate $= \mu' = \frac{\mu}{1.3}$ per unit time

We have,

Number of trucks in the queue system $= N_Q = \frac{\lambda}{\mu' - \lambda}$

$$N_Q = \frac{0.7\,\mu}{\frac{\mu}{1.3} - 0.7\,\mu}$$

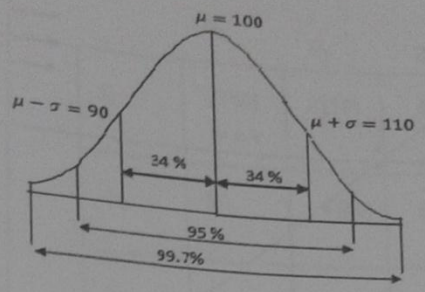
$$\therefore \quad N_Q = 10$$

Q.33 Pull from a underground tunnel blasting is normally distributed with a mean of 100 tonnes and variance 100 $(tonnes)^2$. The probability that the tonnage value from a blast exceed 110 is

(A) 0.60 (B) 0.80 (C) 0.16 (D) 0.32

Answer (C)

solution .



Mean $= \mu = 100$

Variance $= 100(tonne)^2$

$\therefore$ standard deviation $= \sigma = 10\ tonne$

Hence, the probability that the tonnage value from a blast exceeds 110 is :-

$$(100 - 50 - 34) = 16\% = 0.16$$

Q.34 **The feasibility region of an LP problem in variable x and y is given by the following constraints, in addition to the non-negativity constraints.**

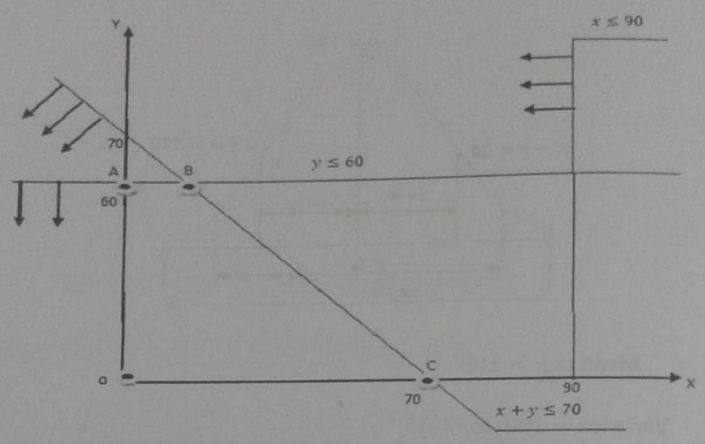
$y \leq 60; x \leq 90; x + y \leq 70.$

The number of corner point feasible solutions for this problem are

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

Answer (B)

solution .



Hence, corner point feasible solution will be 4 i.e. O,A,B,C.

Q .35 **The unit cost matrix of a balanced transportation problem is shown below**

Destination	D_1	D_2	D_3	supply
S_1	7	3	6	60
S_2	5	4	9	60
S_3	8	6	7	80
Demand	50	120	30	

Source

The transportation cost of the initial basic feasible solution obtained by the North – West rule is

(A) 1025 **(B) 1075** **(C) 1130** **(D) 1226**

Answer (C)

Solution .

Destination		D_1	D_2	D_3	Supply
Source	S_1	7 (50)	3 (10)	6	60/10/0
	S_2	5	4 (60)	9	60/0
	S_3	8	6 (50)	7 (30)	80/30/10
Demand		50/0	120/110/50	30/0	

Hence , transportation cost $= 7 \times 50 + 3 \times 10 + 4 \times 60 + 6 \times 50 + 7 \times 30$

$= 1130$

Q. 36 **A high volume air sampler is operated for 8 hours in a mine with the flow rate of air varying from 1.5 m^3/min to 1.3. m^3/min .The empty weight of the filter paper is 2.30 g and the final weight is 2.65 g. The mean concentration of the suspended particulate matter (SPM) during the study period in $\mu g/m^3$ is**

(A) 591 **(B) 550** **(C) 545** **(D) 521**

Answer (D)

Solution .

Total suspended solids/suspended particulate matter is given by-

$$\text{TSS/SPM} = \frac{(A-B)}{C}, \mu g/m^3$$

Where, A- weight of filter plus retained solids in μg =2.65 gm = 2.65×10^6 μg

B- weight of clean filter in μg = 2.30 gm = 2.30×10^6 μg

C- volume of sample filtered in m^3

Now, $C = \frac{1.5 + 1.3}{2} = 1.4\ m^3/\text{minute}$

$\because$ 1 minute = $1.4\ m^3$

$\therefore$ 8 hour = $8 \times 1.4 \times 60\ m^3$

Therefore,

$$\text{TSS/SPM} = \frac{2.65 - 2.30}{1.4 \times 8 \times 60} \times 10^6 = 521\ \mu g$$

Q .37 **A developed panel for a coal seam having incubation period of 6 months has 32 square pillars under extraction having size 25 m, and height 3.0 m. Density of tha coal is 1.4 tonne/m^3. Extraction ratio during depillaring is expected to be 75%. To depillar the panel within the incubation period, assuming 25 workings days in a month, the production from the panel in tone/day is**

(A) 420 **(B) 480** **(C) 560** **(D) 680**

Answer (A)

Solution .

Production from one pillar= $25 \times 25 \times 3 \times 1.4$ =2625 tonnes

So, production from 32 pillars = $32 \times 2625 = 84000$ tonnes

$\therefore$ Production of panel within incubation period $(6 \times 25 = 150\ days) = 84000$ tonnes

Theredore ,

Production from panel with 75% percentage of extraction in tonne/day is:-

$$= \frac{84000}{150} \times 0.75 = 420 \text{ tonnes /day}$$

Q.38 **A closed traverse ABCDE of perimeter 425 m has a total error +0.25 m in latitude and −0.44m in departure. The precision of traverse is**

(A) 1 in 556 **(B) 1 in 775** **(C) 1 in 833** **(D) 1 in 1024**

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Answer (C)

Solution .

We know,

$$\text{Closing error} = \sqrt{(latitude)^2 + (longitude)^2}$$

$$\text{Closing error} = \sqrt{(0.25)^2 + (-0.44)^2}$$

$$\text{Closing error} = 0.51\ m$$

Since 425 m has a error of 0.51 m

1 m has a closing error of $\frac{0.51}{425}$ or $\frac{1}{425/0.51}$ or $\frac{1}{833}$

Hence , precision of traverse is 1 in 833.

Q.39 The value of the given integral is

$$\int_{\frac{\pi}{5}}^{\frac{3\pi}{10}} \frac{\sin x}{(\sin x + \cos x)} dx$$

(A) $\frac{\sin \pi/8}{10}$ (B) $\frac{\pi}{10}$ (C) $\frac{\sin \pi/5}{10}$ (D) $\frac{3\pi}{10}$

Solution .

Let $I = \int_{\frac{\pi}{5}}^{\frac{3\pi}{10}} \frac{\sin x}{\sin x + \cos x} dx$ ..... (1)

$$I = \int_{\frac{\pi}{5}}^{\frac{3\pi}{10}} \frac{\sin\left(\frac{3\pi}{10} + \frac{\pi}{5} - x\right)}{\sin\left(\frac{3\pi}{10} + \frac{\pi}{5} - x\right) + \cos\left(\frac{3\pi}{10} + \frac{\pi}{5} - x\right)} dx$$

[Since property $\int_a^b f(x)dx = \int_a^b f(a+b-x)dx$]

$$I = \int_{\frac{\pi}{5}}^{\frac{3\pi}{10}} \frac{\sin\left(\frac{\pi}{2} - x\right)}{\sin\left(\frac{\pi}{2} - x\right) + \cos\left(\frac{\pi}{2} - x\right)} dx$$

$$I = \int_{\frac{\pi}{5}}^{\frac{3\pi}{10}} \frac{\cos x}{\sin x + \cos x} dx \quad \text{..... (2)}$$

Adding (1) & (2),

$$2I = \int_{\frac{\pi}{5}}^{\frac{3\pi}{10}} \frac{\sin x + \cos x}{\sin x + \cos x} dx$$

$$2I = \int_{\frac{\pi}{5}}^{\frac{3\pi}{10}} 1 \; dx$$

$$2I = [x]_{\frac{\pi}{5}}^{\frac{3\pi}{10}}$$

$$\therefore \; I = \frac{\pi}{20}$$

Q. 40 **The probability of hitting a target by A and B are 1/3 and 2/5 respectively. A shoots at the target once, followed by B shooting at the target once. The probability of hitting the target is**

(A) 2/15 **(B) 5/15** **(C) 8/15** **(D) 9/15**

Answer (D)

Solution .

Let , p(A) =1/3 & p(B) =2/5

∴ The probability of hitting the target is:-

$$P = p(A)\,p(B) + p(A)\,p(\bar{B}) + p(\bar{A})\,p(B)$$

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

$$\therefore \; P = \frac{9}{15}$$

Q.41 **The value of k for which the points (5,5),(k,1),(10,7) lie on a straight line is**

(A) -5 **(B) $+5$** **(C) -2** **(D) $+2$**

Answer (A)

Solution .

Equation of line is given by : -

$$y = mx + c$$

Where, m - slope of the line

c- the y-intercept of line

Now , for point (5, 5)

$5 = 5m + c$.....(1)

For point (k, 1)

$1 = km + c$.....(2)

For point (10, 7)

$7 = 10m + c$.....(3)

Solving (1) & (2),

$m = \frac{2}{5}, c = 3$

from equation (2)

$$1 = \frac{2}{5} \times k + 3$$

$$\therefore k = -5$$

Q.42 A steel wire ropes of 25 mm diameter weighing 37 N/m has 6 strands of 7 wires each. The diameter and tensile strength of each wire are 2.5 mm and 1800 MPa, respectively. The factor of safety for raising a cage of weight 60 kN from a depth of 200 m is

(A) 5.60 (B) 4.50 (C)4.25 (D)4.15

Answer (A)

Solution .

We have,

$$\text{Factor of safety} = \frac{Strength\ of\ rope}{Weight\ on\ rope}$$

Now, strength of rope = $(6 \times 7) \times$ strength of wire $\times$ cross sectional area of wire

$$\text{Strength of rope} = (6 \times 7) \times 1800 \times 10^6 \times 3.14 \times \frac{(2.5 \times 10^{-3})^2}{4}$$

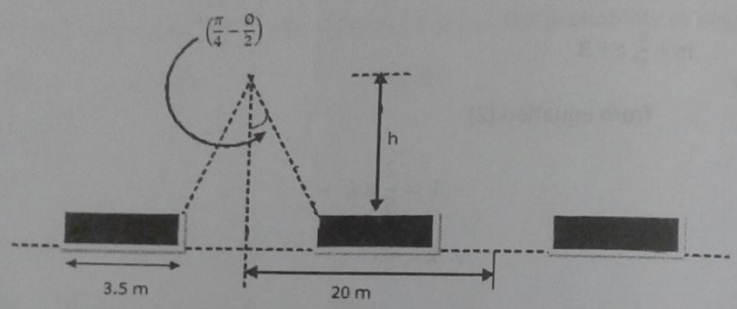
$\therefore$ Strength of rope = 370912.5 N

Weight on rope = $60 \times 10^3 + 37 \times 200$

$\therefore$ Weight on rope = 67400 N

$\therefore$ Factor of safety = $\frac{370912.5}{67400} = 5.5$

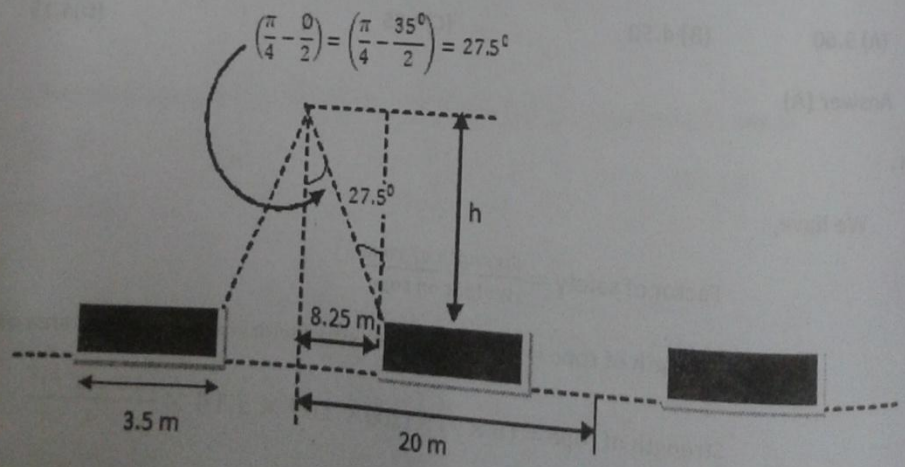
Q.43 In block caving operation the draw points are placed at 20 m center to center , with the pillar width 3.5 m as shown in the figure below. The muck is assumed to have zero cohesion and 35^0 angle. The height of draw cone (h) in m is



(A) 12.5 **(B) 14.6** **(C) 15.8** **(D) 16.5**

Answer (C)

Solution .



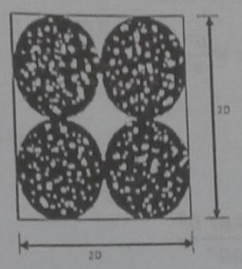
In Δ abc ,

$$\tan 27.5^0 = \frac{8.25}{h}$$

$$\therefore h = 15.8$$

Common data for questions 44 and 45 :

The granular media in ore bin is assumed to be of regular spherical shape represented by the geometry as shown in the figure. The unit weight of solids is 25 kN/m^3.



Q. 44 **The void ratio is**

(A) 0.91 **(B) 0.84** **(C) 0.78** **(D) 0.69**

Answer (A)

Solution .

$$\text{Void ratio} = \frac{volume\ of\ void}{volume\ of\ solid}$$

$$\text{Volume of solid} = 8 \times \frac{4}{3} \times \pi \times \frac{D^3}{8} = \frac{4}{3} \times \pi \times D^3$$

$$\text{Volume of void} = 8D^3 - 8 \times \frac{4}{3} \times \pi \times \frac{D^3}{8}$$

$$= 8D^3 - \frac{4}{3} \times \pi \times D^3$$

$$\therefore \text{Void ratio} = \frac{8D^3 - \frac{4}{3} \times \pi \times D^3}{\frac{4}{3} \times \pi \times D^3}$$

$$\therefore \text{Void ratio} = 0.91$$

Q.45 The dry density in kN/m^3 is

(A) 13.09 (B) 12.50 (C) 11.74 (D) 10.87

Answer (A)

Solution .

$$\text{Dry density} = \frac{weight}{volume}$$

$$\text{And unit weight} = \frac{weight}{volume}$$

Or weight = unit weight × volume

$$= 25 \times 8 \times \frac{4}{3} \times \pi \times \frac{D^3}{8}$$

$$= 104.67\ D^3$$

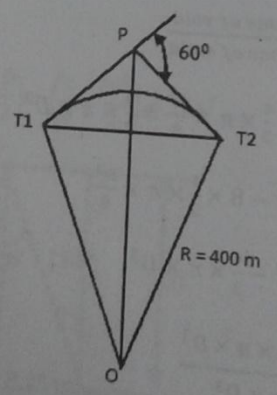
And volume = $8D^3$

$$\text{Dry density} = \frac{weight}{volume} = \frac{104.67\ D^3}{8D^3}$$

$$\text{Dry density} = 13.09\ kN/m^3$$

<u>Common date for question 46 and 47</u>

Match the elements of a simple curve as given in the figure below.



Q. 46 The tangent length in m is

(A) 215.5 (B) 220.4 (C) 228.4 (D) 230.9

Answer (D)

Solution .

We have ,

Tangent length (L) of simple curve $= R \tan\frac{\Delta}{2}$

Where, R- radius of curve

Δ- intersection angle

$$L = 400 \tan\frac{60^0}{2}$$

$$L = 230.9 \text{ m}$$

Q.47 The length of the long chord in m is

(A) 375 (B)400 (C) 415 (D) 450

Answer (B)

Solution .

We have ,

Length of long chord (C) $= 2R \sin\frac{\Delta}{2}$

$$C = 2 \times 400 \times \sin\frac{60^0}{2}$$

$$C = 400\, m$$

<u>Statement for linked Answer Questions 48 and 49:</u>

A longwall panel with a face height of 3 m and face length of 150 m is worked in 3 shifts per day employing 40 men per shift. The depth of web of the shearer cutting coal is 0.5 m. The unit weight of the coal is 1.4 tonne/m^3. Two full face cuts are executed per shift.

Q.48 The daily production from the panel in tonnes is

(A) 945 (B) 1240 (C) 1890 (D)2530

Answer (C)

Solution .

Daily production of shearer in tonnes = (number of shift) × (two full face cuts) × (face length) × (face height) × (web depth) × (unit weight of coal)

Daily production of shearer in tones $= 3 \times 2 \times 150 \times 3 \times 0.5 \times 1.4$ tonnes

$= 1890$ tonnes

Q.49. The panel OMS in tonnes is

(A) 12.75 (B) 15.75 (C) 8.75 (D) 5.25

Answer (B)

Solution .

Panel OMS in tonnes $= \frac{production\ in\ three\ shift}{employing\ in\ three\ shift}$

Panel OMS in tonnes $= \frac{1890}{40 \times 3} = 15.75$ tonnes

Statement for linked Answer Questions 50 and 51:

Air at a density of 1.2 kg/m^3 flows in a straight duct such that the velocity at the centre is 12.5 m/s. The method factor for the velocity profile is known to be 0.80.

Q .50 The velocity pressure value in the duct in Pa is

(A) 31 (B) 47 (C) 60 (D) 83

Answer (C)

Solution .

Velocity pressure $(P_v) = \frac{1}{2} \times v^2 \times \rho$

$$P_v = \frac{1}{2} \times (12.5 \times 0.80)^2 \times 1.2$$

Note – method factor is the ratio of true velocity to the observed velocity.

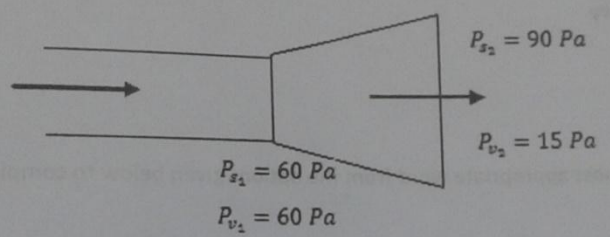
$P_v = 60\ Pa$

Q.51 The air flow encounters a symmetric expansion such that the cross- sectional area of the duct becomes double. The static pressure value at the inlet and outlet of the expansion are 60 Pa and 90 Pa, respectively. Neglecting friction, the shock pressure loss on account of expansion in Pa is

(A) 15 (B) 22 (C) 38 (D) 46

Answer (A)

Solution .



$$\because V_2 = \frac{Q}{A_2} = \frac{Q}{2\,A_1} = \frac{A_1 V_1}{2A_1} = \frac{V_1}{2} = \frac{10}{2} = 5 \text{ m/sec}$$

$$\therefore \quad P_{v_2} = \frac{1}{2} \times v_2{}^2 \times \rho = \frac{1}{2} \times 5^2 \times 1.2 = 15 \text{ Pa}$$

Now,

Total Inlet pressure = 60 + 60 = 120 Pa

Total outlet pressure = 15 + 90 = 105 Pa

Therefore,

Shock pressure loss = 120 −105 = 15 Pa

Q.52 Which of the following options is the closest in meaning to the word below:

Exhert

(A) urge

(B) condemn
(C) restrain
(D) scold

Answer (A)

Q.53 The questions below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair.

Preamble : constitution

(A) amendment : law
(B) prologue : play
(C) episode : serial
(D) plot : story

Answer (B)

Q. 54 Choose the most appropriate word from the options given below to complete the following sentence :

The committee wrote a _____ report, extolling only the strength of the proposal.

(A) reasonable
(B) supportive
(C) biased
(D) fragmented

Answer (C)

Q.55 Choose the most appropriate word from the options given below to complete the following sentence :

If the country has to achieve real prosperity, it is_____ that the fruits of the progress reach all, and in equal measure.

(A) inevitable
(B) contingent

(C) oblivious
(D) imperative

Answer (D)

Q.56 A person invests Rs. 1000 at 10% annual compound interest for 2 years. At the end of two years the whole amount is invested at an annual simple interest of 12% for 5 years. The total value of the investment finally is :

(A) 1776 (B) 1760 (C) 1920 (D) 1936

Answer (D)

Solution .

We have,

$$\text{Compound interest} = P\left[1+\frac{R}{100}\right]^T$$

$$= 1000\left[1+\frac{10}{100}\right]^2$$

$$= Rs.1210$$

$$\text{And simple interest} = \frac{P.R.T}{100}$$

$$= \frac{1210 \times 12 \times 5}{100}$$

$$= Rs.726$$

$\therefore$ Total investment = 1210 + 726

= 1936 rupees

Q.57 The ban on smoking in designated public places can save a large number of people from the well know effects of environmental tobacco smoke. Passive smoking seriously impairs respiratory health. The ban rightly seeks to protect non- smokers from its all effects. Which of the following statements best sums up the meaning of the above passage.

(A) Effects of environmental tobacco are well known

(B) The ban on smoking in public places protects the non smokers
(C) Passive smoking is bad for health
(D) The ban on smoking in public places excludes passive smoking

Answer (B)

Q. 58 Given the sequence A,B,B,C,C,C,D,D,D,D,.....etc., that is one A, two Bs, three Cs, four Ds, five Es and so on, the 240th letter in the sequence will be :

(A) V (B) U (C) T (D) W

Answer (A)

Solution .

We know, sum of n natural numbers is

$$S = \frac{n(n+1)}{2}$$

$$\therefore 240 = \frac{n(n+1)}{2}$$

Or $n^2 + n - 480 = 0$

$$\therefore n = 22$$

Therefore, 22th letter will be V.

Q.59 Consider the set of integers $\{1, 2, 3, \ldots\ldots, 5000\}$. The number of integers that is divisible by neither 3 nor 4 is :

(A) 1668 **(B) 2084** **(C) 2500** **(D) 2916**

Answer (C)

Solution .

When, 5000 is divided by 4 then quotient = 1250

5000 is divided by 3 then quotient = 1666.67

5000 is divided by (4×3) =12 then quotient = 416.67

Hence,

Number of integers that is divisible by neither 3 nor 4 = 5000 − (1250 + 1666.67 − 416.67)

= 2500

Q.1 If A is an orthogonal matrix, then

(A) $A^T = A^{-1}$ (B) $A^T = -A^{-1}$ (C) $A = A^{-1}$ (D) $A = -A^{-1}$

Answer (A)

Solution .

In case of the orthogonal matrix –

$$A\,A^T = A^T A = I$$

Or $$A^T = A^{-1}$$

Q.2 In a normal (Gaussian) distribution curve, the area between one standard deviation from mean on either side in percent is

(A) 50 (B) 68 (C) 86 (D) 95

Answer (B)

Q3. A measure of dispersion of a sample data set is

(A) mean (B) median (C) mode (D) standard deviation

Answer (D)

Q 4. The value of limit $\lim_{x\to 2}\left(\frac{2\sqrt{4-x^2}}{5}\right)$ is

(A) $\frac{-2\sqrt{8}}{5}$ (B) 0 (C) $\frac{2\sqrt{8}}{5}$ (D) Non-existent

Answer (B)

Solution .

$$\lim_{x\to 2}\left[\frac{2\sqrt{4-x^2}}{5}\right]$$

$$\to \left[\frac{2\sqrt{4-2^2}}{5}\right]$$

Q 5. $\hat{\imath}, \hat{\jmath}$ *and* $\hat{k}$ represent the unit vectors in the positive x, y and z directions of a Cartesian coordinate system. Using the right- hand rule, $\hat{k} \times \hat{\jmath}$ represents

(A) 0 (B) 1 (C) $-\hat{\imath}$ (D) $\hat{\imath}$

Answer (C)

Q 6. The rock mass classification system that considers "active stress" factor is

(A) Q-system (B) RMR (C) RQD (D) GSI

Answer (A)

Q 7. In a triaxial compression test if σ_1 is a axial stress and σ_2 and σ_3 are confining stresses, then

(A) $\sigma_3 > \sigma_2 = \sigma_1$ (B) $\sigma_1 > \sigma_2 = \sigma_3$ (C) $\sigma_1 = \sigma_2 > \sigma_3$ (D) $\sigma_3 = \sigma_2 > \sigma_1$

Answer (B)

Q 8. In a longwall mining subsidence phenomenon, the "angle of break" is the angle between

(A) the vertical line at the panel edge and line connecting the panel edge and zero subsidence on the surface

(B) the vertical line at the panel edge and line connecting the panel edge and point of critical deformation on the surface

(C) the vertical line at the panel edge and line connecting the panel edge and the point of the maximum tensile strain on the surface

(D) the horizontal line and the line connecting the panel edge and zero subsidence on the surface

Answer (C).

Q 9. Pocket and wing technique of pillar extraction is related to

(A) bord and pillar method (B) room and pillar

(C) Wongawilli method (D) shortwall method

Answer (A)

Q 10. A non-electric detonating relay DOES NOT contain

(A) delay element (B) fuse head

(C) metal sleeve (D) neoprene connecting tube

Answer (C)

Q 11. An iron ore deposit has a mean grade of 63% Fe. During the course of mining, 30% fines by weight are generated at a grade of 72% Fe which are rejected. The effective mean grade of the deposit in FE percentage is

(A) 59.1 (B) 53.1 (C) 50.4 (D) 41.4

Answer (A)

Solution .

Assume W is insitu tonnage of Fe deposit –

$$\therefore \text{effective mean grade (Fe \%)} = \frac{(0.63 \times W - 0.3 \times 0.72 \times W)}{0.7 \times W} \times 100$$

$$= \frac{0.414}{0.7} \times 100$$

$$= 59.1\%$$

Q 12. Koepe system of winding does NOT include

(A) tapper guide (B) limit switches

(C) safety hook (D)brake

Answer (C)

Q 13. A gas mask does NOT include

(A) check valve (B) warning device

(C) face piece assembly (D) coolant canister

Answer (D)

Q 14. Resuing stoping method is adopted when ore body is

(A) flat and thick (B) very steep and thick

(C) flat and thin (D) very steep and thin

Answer (A)

15. Moody diagram represents resistance coefficient in terms of

(A) Reynolds number and asperity ratio (B) viscosity and aspect ratio

(C) surface tension and viscosity (D) Reynolds number and surface tension

Answer (A)

Q 16 . An area of 100 m^2 is measured on a plan having R.F. of 1/800. If the R.F. were to be 1/2000,

The area in m^2 would be

(A) 16 (B) 40 (C) 250 (D) 625

Answer (D).

Solution.

$$\text{R.F} = \frac{Drawing\ demension\ of\ object}{actual\ dimension\ of\ object}$$

Given, actual area of object = 100 m^2

Actual length or width of object = $\sqrt{100}$ = 10 m

$$\frac{1}{800} = \frac{Drawing\ length\ or\ width\ of\ object}{10}$$

∴ Drawing length or width of object = 0.0125 m

Now,

$$\frac{1}{2000} = \frac{0.0125}{actaul\ length\ or\ width\ of\ object}$$

∴ actual length or width of object = 25 m

∴ actual area of object = 625 m^2

Q 17. As per the DGMS norms, the severity index is a measure of

(A) fatality rate
(B) serious injury rate
(C) number of reportable injuries
(D) accident proneness of mine

Answer (D)

Q 18. A balanced transportation problem is characterized by

(A) total supply exceeds total demand
(B) total demand exceeds total supply
(C) total demand is equal to total supply
(D) total supply is either equal to or more than total demand`

Answer (C)

Q 19. In the context of project management techniques, the TRUE statement is

(A) CPM is stochastic and PERT is deterministic
(B) CPM is deterministic and PERT is stochastic
(C) Both CPM and PERT are deterministic
(D) Both CPM and PERT are stochastic

Answer (B)

Q20. For mining property appraisals, typical reports prepare are Bankable Feasibility report (BFR), Conceptual Plan Report (CPR), Feasibility Report (FR) and Detailed Project Report (DPR). The chronological order for the preparation of these reports is

(A) CPR → FR → BFR→ DPR
(B) BFR →CPR →DPR→ FR
(C) FR → BFR → CPR→ DPR
(D) CPR→ BFR → DPR→ FR

Answer (C)

Q 21. The mean of the cubes of the first n natural numbers is

(A) $\frac{n(n+1)^2}{4}$ (B) $\frac{n(n+1)(n+2)}{8}$ (C) $\frac{n^4+1}{n}$ (D) $\frac{n^3}{4}$

Answer (A)

Q 22. The sum of the eigenvalues of the matrix $\begin{bmatrix} 1 & 2 \\ 1 & 0 \end{bmatrix}$ is

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

Answer (C)

Solution .

The sum of the Eigen value of a matrix is the sum of the element of the principal diagonal.

$$\therefore 1+0 = 1$$

Q 23. The value of $\nabla . F$of a vector F = $4x^2\hat{\imath} + 3xy^2\hat{\jmath} + xyz^3\hat{k}$ at the point (1, 1, 2) is

(A) 24 (B) 26 (C) 30 (D) 32

Answer (B)

Solution .

$$\vec{F} = 4x^2\hat{\imath} + 3xy^2 + xyz^3\hat{k}$$

$$\nabla . F = \left(I\frac{\partial}{\partial x} + J\frac{\partial}{\partial y} + k\frac{\partial}{\partial z}\right).\left(4x^2\hat{\imath} + 3xy^2 + xyz^3\hat{k}\right)$$

$$\nabla . F = (8x + 6xy + 3xyz^2)$$

At point (1,1,2)

$$\nabla . F = (8 \times 1 + 6 \times 1 \times 1 + 3 \times 1 \times 1 \times 4)$$

$$\nabla . F = 26$$

Q 24. The function f(x) = $x^3(1-x)$ is integrated between 0 and 1 (both inclusive) using closed form method and also by Simpson's 1/3 rule. the difference in the values obtained from

these methods is

(A) 0 (B) 1/480 (C) 1/120 (D) 1/20

Answer (C)

Solution .

→ closed form method

$$\int_0^1 f(x)dx = \int_0^1 x^3(1-x)dx$$

$$\int_0^1 f(x)dx = \left|\frac{x^4}{4} - \frac{x^5}{5}\right|_0^1$$

$$\therefore \quad \int_0^1 f(x)dx = \frac{1}{20}$$

→ Simpson's 1/3 rule

$$\int_a^b f(x)dx = \frac{b-a}{6}\left[f(a) + 4f\left(\frac{a+b}{2}\right) + f(b)\right]$$

$$\int_0^1 x^3(1-x)dx = \frac{1-0}{6}\left[0 + 4 \times \frac{1}{8\times 2} + 0\right]$$

$$\int_0^1 x^3(1-x)dx = \frac{1}{24}$$

Therefore,

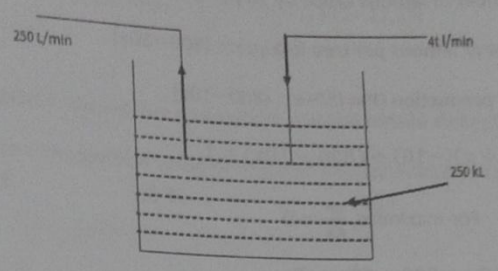
Difference in values = $\frac{1}{20} - \frac{1}{24} = \frac{1}{120}$

Q 25. **Water starts to flow into a sump initially containing 250 kL of water. The inflow rate of water is 4t L/min where t refers to time elapsed in min. If the pumping rate of water out of the sump is 250 L/min, the total volume of water in the sump after 3 hours in KL is**

(A) 250.5 (B) 255.6 (C) 269.8 (D) 280.9

Answer (C)

Solution .



In 3 hours total water that has discharged from sump -

$$D_s = \frac{250\times3\times60}{1000} = 45\ KL$$

In 3 hours total water inlet into the sump -

$$I_s = \int_0^{180} 4\,t\,dt = |2\,t^2|_0^{180}$$

$$I_s = 64.8\ KL$$

∴ Total water in sump after 3 hours -

$$W_s = 250 + 64.8 - 45$$

$$W_s = 269.8\ KL$$

Q 26. There are 50 lemon trees in a reclaimed mine area. Each tree produces 800 lemons per year. For each additional tree planted in this area, considering all trees, the output number of fruits per tree drops by 10 lemons in a year. The number of trees that to be added to the existing reclaimed area in order to maximize the total number of lemons in the year is

(A) 10 (B) 15 (C) 16 (D) 26

Answer (B)

Solution .

Before planted additional tree , total number of lemon production =50×800=40000

Let x number of trees added to maximize number of lemons.

Then, total number of tree= (50+x)

But output number of lemons drops by 10 per tree in a year.

So, total number of lemons per tree in a year= (800−10x)

Therefore, total production (P)= (50+x) . (800−10x)

Now, $\frac{dP}{dx} = (50 + x)(-10) + (800 - 10x) \times 1$

For maximize, $\frac{dP}{dx} = 0$

$$-500 - 10x + 800 - 10x = 0$$

$$-20\,x = -300$$

$$x = 15$$

Q 27. The grain density and bulk density of a dry coarse grained sandstone rock sample are 3.0 gm/cc and 2.7 gm/cc respectively. The void ratio of the sample in percentage is

(A) 8.4 (B) 10.0 (C) 11.1 (D) 30.5

Answer (C)

Solution .

We know,

$$\text{Void ratio} = \frac{volume\ of\ void}{volume\ of\ grain} = \frac{volume\ of\ sample - volume\ of\ grain}{volume\ of\ grain}$$

$$\text{Void ratio} = \frac{volume\ of\ sample}{volume\ of\ grain} - 1$$

$$\text{Void ratio} = \frac{\frac{mass\ of\ sample}{density\ of\ sample}}{\frac{mass\ of\ grain}{density\ of\ grain}} - 1$$

$$\text{Void ratio} = \frac{\frac{mass\ of\ grain}{density\ of\ sample}}{\frac{mass\ of\ grain}{density\ of\ grain}} - 1$$

$$\text{Void ratio} = \frac{density\ of\ grain}{density\ of\ sample} - 1$$

$$\text{Void ratio} = \left(\frac{3}{2.7} - 1\right) = 0.111 = 11.1\%$$

Q 28. **The ratio of uniaxial compressive strength to uniaxial tensile strength of a sandstone specimen is 8:1.The theoretical value of angle of internal friction of the specimen in degree is**

(A) 51 **(B) 41** **(C) 32** **(D) 7**

Answer (A)

Solution .

We have,

$$\frac{\sigma_c}{\sigma_t} = \frac{1 + \sin\emptyset}{1 - \cos\emptyset}$$

$$\therefore \frac{1}{8} = \frac{1 + \sin\emptyset}{1 - \sin\emptyset}$$

$$\therefore \sin\emptyset = \frac{7}{9}$$

$$\therefore \emptyset = 51^0$$

Q 29. **A circular tunnel is made underground where far field vertical and horizontal stresses are Po and KPo respectively. The tangential stress ($\sigma_{\theta\theta}$) at the boundary of the tunnel for θ= 45^0 from the horizontal plane is 3Po. The value of K is**

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

Answer (C)

Solution .

$$\text{Tangential stress } (\sigma_{\theta\theta}) = P_Z[(1 + k) - 2\,(1 - k)\cos 2\theta]$$

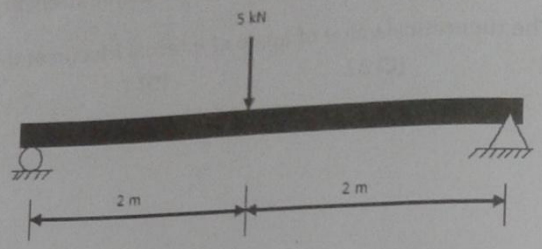
Given that, vertical stress $(P_Z) = P_0$

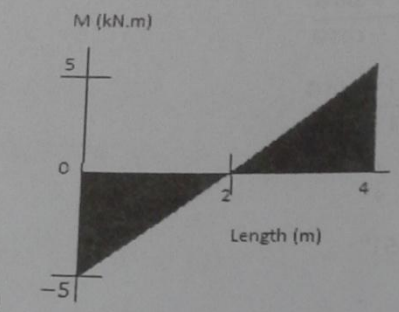
And tangential stress $(\sigma_{\theta\theta}) = 3P_0\,,\ \theta = 45^0$

$$\therefore 3\,P_0 = P_0[(1 + k) - 2(1 - k)\cos(2 \times 45^0)]$$

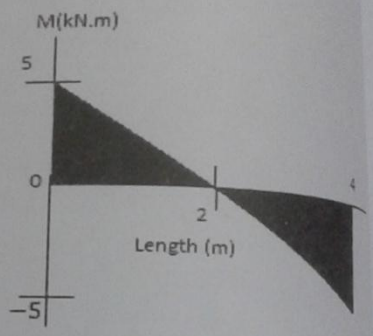
$$\therefore K = 2$$

Q.30. The bending moment diagram for the shaft shown below resembles which one of the Following graphs?

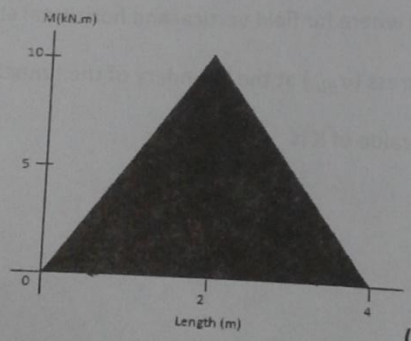




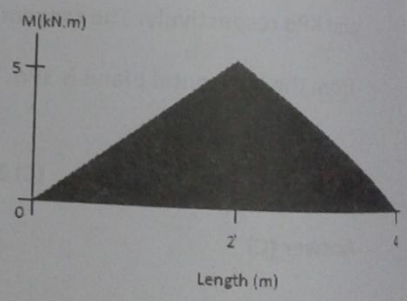
(A)



(B)



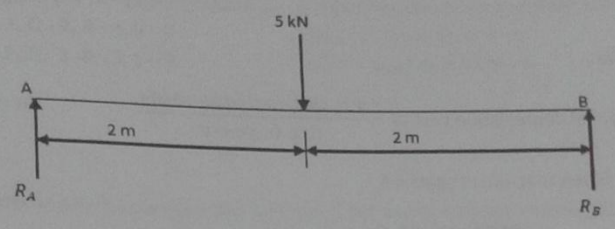
(C)



(D)

Answer (D)

Solution .



$$\therefore \sum M_B = 0$$

$$R_A \times 4 - 5 \times 2 = 0$$

$$R_A = 2.5\ KN$$

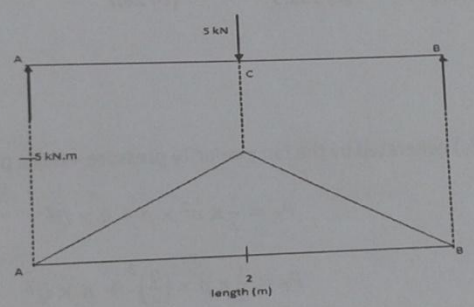
And also, $\sum V = 0$

$$R_A + R_B - 5 = 0$$

$$\therefore\ R_B = 2.5\ KN$$

Now, bending moment calculation

$$M_A = 0, \qquad M_B = 0, \qquad M_c = 2.5 \times 2 = 5\ KN.m$$



Q 31. A mining equipment has a life of 5 years with no salvage value. Assuming that the depreciation of the equipment is calculated by the straight line method, the average annual value of equipment in percentage of its original value is

(A) 20 (B) 40 (C) 50 (D) 60p

Answer (A)

Solution .

We have ,

$$\text{Annual depreciation cost} = \frac{first\ cost - solvage\ value}{life\ in\ years}$$

Given that, life in years = 5

Solvage value = 0.

$$\text{The average annual value (D) of equipment in percentage} = \frac{first\ cost\ (original\ cost) - 0}{5} \times 100$$

D = 20 % of first cost (original cost)

Q32. Air flows at 2 m^3/s through a forcing fan duct of 0.3 m^2 having uniform cross-section. The Duct resistance is 40 $Ns^2m^{-8}$and air density is 1.2 kg/m^3. The total pressure generated by the fan is Pa is

(A) 186.7 (B) 160.0 (C) 133.3 (D) 26.7

Answer (A)

Solution .

Total pressure(P_T) generated by the fan = velocity pressure +static pressure

$$P_T = \frac{1}{2} \times v^2 \times \rho + R \times Q^2$$

$$P_T = \frac{1}{2} \times \rho \times \left(\frac{Q}{A}\right)^2 + R \times Q^2$$

$$\therefore P_T = \frac{1}{2} \times 1.2 \times \left(\frac{2}{0.3}\right)^2 + 40 \times 2^2$$

$$\therefore P_T = 186.7\ Pa$$

Q 33. Match the following in the context of Indian mining practice:

Equipment	Power source
P. Rocker shovel	1. Battery
Q. Locomotive	2. Compressed air
R. Shearer	3. Electricity (maximum voltage 6.6 kV AC)

S. Dragline (24 m^3 bucket capacity) 4. Electricity (maximum voltage 1.1 kV AC)

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

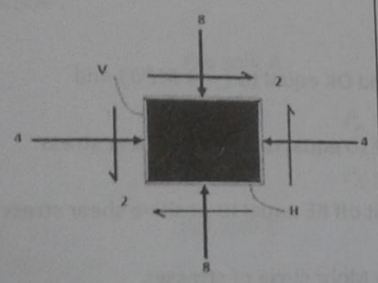
(B) P - 2, Q - 1, R - 4, S - 3

(C) P - 2, Q - 1, R - 3, S – 4

(D) P - 1, Q - 3, R - 2, S – 4

Answer (B)

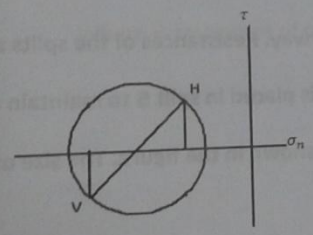
Q 34. The planes H and V represent the horizontal and vertical planes respectively as shown in the figure. Which one of the following Mohr circles represents the stress conditions applied in planes H and V?



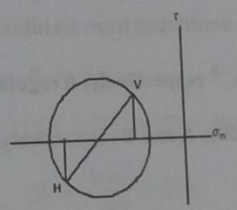
All stresses in MPa

τ and σ_n refer shear stress and normal stresses respectively

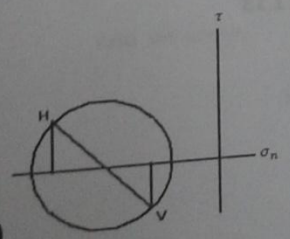
Note- shear stress is positive if it tries to rotate the element in clock wise direction



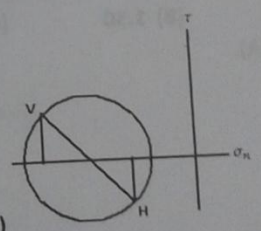
(A)



(B)



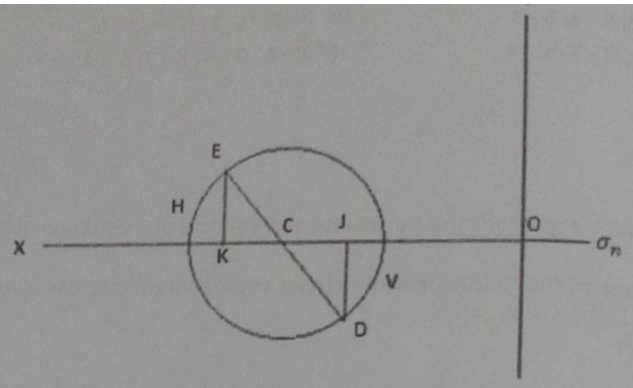
(C)



(D)

Answer (C)

Solution .



Note –

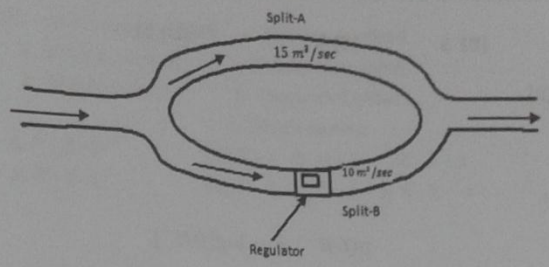
1. Take point O and draw a horizontal line OX, cut off OJ and OK equal to $(-4\ MPa)$ and $(-8\ MPa)$ respectively.
2. Now erect a perpendicular at J below line OX and cut off JD equal to negative shear stress $(-2MPa)$.
3. Similarly erect a perpendicular at K above OX line and cut off KE equal to positive shear stress $(2MPa)$. join DE and bisect it at C.
4. Now with C as centre and radius equal to CD or CE, draw Mohr circle of stresses.

Q 35. Two splits A and B are ventilated from an intake airway. Resistances of the splits are 0.5 Ns^2m^{-8} and 0.8 Ns^2m^{-8} respectively. A regulator is placed in split B to maintain a flow of 15 m^3/s and 10 m^3/s in splits A and B respectively, as shown in the figure. The size of the regulator in m^2 is

(A) 2.10 **(B) 1.30** **(C) 1.20** **(D) 1.13**

Answer (A).

5.



Solution .

For split A

$$P_A = R_A \times Q^2{}_A$$

$$P_A = 0.5 \times 15^2 = 112.5\ Pa$$

For split B

$$P_B = (R_B + R) \times Q^2{}_B$$

$$P_B = (0.8 + R) \times 10^2$$

Where R-resistance of regulator

Here, $P_A = P_B$

$$112.5 = (0.8 + R) \times 10^2$$

$$\therefore \quad R = \frac{112.5}{100} - 0.8$$

$$R = 0.325\ Ns^2m^{-8}$$

And we know,

Size of regulator (A) $= \frac{1.2}{\sqrt{R}}$

$$A = \frac{1.2}{\sqrt{R}}$$

$$A = \frac{1.2}{\sqrt{0.325}} = 2.10\ m^2$$

Q 36. The concentration of OH^- ion in a mine water sample is 10^{-11} mol/L . the pH of sam

(A) 2 (B) 3 (C) 4 (D) 11

Answer (B).

Solution .

We have,

$$p(OH^-) = -\log[OH^-]$$

$$p(OH^-) = -\log[10^{-11}]$$

$$\therefore\ p(OH^-) = 11$$

$$\text{Since } p(H^+) + p(OH^-) = 14$$

$$\therefore p(H^+) + 11 = 14$$

$$\therefore p(H^+) = 3$$

Q 37. A mine having a reserve of 320 Mt produces 4 Mt of ore at the end of 1st year. If the mine Increase production by 10% every year, the percentage of the reserve that still remains at the end of 21st year is

(A) 50 (B) 35 (C) 25 (D) 20

Answer (D)

Solution .

Percentage of reserve (R) that still remains at the end of 21th year:-

$$R = \frac{320 - 4\{1 + (1+0.1) + (1+0.1)^2 + \cdots + (1+0.1)^{20}\}}{320} \times 100$$

$$R = \frac{320 - 4\{(1.1)^0 + (1.1)^1 + (1.1)^2 + \cdots + (1.1)^{20}\}}{320} \times 100$$

$$R = \frac{320 - 4\left\{\frac{1-(1.1)^{21}}{1-1.1}\right\}}{320} \times 100$$

$$R = 20\%$$

Q38. Match the following:

Type of ore deposit	ore, rock strength	Mining method
P. flat, thin	1. Strong, strong	a. Sublevel stoping
Q. Massive	2. Weak, weak	b. room and pillar
R. Steep, thick		c. Block caving

(A) P - 1 - c, Q - 1 - a, R - 2 - b
(B) P - 1 - b, Q - 2 - c, R - 1 - a
(C) P - 2 - b, Q - 1 - a, R - 1 - c
(D) P - 1 - c, Q - 1 - b, R - 2 – a

Answer (B)

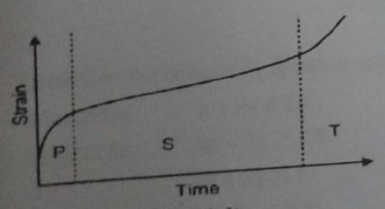
Q39. Match the following:

Stoping method	Advance of stoping face
P. Shrinkage stoping	1. Sideward vertical slices
Q. Rill stoping	2.Upward horizontal slice
R. Blasthole stoping	3.Downward horizontal slice
S. top slicing	4. Sideward inclined slices

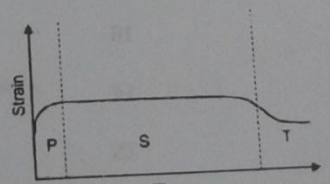
(A) P-3, Q-1, R-4, S-2
(B) P-2, Q-3, R-1, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-3, R-2, S-1

Answer (C)

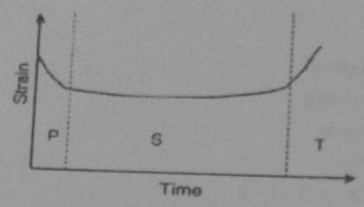
Q 40. Which one of the following graphs typically represents the standard strain-time creep behavior of an isotropic rock material under constant temperature? P, S and T in the figure refer to primary creep, secondary creep and tertiary creep respectively.



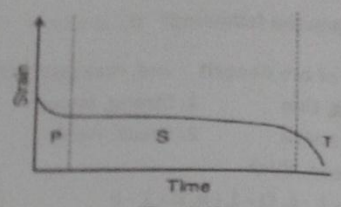
(Graph I)



(Graph II)



(Graph III)



(Graph IV)

(A) Graph-I (B) Graph-II (C) Graph-III (D) Graph-IV

Answer (A)

Q 41. The following data represent the number of workers suffering from pneumokoniosis in 10 coal mines.

Mine	I	II	III	IV	V	VI	VII	VIII	IX	X
Number	10	16	14	15	14	12	17	13	15	12

The number of mines falling above the 50th percentile in terms of the number of workers Suffering from pneumokoniosis is

(A) 2 (B) 3 (C) 4 (D) 5

Answer (D)

Solution .

Mine (M)	Number(N)	Cumulative Number (CN)
I	10	10
II	16	26
III	14	40
IV	15	55
V	14	69
VI	12	81
VII	17	98

VIII	13	111
IX	15	126
X	12	138

Now, for 50th percentile = $\frac{138}{2}$ = 69

So, number of mines falling above the 50th percentile = 5.

Q 42. Cause –wise data for injuries in an underground coal mine for a five year period is given below:

Cause of injury	Number of injuries
Fall of roof	27
Fall of person	22
Rope haulage	17
Explosive	5
Other causes	4

The cumulative probability of injury due to fall of roof and fall of person is

(A) 0.65 (B) 0.50 (C) 0.36 (D) 0.29

Answer (A)

Solution .

Cumulative probability of injury rate due to roof fall and fall of person is –

$$= \frac{27 + 22}{27 + 22 + 17 + 5 + 4}$$

$$= 0.65$$

Q 43. Consider the following linear programming problem:

Maximize $z = 3x + 2y$

Subject to $3x + 2y \geq 15$

$2x + 3y \leq 6$

$x \geq 0, y \geq 0$

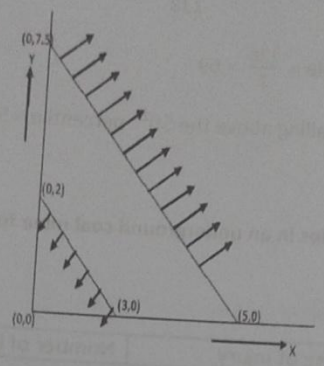
The above linear programming problem has

(A) unique optimal solution **(B) multiple optimal solutions**

(C) unbounded solution **(D) infeasible solution**

Answer (D)

Solution .



∴ given linear programming has infeasible solution.

Infeasible solution- In linear programming, there is no common shaded area.

Q 44. A mine workshop has 4 lathe machines and 4 tasks for completion. Each of the machines can be perform each of the 4 tasks. Each task can be assigned to one and only one machine. Estimate cost in rupees to complete each task is given in the matrix below.

Machine

Task

	M_1	M_2	M_3	M_4
T_1	61	92	52	72
T_2	42	49	69	85
T_3	47	59	80	71
T_4	65	70	68	72

The total optimum cost in Rupees for assigning the tasks to the machines is

(A) 210 (B) 215 (C) 220 (D) 286

Answer (C)

Solution .

		Machine			
		M_1	M_2	M_3	M_4
Task	T_1	9	40	0	20
	T_2	0	7	27	43
	T_3	0	12	33	24
	T_4	0	5	3	7

		Machine			
		M_1	M_2	M_3	M_4
Task	T_1	9	35	$\boxed{0}$	13
	T_2	$\boxed{0}$	2	27	36
	T_3	0	7	33	17
	T_4	0	$\boxed{0}$	3	0

		Machine			
		M_1	M_2	M_3	M_4
Task	T_1	11	35	$\boxed{0}$	13
	T_2	$\boxed{0}$	0	25	34
	T_3	0	5	31	15
	T_4	2	$\boxed{0}$	3	0

		Machine			
		M_1	M_2	M_3	M_4
Task	T_1	16	35	$\boxed{0}$	13
	T_2	5	$\boxed{0}$	25	34
	T_3	$\boxed{0}$	0	26	15
	T_4	7	0	3	$\boxed{0}$

Hence, Total optimum cost is = 52 + 49 + 47 + 72

= 220 rupees

Q 45. A 1100 V, 3 Φ power supply system of a mine draws a load of 185 kW. The ammeter reading shows 115 a. The power factor of the system is

(A) 0.84 (B) 0.73 (C) 0.64 (D) 0.48

Answer (A)

Solution.

We have,

$$\text{Power} = \sqrt{3} \times V_L \times I_L \times \cos \emptyset$$

$$185 \times 10^3 = \sqrt{3} \times 1100 \times 115 \times \cos \emptyset$$

$$\therefore \cos \emptyset = \frac{185 \times 10^3}{\sqrt{3} \times 1100 \times 115}$$

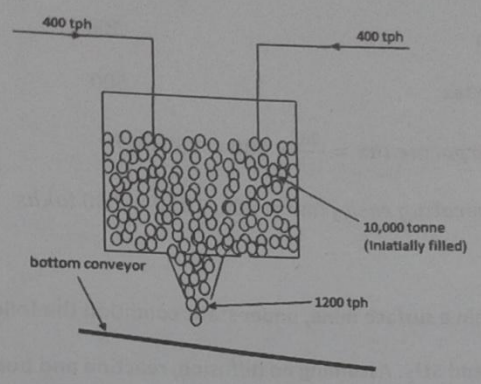
$$\therefore \cos \emptyset = 0.84$$

Q 46. Two belt conveyors load a ground bunker, each at a rate of 400 tph, which is initially filled with 10000 t of coal. Coal is discharged from the bottom of the ground bunker onto a belt conveyor at a rate of 1200 tph. The time elapsed in hours before the bottom conveyor starts to operate below its rated capacity is

(A) 6.5 (B) 8.5 (C) 12.5 (D) 25.0

Answer (D)

Solution .



Here , 400 tonne of coal is produced from initially filled coal in the bunker to maintain discharge rate 1200 tph on bottom belt conveyor.

So, the time(T) till belt conveyor works at its rated capacity:-

$$T = \frac{10000}{400} = 25\ hours$$

Q 47. The case flow table of manganese mine for a particular year is shown be

Item	Amount (Rs. in lakhs)
Revenue	900
Cost (other than depreciation)	300
Depreciation	100
Profit before tax	500

If the corporate tax is 50% of the Profit before tax, the operating cash inflow in lakhs of Rupees is

(A) 400 (B) 350 (C) 250 (D) 200

Answer (C)

Solution .

Note - corporate tax is imposed on net profit.

Item	amount (Rs. in lakhs)
Revenue	900
Cost (other than depreciation)	300
Depreciation	100
Profit before tax	500

$$\therefore corporate\ tax = \frac{50}{100} \times 500 = 250\ lakhs$$

$$\therefore operating\ cash\ flow = 500 - 250 = 250\ lakhs$$

Q 48. In an area within a surface mine, under static condition the following gases are found: NO_2, CO_2, O_3 and SO_2. Assuming no diffusion, reaction and bonding of the gases, the concentration of the gases from bottom upwards will be in the order of

(A) NO_2 CO_2, O_3 and O_2

(B) SO_2, NO_2, CO_2 and O_3

(C) SO_2, O_3, NO_2 and CO_2

(D) NO_2, CO_2, SO_2 and O_3

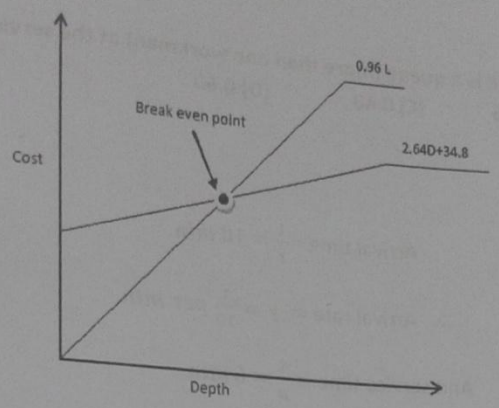
Answer (C)

Q 49. In a mine site, the cost of shaft sinking in lakhs of Rupees is given as 2.64D + 34.8, where D is the shaft depth in m. In the same site, the corresponding cost of driving an incline is 0.96L, where L is the length of the incline in m. Assuming L by D ratio is 3.0, the depth in m beyond which the shaft, sinking becomes more economical is

(A) 43 (B) 48 (C) 145 (D) 155

Answer (C)

Solution .



$\frac{L}{D} = 3$

At breakeven point,

$$C_S = C_l$$

$$2.64D + 34.8 = 0.96L$$

$$\therefore \quad D = \frac{34.8}{0.24}$$

$$\therefore \quad D = 145\ m$$

Q 50 . Match the following:

Seam characteristics	Coal mining method
P. 12 m thick flat seam	1. Mechanized longwall
Q. 7 m thick seam at 65^0 inclination	2 Descending shield
R. 3 m thick flat seam	3. Mechanized integral caving
S. 7 m thick seam at 25 inclination	4. Jankowice

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

Common data for questions 51 and 52 :

Workmen arrive at a mine workshop to receive tools for maintenance . The inter-arrival time of workmen at service counter is exponentially distributed with an average time of 10 min. the service time at the counter is also distributed exponentially with a mean time

of 6 min.

Q51. **Probability that there is a queue (more than one workman) at the service counter is**

(A) 0.24 **(B) 0.36** **(C) 0.40** **(D) 0.60**

Answer (D)

Solution .

$$\text{Arrival time} = \frac{1}{\gamma} = 10\ min.$$

$$\therefore\ \text{Arrival rate} = \gamma = \frac{1}{10}\ per\ min.$$

$$\text{And service time} = \frac{1}{\mu} = 6\ min.$$

$$\therefore\ \text{Service rate} = \mu = \frac{1}{6}\ per\ min.$$

Therefore ,

Probability that there is a queue (more than one workmen) at the service counter = traffic intensity or utilization ratio (ρ) :-

$$\rho = \frac{\gamma}{\mu} = \frac{\frac{1}{10}}{\frac{1}{6}} = 0.60$$

Q52. **Average time spent by a workman waiting for this turn to be served in min is**

(A) 9 **(B) 12** **(C) 15** **(D) 18**

Answer (C)

Solution .

Average time spent (T) by a workmen waiting for his turn to be served $= \frac{1}{\mu-\gamma}$

$$T = \frac{1}{\frac{1}{6} - \frac{1}{10}} = 15 \text{ minutes}$$

<u>Common Data for Questions 53 and 54</u>:

A tacheometer is set up at a station 'B'. The RL of the station B is 150 m and above the MSL by holding staff vertically at a station 'A', the following readings are taken.

vertical angle	staff readings(m)		
	Lower	middle	Upper
$26^0 36'$	0.08	3.08	5.36

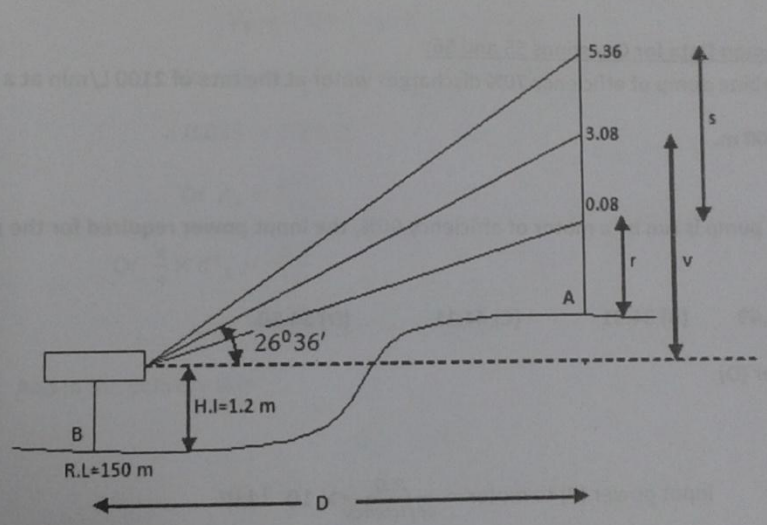
The multiplying factor and additive constant of the instrument are 100 and 1.9 m respectively

Q53. The horizontal distance between the stations A and B in m is

(A) 364.6 (B) 366.3 (C) 409.4 (D) 457.6

Answer (B)

Solution .



Multiplying factor = 100, and S = 5.36 – 0.80 = 4.56 m

Additive constant = 1.9 m

We have,

$$D = KS\,(\cos\theta)^2 + (f + d)\cos\theta$$

$$D = 100 \times 4.56 \times (\cos 26^0 36)^2 + 1.9 \times (\cos 26^0 36)$$

$$\therefore D = 366.298\ m$$

Q 54. If the height of the instrument is 1.2 m, the RL of the station 'A' above the MSL is m is

(A) 337.6 (B) 334.5 (C) 331.5 (D) 330.3

Answer (C)

Solution .

We have,

$$V = KS\sin\theta\cos\theta + (f + d)\sin\theta$$

$$V = 100 \times 4.56 \times (\sin 26^0 36) \times (\cos 26^0 36) + 1.9 \times (\sin 26^0 36)$$

$$\therefore V = 183.45\ m$$

$\therefore$ R.L of station A above M.S.L $= 150 + 1.2 + 183.45 - 3.08 = 331.5\ m$

<u>Common Data for Questions 55 and 56:</u>

A turbine pump of efficiency 70% discharges water at the rate of 2100 L/min at a total head of 100 m.

Q55. If the pump is run by a motor of efficiency 90%, the input power required for the motor in kW is

(A) 22.49 (B) 34.31 (C) 44.11 (D) 54.50

Answer (D)

Solution .

$$\text{Input power (P) to motor} = \frac{P.Q}{efficiency} \times 10^{-3}\ kW$$

$$P = \rho.g.h = 1000 \times 100 \times 9.81 = 981000\ Pa$$

$$Q = 2100\frac{L}{min} = 0.035\ m^3/sec$$

$$\text{Now, input power (P) to motor} = \frac{981000 \times 0.035 \times 10^{-3}}{0.70 \times 0.90}\ \text{kW}$$

$$P = 54.5\ kW$$

Q56. If the velocity of water in suction and delivery pipes of the pump are 1.8 m/s and 2.5 m/s respectively, the diameter of suction and delivery pipes in cm are

(A) 15.73 and 13.35
(B) 7.86 and 6.67
(C) 5.78 and 6.02
(D) 4.97, 4.22

Answer (A)

Solution .

We have,

$$Q = A_1V_1 = A_2V_2$$

$$Q = 2100\frac{L}{min} = 0.035\ m^3/sec$$

$$V_1 = 1.8\ m/sec, V_2 = 2.5\ m/sec$$

Now, $Q = A_1V_1$ [in the suction side]

$$\therefore 0.035 = 1.8 \times A_1$$

Or $A_1 = \frac{0.035}{1.8}$

Or $\frac{\pi}{4} \times d^2{}_1 = \frac{0.035}{1.8}$

$$\therefore\ d_1 = 0.1573\ m = 15.73\ cm$$

And in the delivery side-

$$Q = A_2V_2$$

$$0.035 = A_2 \times 2.5$$

$$\therefore\ d_2 = 0.1335\ m = 13.35\ cm$$

Statement for Linked Answer Questions 57 and 58:

A fan running at a speed of 280 rpm circulates 105 m^3/s of air in a mine.

Q 57. If the power input to the motor for driving the fan is recorded to be 75 kW, with the combined efficiency of fan and motor at 70 %, the fan pressure in Pa is

(A) 50 (B) 350 (C) 500 (D)650

Answer (C)

Solution .

We have,

$$\text{Input power (P) to motor} = \frac{P.Q}{efficiency} \times 10^{-3}\ kW$$

$$75 = \frac{P \times 105}{0.7} \times 10^{-3}$$

$$\therefore P = 500\ Pa$$

Q58. If the fan pressure is to be increased by 200 Pa by changing the fan speed, the fan speed in rpm will become

(A)768 (B) 549 (C) 392 (D)332

Answer (D)

Solution .

We have,

$$pressure \propto (speed)^2$$

$$\text{Or} \quad \frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^2$$

Given that,

$$P_1 = 500\ pa$$

$$P_2 = 500 + 200 = 700\ pa$$

$$N_1 = 280\ rpm$$

$$\therefore \frac{500}{700} = \left(\frac{280}{N_2}\right)^2$$

$$\therefore N_2 = 332\ rpm$$

<u>Statement for Linked Answer Questions 59 and 60:</u>

A surface mine blast design has 9 holes in a row, each of 8 m length and 200 mm diameter. the spacing and burden are 6 and 5 m respectively. The length of subgrade drilling is 1 m and

the density of in-situ rock is 2.43 t/m^3.

Q59. Assuming no back break, the output per blast in t is

(A) 4593 (B) 5905 (C) 6124 (D) 6299

Answer (A)

Solution .

We have,

$$output\ per\ blast$$
$$= No.of\ holes \times spacing \times burden \times density$$
$$\times (length\ of\ holes - subgrade\ length)$$

$$= 9 \times 6 \times 5 \times (8-1) \times 2.43 = 4593\ tonnes$$

Q60. Considering an explosive density of 0.9 t/m^3 and stemming length of 2 m, the powder factor from the blast in t/kg

(A) 4.00 (B) 4.12 (D) 3.01 (C) 3.86

Answer (D)

Solution .

$$Explosive\ required\ per\ round\ of\ blasting$$
$$= cross\ sectional\ area\ of\ hole \times No.of\ hole$$
$$\times (length\ of\ hole - stemming\ height) \times explosive\ density$$

$$= \frac{\pi}{4} \times 0.2^2 \times 9 \times (8-2) \times 0.9 \times 1000$$

$$= 1526.04\ kg$$

$$\therefore Powder\ Factor = \frac{output\ per\ blast\ (tonne)}{explosive\ required\ (kg)}$$

$$= \frac{4593}{1526.04}$$

$$= 3.01\ t/kg$$

Q 1. The trace of the matrix is

$$\begin{bmatrix} 2 & 2 & 3 \\ 3 & 2 & 3 \\ 4 & 1 & 2 \end{bmatrix}$$

(A) 6 (B) 7 (C) 8 (D)9

Answer (A)

Solution .

Note- Trace of the matrix - sum of diagonal elements of a square matrix is called trace of matrix.

$\therefore$ Trace of the matrix $= 2 + 2 + 2 = 6$

Q 2. If X is a continuous random variable and $f(x)$ defines its probability density function , then the expected value of X is

(A) $\int_{-\infty}^{+\infty} f(x)\,dx$ (B) $\sum_{i=-\infty}^{+\infty} x_i$

(C) $\sum_{i=-\infty}^{+\infty} x_i f(x)$ (D) $\int_{-\infty}^{+\infty} x f(x)\,dx$

Answer (D)

Q 3. The tool used to correct borehole deviation is

(A) string shot (B) Kelly (C) Whipstock (D) Rachet

Answer (C)

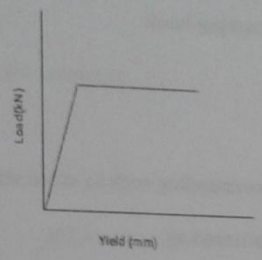
Q 4. A phreatic surface experiences a pressure

(A) less than atmospheric pressure (B) equal to atmospheric pressure

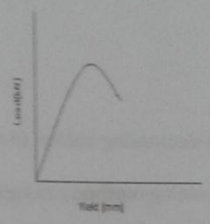
(C) more than barometric pressure (D) less than barometric pressure

Answer (B)

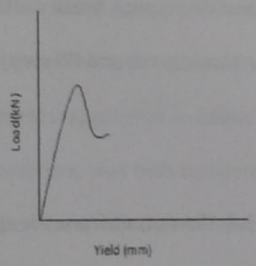
Q 5. The load yield characteristics of a hydraulic prop is represented by the curve



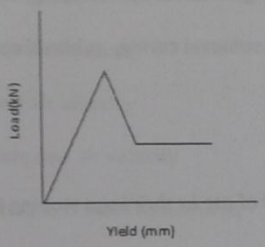
(A)



(B)



(C)



(D)

Answer (A)

Q 6. In longwall caving, the thickness of immediate roof is calculated from

(A)Bulking factor and width of the longwall face

(B) Seam thickness and width of the longwall face

(C) Seam thickness and bulking factor

(D) Seam thickness and length of the panel

Answer (C)

Q 7. During over-winding, a cage is safely suspended in the headgrear due to

(A) Bulk chain (B) Rope capel

(C) D-link (D) Detaching hook

Answer (D)

Q 8. Depending upon the decreasing ability of surrounding rock to store strain energy, the underground metal mining method can be ordered as

(A) Cut and fill stoping, sublevel caving, sublevel open stoping , block caving

(B) Sublevel open stoping, cut and fill stoping, sublevel caving, block caving

(C) Sublevel caving, sublevel open stoping, cut and fill stoping, block caving

(D) Block caving, sublevel caving, sublevel open stoping, cut and fill stoping

Answer (B)

Q 9. If the swell factor of ore in shrinkage stoping is 1.4. the output from the stope in percentage of broken ore is

(A) 0 (B) 29 (C) 40 (D) 100

Answer (B)

Solution .

$$\% \text{ of broken ore} = \frac{extra\ volume}{broken\ ore\ volume} \times 100$$

$$= \frac{(1.4-1)}{1.4} \times 100$$

$$= 29\ \%$$

Q 10. The velocity of the wave type that determines the 'rippability' of rockmass is

(A) P-wave (B) S –wave (C) Raleigh wave (D) Love wave

Answer (A)

Q 11. In the order of the chronological development, the longwall support system are arranged as

P. Powered support

Q. Link bar and friction support

R. Frame support

S. Hydraulic support

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

Answer (B)

Q 12. Effective temperature is estimated from

(A) Wet bulb temperature ,relative humidity and air velocity

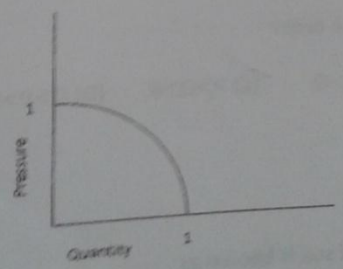
(B) Dry bulb temperature, relative humidity and air velocity

(C) Dry bulb temperature, wet bulb temperature and air velocity

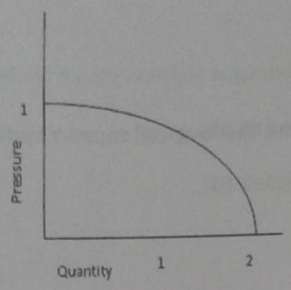
(D) Dry bulb temperature, wet bulb temperature and relative humidity

Answer (C)

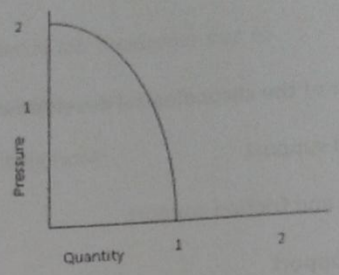
Q 13. Pressure –quantity characteristics of a mine fan is given below:



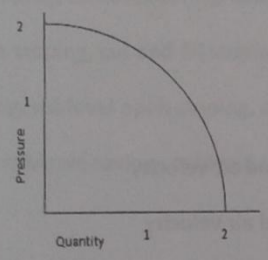
The combined characteristics of two such identical fan installed in parallel is



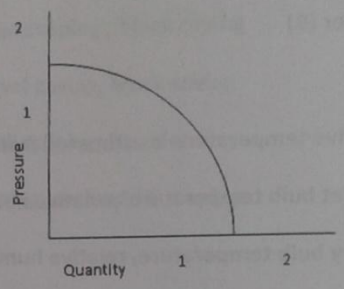
(A)



(B)



(C)



(D)

Answer (A)

Q 14 Under identical water head and roadways condition for water dam construction, if P,Q and R represent the thickness of flat dem; cylindrical dam and spherical dam respectively. The thickness would follow the order

(A) R>P>Q (B) P>R>Q (C) P>Q>R (D) Q>P>R

Answer (C)

Q 15. The grain size distribution of soil is known as

(A) Permeability (B) Structure (C) Porosity (D) Texture

Solution (B)

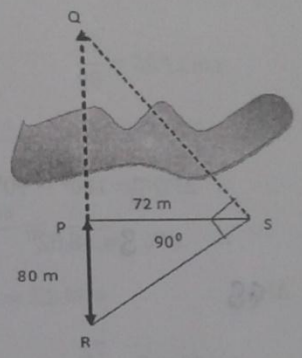
Q 16. Electrostatic precipitator works on the principle of

(A)Capacitance change (B) Ionization of particles

(C) Electro heating of gases (D) Centrifuging the gaseous molecules

Answer (B)

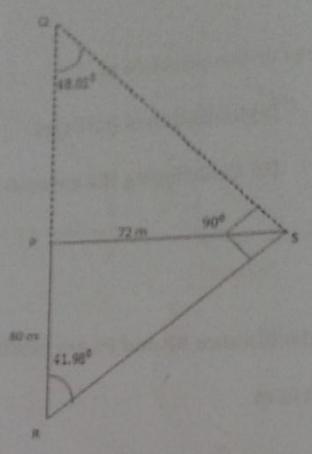
Q 17. In the figure shown below , the distance RP and PS are measured to be 80 m and 72 m respectively. The distance PQ in m



(A) 60.4 (B) 66.4 (C) 64.8 (D) 68.4

Answer (C)

Solution .



$$\tan \angle PRS = \frac{72}{80}$$

$$\therefore \angle PRS = 41.98^0$$

$$\therefore \quad \angle PQR = 180^0 - 90^0 - 41.98^0$$

$$\therefore \quad \angle PQS = 48.02^0$$

Now, In ΔPQS

$$\tan 48.02^0 = \frac{72}{PQ}$$

$$\therefore \quad PQ = 64.8 \text{ m}$$

Q 18. In PERT network, the activity duration is assumed to follow

(A) Beta distribution **(B) Binomial distribution**

(C) Normal distribution **(D) Weilbull distribution**

Answer (A)

Q 19. For an LP problem, identify the INCORRECT statement

(A) Optimal points lies in one of the corner points

(B) Objective function is linear

(C) All the constraints are linear

(D) Optimal point lies in any of the interior points of the feasible region

Answer (D)

Q 20. In an bi-axial stress field the vertical stress is 10 MPa and the poisson ratio for the rock mass is 0.2. The horizontal stress in MPa is,

(A) 1.5 (B) 2.5 (C) 2.0 (D) 5.0

Answer (B)

Solution .

We have,

$$\frac{horizontal\ stress}{vertical\ stress} = \frac{poisson\ ratio}{1-poisson\ ratio}$$

$$\therefore \frac{horizontal\ stress}{10} = \frac{0.2}{1-0.2}$$

$\therefore$ horizontal stress $= 2.5$ MPa

Q 21. Given :-

Bench height - 12 m

Burden - 4 m

Spacing - 5 m

Sub- grade drilling - 2 m

Explosive per hole - 120 kg

Density of rock - 2600 kg/m^3

The powder factor in tonne/kg is

(A) 2.0 (B) 4.6 (C) 5.2 (D) 7.3

Answer (C)

Solution .

We have,

$$\text{Powder Factor} = \frac{blasted\ material\ (tonne)}{explosive\ required\ (kg)}$$

$$= \frac{hole\ length \times spacind \times burden \times rock\ density\ (tonne)}{explosive\ required\ (kg)}$$

$$= \frac{12 \times 4 \times 5 \times 2600/1000}{120}$$

$$= 5.2$$

Q 22. Match the following

Equipment	slice thickness (range in m)	Action
P. Dragline	1. 6 - 12	a. Crowding
Q. Shovel	2. 30 - 40	b. Hoisting
R. Surface miner	3. 0.2 - 0.4	c. Cutting

(A) P-1-b; Q-2-a; R-3-c (B)) P-2-b; Q-1-a; R-3-c

(C) P-2-a; Q-1-b; R-3-c (D)) P-1-b; R-1-a; Q-3-c

Answer (B)

Q 23. Given:

Value of ore : Rs.600 per tonne

Production cost : Rs.600 per tonne

Cost of overburden removal : Rs. 50 per m^3

The break- even stripping ratio in m^3/tonne is

(A) 4:1 (B) 3:1 (C) 1:3 (D) 1:4

Answer (A)

Solution .

We know,

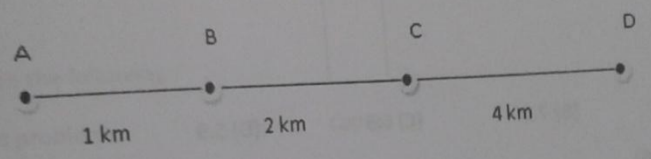
Break even stripping ratio

$$= \frac{recoverable\ price\ per\ tonne\ of\ ore - O.C\ production\ cost\ per\ tonne\ of\ ore}{cost\ of\ extraction\ per\ cubic\ meter\ of\ overburden\ material}$$

$$= \frac{600 - 400}{50}$$

$$= 4:1$$

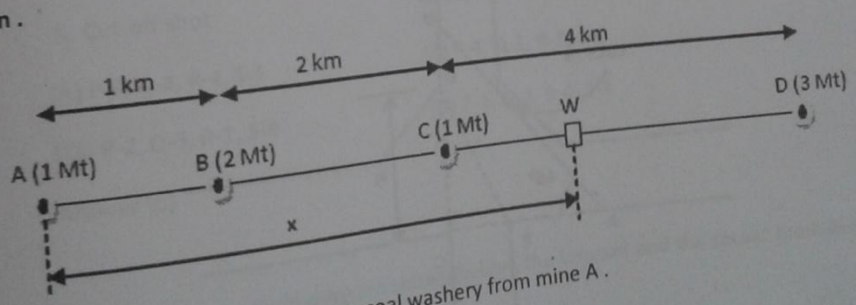
Q 24. Four mines A, B, C and D are located along a road as shown with production in Mt per year 1, 2, 1 and 3 respectively. In order to handle total coal produced, the distance of the coal washery along the road from the mine A in km is



(A) 4.01 **(B) 3.91** **(C) 3.81** **(D) 3.71**

Answer (D)

Solution .



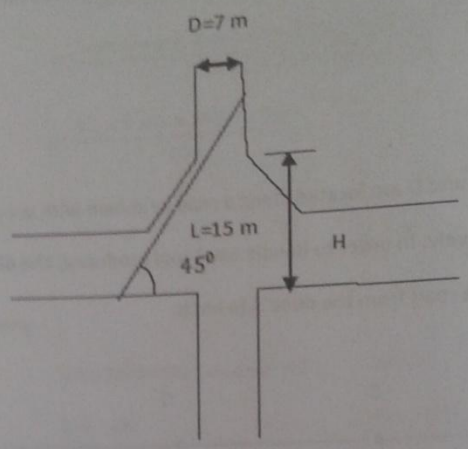
Where, x - ideal distance from coal washery from mine A .

$$\therefore\ x \times 1 + 2 \times (x - 1) + 1 \times (x - 3) = 3 \times (7 - x)$$

$$x + 2x - 2 + x - 3 = 21 - x$$

$$\therefore x = 3.71\ km$$

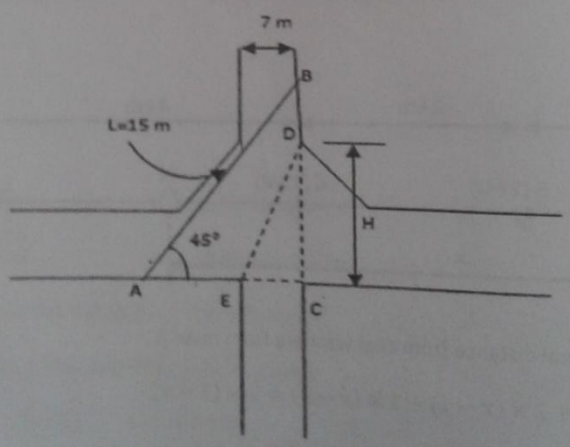
Q 25. A shaft inset is as shown below. To transport a 15 m long object, the height 'H' of the inset in m should be



(A) 10.5 (B) 7.0 (C) 6.5 (D) 5.9

Answer (B)

Solution .



In ΔABC

$$\cos 45^0 = \frac{AC}{15}$$

$$\therefore AC = 10.606 \text{ m}$$

And $BC = \sqrt{(15)^2 - (10.606)^2} = 10.606\ m$

In ΔABC & ΔCDE

$$\therefore \quad \frac{H}{EC} = \frac{BC}{AC}$$

$$\frac{H}{7} = \frac{10.606}{10.606}$$

$$\therefore \quad H = 7\ m$$

Q 26. Match the following

Blast problem	Cause
P. Misfire	1. Poor stemming
Q. Vibration	2. Low current
R. Blown –out-shot	3. Excess charge
S. Cut-off shot	4. Improper delays

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

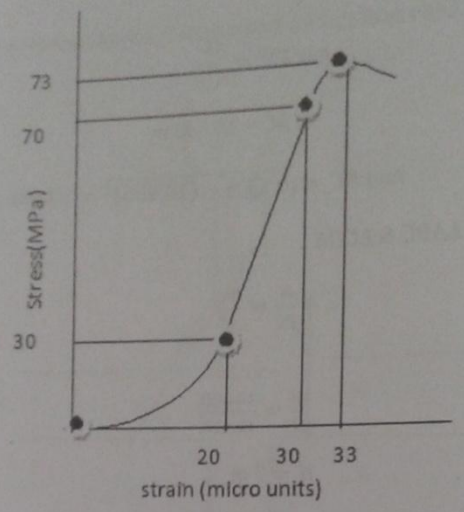
(B) P-4, Q-1, R-2, S-3

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

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

Answer (C)

Q 27. From the stress- strain diagram shown below, the tangent and the secant modulli of elasticity in GPa are

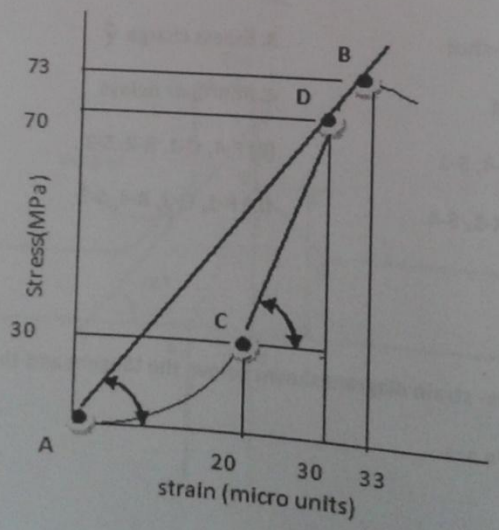


(A) 4.0,2.2 (B) 3.3,2.3

(C) 3.3, 1.5 (D) 4.0,1.5

Answer (A)

Solution .



Tangent - tangent to a plane curve at a given point is the straight line that touches the curve

at that point.

Secant- secant to a curve is a line that intersect two point on the curve.

∴ In above figure CD is tangent and AB is secant

Hence,

Tangent modulus $= \frac{70-30}{30-20} = \frac{40}{10} = 4$

Secant modulus $= \frac{73}{33} = 2.2$

Q 28. **A bord and pillar operatios ia planned at a depth of 300 m in a strata of average unit weight 24.5 kN/m^3 and compressive strength 15.50 MPa. If the width of opening is 6 m considering a factor of safety of 1 , the maximum possible extraction ratio in percentage is**

(A) 28 **(B) 34** **(C) 45** **(D) 53**

Answer (D)

Solution .

Strength of pillar = 15.5 MPa = $15.5\times 10^6\ N/m^2$

Depth = 300 m

Unit weight (w) = 24.5 kN/m^3 = $24.5 \times 10^3\ N/m^3$

Width of gallery or opening (b) = 6 m

Factor of safety = $\frac{strength\ of\ pillar}{load\ acting\ on\ pillar}$

And in case of square pillar ,load acting on pillar = $w.D\frac{(a+b)^2}{a^2}$

$$\therefore 1 = \frac{15.5 \times 10^6}{w.D\frac{(a+b)^2}{a^2}}$$

$$\therefore 1 = \frac{15.5 \times 10^6}{24.5 \times 10^3 \times 300\frac{(a+6)^2}{a^2}}$$

On solving, we found that

a = 13.268 m

Now,

$$\text{Extraction ratio } (\%) = 1 - \frac{a^2}{(a+b)^2} \times 100$$

$$= 1 - \frac{13.268^2}{(13.268+6)^2} \times 100$$

$$= 53\ \%$$

Q 29. Match the following

Stoping method	Ore handling system	Support system
P. Breast stoping	1. LHD	a. In situ pillar
Q. Cut and fill	2. Scraper	b. Unsupported
R. Sublevel stoping	3. Gravity flow	c. Mill tailings

(A) P-2-a; Q-1-c; R-3-b

(B) P-1-a; Q-3-c; R-2-b

(C) P-2-b; Q-1-a; R-3-c

(D) P-1-c; Q-3-a; R-2-b

Answer (A)

Q 30. Match the following

Access	Haulage	Mineralisation location
P. Shaft	1. Track	a. moderate depth
Q. Decline	2. Trackless	b. Deep seated
R. Adit	3. Hoisting	c. Hillock

(A) P-1-a; Q-3-b; R-2-c

(B) P-3-b; Q-2-a; R-1-c

(C) P-2-a; Q-1-b; R-3-c

(D) P-2-b; Q-3-c; R-1-a

Answer (B)

Q 31. Match the following

Mining method	Operation
P. Bord and pillar	1. Longhole radial drilling
Q. Sublevel caving	2. Splitting and slicing
R. Longwall retreating	3. Loosening under strata pressure
S. Integrated Caving	4. Mechanical cutting

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

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

Answer (D)

Q 32. A 30 m tape has an error of ± 0.005 m. If a length of 1500 m is measured with this tape, the expected total error made in the measurement in m is

(A) ± 0.025 (B) ± 0.030 (C) ± 0.035 (D) ± 0.04

Answer (C)

Solution.

The expected total error made in the measurement is $= \pm 0.005 \times \sqrt{\frac{1500}{30}}$

$= \pm 0.035$

Q 33. Match the following

Instrument	Principal features	Application
P. Tilting level	1. Micrometer	a. Levelling
Q. Microoptic theodolite	2. Magnetic needle	b. Traversing
R. Telescopic alidade	3. U-tube	c. Azimuth
S. Compass	4. Plane table surveying	d. Contouring

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

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

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

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

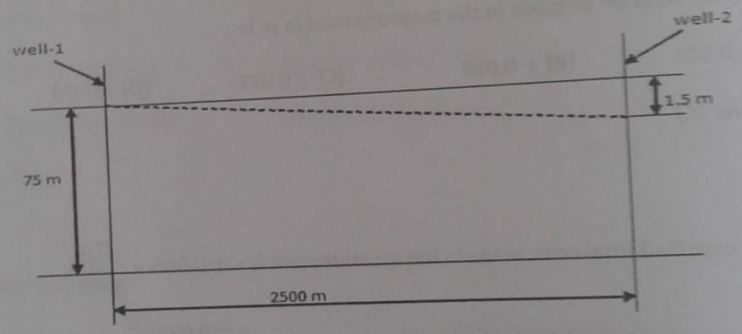
Answer (D)

Q 34. A confined aquifer of 75 m thickness has 2 monitoring wells spaced 2500 m apart along the direction of water flow. The hydraulic conductivity of the aquifer is 40 m per day. The water head difference between the wells is 1.5 m. applying the Darcy law's, the rate of flow per minute of distance perpendicular to the direction of flow in m^3/day is

(A) 2.1 (B) 1.8 (C) 1.45 (D)1.2

Answer (B)

Solution .



We have from Darcy law,

$$Q = kiA$$

Where,

k- hydraulic conductivity = 40 m/day

A - Cross sectional area = 75 × 1 = 75 m^2

i - hydraulic gradient = $\frac{h}{L} = \frac{1.5}{2500}$

[h- difference of hydraulic head over distance L]

Hence,

$$Q = 40 \times \frac{1.5}{2500} \times 75$$

$$Q = 1.8\, m^3/day$$

Q 35. **Precipitation of the metallic ion in mine water drainage is carried out by**

(A) $CaSO_4$ **and** $mgSO_4$ **(B)** $CaCO_3$ **and** $mgCO_3$

(C) $Ca(OH)_2$ **and NaOH** **(C)** $CaCO_3$ **and** $mgSO_4$

Answer (D)

Q 36. **A drum winder of radius 2.5 m draws a power of 308 KW when the maximum roe speed is 7 m/s. The RMS torque in kNm is**

(A) 55 **(B) 76** **(C) 110** **(D) 144**

Answer (C)

Solution .

Power = force × velocity

308 × 1000 = force ×7

∴ force = 44000 N

∴ The RMS torque in kNm = force × radius

= 44000 × 2.5

= 110 kNm.

Q 37. **A belt conveyor conveys material of average cross-sectional area of 0.09** m^2 **0f bulk density 1.5 toone/**m^3 **,at a speed 2 m/s. The carrying capacity of the belt in tonne/hr is**

(A) 972 **(B) 864** **(C) 732** **(D) 643**

Answer (A)

Solution .

Carrying capacity (T) of belt conveyor is given by:-

$$T = a.b.v \text{ tonne/s}$$

Where,

a = cross sectional area = 0.09 m^2

b = bulk density = 1.5 tonne/m^3

v = 2 m/s

$T = 0.09 \times 1.5 \times 2$

T = 0.27 tonne/s

T = 972 tonne/hour

Q 38. The wt % of solids in a sand-water stowing pipe is 60. If the solids density 3000 kg/m^3 , the pulp density of the slurry in kg/m^3

(A) 1380 (B) 1420 (C) 1560 (D) 1670

Answer (D)

Solution .

We have,

$$\text{Pulp density} = \frac{Mass\ of\ pulp}{Volume\ of\ pulp}$$

$$\text{Pulp density} = \frac{Mass\ of\ pulp}{Volume\ of\ water + Volume\ of\ sand}$$

$$\text{Or pulp density} = \frac{mass\ of\ pulp}{\frac{mass\ of\ water}{density\ of\ water} + \frac{mass\ of\ sand}{density\ of\ sand}}$$

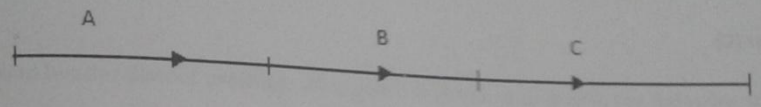
Mass of sand = mass of pulp × 60 % = mass of pulp × 0.6

Mass of water = mass of pulp × (100−60)% = mass of pulp × 0.4

$$\therefore \text{Pulp density} = \frac{mass\ of\ pulp}{mass\ of\ pulp\left[\frac{0.4}{1000} + \frac{0.6}{3000}\right]}$$

$\therefore$ Pulp density = 1666.7 kg/m^3

Q 39. **A mining project comprising of A,B and C activities is scheduled for 90 days at a cost of Rs 1200 million. The manager of project decides to reduce the time for completion of the project to 85 days. The decision was taken after 45 days.**



Activity	A	B	C
Duration (days)	40	15	35
Crashing cost /day (million rupees)	15	25	20

The minimum project cost in million rupees after crashing by 5 days is-

(A) 1100 (B) 1300 (C) 1475 (D) 1825

Answer (B)

Solution.

Here, crashing of project is done along C activity duration because having minimum crashing cost as comparaed to B activity duration.

$\therefore$ minimum cost of project after 5 days crashing is = 1200 + 5 × 20 = 1300 million rupees

Q 40 . **the following information is provided for an ore deposit**

Number of waste blocks = 10

Number of ore blocks = 5

Volume of each waste block,m^3 = 600

Total cost of waste handling per m^3 = Rs. 100

Tonnage of each ore block = 400

Total cost of ore handling per ton = Rs. 150

Sale price of ore per ton = Rs.500

The net cash flow of mining the deposit in lakhs of rupees, is

(A) 3.4 (B) 2.5 (C) 1.0 (D) 0.8

Answer (C)

Solution .

Sale price of ore = $5 \times 400 \times 500$ = 1000000 rupees

Total cost of waste handling = $10 \times 600 \times 100$= 600000 rupees

Total cost of ore handling= $5 \times 150 \times 400$ = 300000 rupees

Hence, net cash flow of mining deposit = 1000000 – 600000 – 300000 = 100000 rupees

= 1 lakh rupees

Q 41. Determine the correctness or otherwise of the following Assertion [a] and the reason [r]

Assertion : While stonedust barrier may be effective against a coal dust explosion , the same is not true is case of firedamp explosion

Reason : In general, firedamp explosion are much more powerful than coal dust explosions.

(A) Both [a] and [r] are false
(B) [a]is true but [r] is false
(C) Both [a] and [r] are true and [r] is the correct reason for [a]
(D) Both [a] and [r] are true but [r] is not the correct reason for [a]

Answer (B)

Q 42. Match the following

Component of flame safety lamp	Purpose of component
P. Asbestos rings	1. Dissipation of heat of flue gases
Q. Wire gauges	2. Formation of air tight joints

R. Outer glass

3. Arrest of explosion inside the lamp

S. Combustion chimney

4. Separation of inlet air from flue gases

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

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

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

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

Answer (A)

Q 43. A road header district produces 20 mg/m^3 of airborne dust with the following size distribution

Size up to	cumulative wt %
1 μm	1
5 μm	5
10 μm	10
20 μm	20
50 μm	50
> 50 μm	100

The concentration of respirable fraction of dust in mg/m^3 is

(A) 0.2 (B) 2.0 (C) 10.0 (D) 1.0

Answer (B)

Solution.

Respirable size of dust $\leq 10\ \mu m$

Hence, concentration of respirable fraction of dust = $20 \times \frac{10}{100}$

= 2 mg/m^3

Q 44. For a person working in atmosphere containing 21 % O_2, the exhaled air contains 4.5 % CO_2 and 16 % O_2. The respiratory quotient of breathing is

(A) 0.21 (B) 0.9 (C) 0.28 (D) 1.11

Answer (B)

Solution .

We know that,

$$\text{Respiratory quotient} = \frac{Co_2 \ produced}{O_2 \ consumed}$$

$$= \frac{4.5}{(21-16)}$$

$$= 0.9$$

Q 45. Total number of injuries in an opencast coal mine employing 800 persons is 16 in a year . As per DGMS norms, the injury rate per 1000 persons employed is

(A) 13 (B) 15 (C) 20 (D) 25

Answer (C)

Solution .

$$\text{Injury rate per 1000 persons employed} = \frac{16}{800} \times 1000$$

$$= 20$$

Q 46. The coefficient of friction between the tub - wheel and haulage track is $1/\sqrt{3}$. for the applicability of direct haulage , minimum inclination (in degrees) of track is

(A) 60 (B) 55 (C) 35 (D) 30

Answer (D)

Solution .

We have ,

Coefficient of friction $= \tan\theta$

Where,

θ- angle of inclination

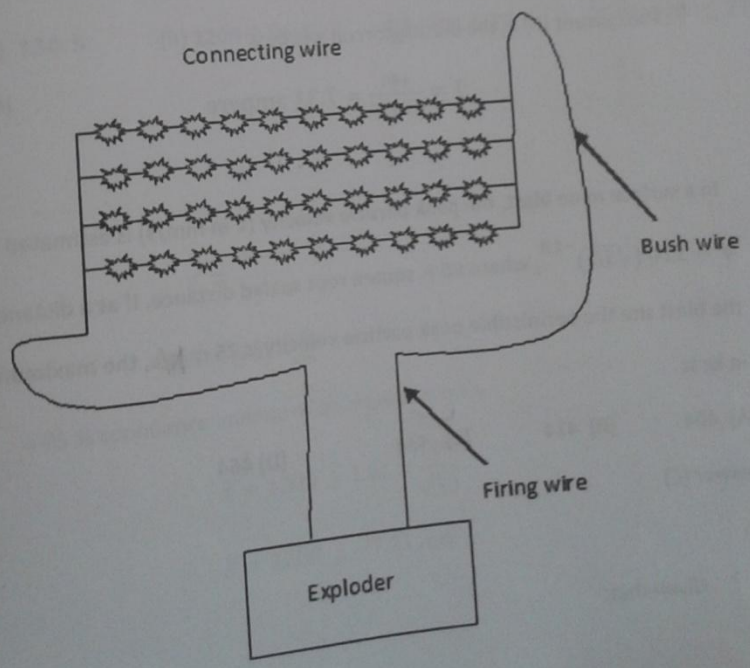
$$\frac{1}{\sqrt{3}} = \tan\theta$$

$$\text{Or } \theta = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

$$\therefore \quad \theta = 30^0$$

Q 47. **A surface mine bast pattern shown below has the following details:**

accessory	Resistance (in Ohms)	Number of length
Detonator	2 per detonator	40 nos
Connecting wire	0.5 /m	100 m
Bus wire	0.5/m	100 m
Firing line	0.01 /m	200 m



If the exploder supplies 440 V, the current in the blasting circuit in amperes is

(A) 5.36 (B) 3.51 (C) 4.83 (D) 2.57

Solution .

In the case of the 10 detonators and 25 m connecting wire the resistance will be:-

$$R = 2 \times 10 + 25 \times 0.5$$

For 40 detonator and 100 m connecting wire, the resistance will be:-

$$\frac{1}{R} = \frac{1}{32.5} + \frac{1}{32.5} + \frac{1}{32.5} + \frac{1}{32.5}$$

$$\therefore R = 8.125 \text{ ohm}$$

Now, total resistance (R_T) of circuit will be:-

$$R_T = 8.125 + 100 \times 0.5 + 0.01 \times 200$$

$$R_T = 60.125 \text{ ohm}$$

Hence,

The current (I) in the blasting circuit will be:-

$$\mathrm{I} = \frac{440}{60.125} = 7.31 \text{ ampere}$$

Q 48. In a surface mine blast, the peak particle velocity (V in mm/s) is estimated from the equation $V = 120\left(\sqrt{SD}\right)^{-1.0}$, where SD is square root sealed distance. If at a distance of 100 m from the blast site the permissible peak particle velocity is 25 mm/s, the maximum charge per delay in kg is

(A) 404 (B) 414 (C) 434 (D) 464

Answer (C)

Solution .

Given that,

$$V = 120(\sqrt{SD})^{-1.0}$$

And $\sqrt{SD} = \frac{D}{\sqrt{Q}}$

$$\therefore V = 120(\frac{D}{\sqrt{Q}})^{-1.0}$$

Or $V = 120\left(\frac{\sqrt{Q}}{D}\right)$

$$25 = 120 \times \frac{\sqrt{Q}}{100}$$

Or $\sqrt{Q} = \frac{25 \times 100}{120}$

$$\therefore Q = 434.03\ kg$$

Q 49. **Daily production measured for a period of 50 days in a coal mine exhibits normal distribution with mean 1200 tpd and standard deviation 100 tpd. The 95 % confidence interval of daily production (standard normal variable Z at 0.025 level of significance is 1.96) in tpd is**

(A) 1200 ± 120.5 **(B) 1200 ± 96.0** **(C) 1200 ± 39.6** **(D) 1200 ± 27.7**

Answer (D)

Solution .

We have,

$$z = \frac{\bar{X} \pm \mu}{\sigma/\sqrt{n}}$$

Or $\bar{X} = \mu \pm z.\frac{\sigma}{\sqrt{n}}$

$\therefore$ 95 % confidence interval of daily production :-

$$\bar{X} = 1200 \pm 1.96 \times \frac{100}{\sqrt{50}}$$

$$\bar{X} = 1200 \pm 27.71\text{ ,tpd}$$

Q 50. In an iron ore deposit alumina is distributed with $\mu = 3\ \%$ and $\sigma = 0.5\ \%$, where as silica is distributed with $\mu = 2.5\%$ and $\sigma = 0.8\ \%$. The combined alumina and silica (as impurities) has μ and σ, in percentage respectively as

(A) 5.5, 0.94 (B) 5.5, 1.3 (C) 0.5, 0.3 (D) 5.5, 0.52

Answer (A)

Solution .

For alumina - $\mu_1 = 3\%$, $\sigma_1 = 0.5\ \%$

For silica - $\mu_2 = 2.5\%$, $\sigma_2 = 0.8\ \%$

Combined mean $(\mu) = \mu_1 + \mu_2 = (3 + 2.5)\%$

$$\mu = 5.5\ \%$$

And combined variance $= (combined\ standard\ deviation)^2$

Or $combined\ standard\ deviation = \sqrt{combied\ variance}$

$$combined\ standard\ deviation = \sqrt{(variation)_{alumina} + (variation)_{silica}}$$

$$combined\ standard\ deviation = \sqrt{(standard\ deviation)_{alumina}{}^2 + (standard\ deviation)_{silica}{}^2}$$

$$\therefore combined\ standard\ deviation = \sqrt{0.5^2 + 0.8^2}$$

$$\therefore\ combined\ standard\ deviation = 0.94\%$$

(σ)

Q 51. The inverse of the following matrix is:

$$\begin{bmatrix} 4 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

(A) $\begin{bmatrix} 16 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ (B) $\begin{bmatrix} 0.25 & 0 & 0 \\ 0 & 0.50 & 0 \\ 0 & 0 & 1.00 \end{bmatrix}$

(C) $\begin{bmatrix} 2 & 0 & 0 \\ 0 & \sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix}$ (D) $\begin{bmatrix} 16 & 0 & 0 \\ 0 & 4 & 1 \\ 0 & 0 & 1 \end{bmatrix}$

Answer (B)

Solution .

$$A = \begin{bmatrix} 4 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Now, $|A| = \begin{vmatrix} 4 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{vmatrix}$

$\therefore \quad |A| = 8$

Here,

$$A_{11} = (-1)^{1+1}\begin{vmatrix} 2 & 0 \\ 0 & 1 \end{vmatrix} = 2$$

$$A_{12} = (-1)^{1+2}\begin{vmatrix} 0 & 0 \\ 0 & 1 \end{vmatrix} = 0$$

$$A_{13} = (-1)^{1+3}\begin{vmatrix} 0 & 2 \\ 0 & 0 \end{vmatrix} = 0$$

$$A_{21} = (-1)^{2+1}\begin{vmatrix} 0 & 0 \\ 0 & 1 \end{vmatrix} = 0$$

$$A_{22} = (-1)^{2+2}\begin{vmatrix} 4 & 0 \\ 0 & 1 \end{vmatrix} = 4$$

$$A_{23} = (-1)^{2+3}\begin{vmatrix} 4 & 0 \\ 0 & 0 \end{vmatrix} = 0$$

$$A_{31} = (-1)^{3+1}\begin{vmatrix} 0 & 0 \\ 2 & 0 \end{vmatrix} = 0$$

$$A_{32} = (-1)^{3+2}\begin{vmatrix} 4 & 0 \\ 0 & 0 \end{vmatrix} = 0$$

$$A_{33} = (-1)^{3+3}\begin{vmatrix} 4 & 0 \\ 0 & 2 \end{vmatrix} = 8$$

$$\therefore \quad \text{adj A} = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 8 \end{bmatrix}$$

Hence,

$$A^{-1} = \frac{adj\ A}{|A|} = \frac{\begin{bmatrix} 2 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 8 \end{bmatrix}}{8}$$

$$A^{-1} = \begin{bmatrix} 0.25 & 0 & 0 \\ 0 & 0.5 & 0 \\ 0 & 0 & 1.00 \end{bmatrix}$$

Q 52. The solution of the following system of linear equations is:

$$x + 4y + 3z = 0$$

$$3x + 5y + 2z = 0$$

$$8x + 10y + 12z = 0$$

(A) (0,0,0) (B) (1,−1,1) (C) (2, −1, −2) (D) (−3,0,1)

Answer (A)

Solution .

Now,

$$\Delta = \begin{vmatrix} 1 & 4 & 3 \\ 3 & 5 & 2 \\ 8 & 10 & 12 \end{vmatrix}$$

$$\Delta = 1\begin{vmatrix} 5 & 2 \\ 10 & 12 \end{vmatrix} - 4\begin{vmatrix} 3 & 2 \\ 8 & 12 \end{vmatrix} + 3\begin{vmatrix} 3 & 5 \\ 8 & 10 \end{vmatrix}$$

$$\Delta = 40 - 4 \times 20 - 3 \times 10$$

$$\Delta = -70$$

Here , $\Delta \neq 0$

Hence, given linear equation has trivial solution , So

$$x = 0, y = 0, z = 0$$

Q 53. The volume of a cone is given by

$$V = \frac{\pi}{3} l^3 sin^2\theta \cos\theta$$

Where, l is the slant height and θ is the semi-vertical angle. The angle (θ) , for which the volume of cone becomes maximum is

(A) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (B) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$

(C) $\cos^{-1}(\sqrt{2})$ (D) $\sin^{-1}(\sqrt{2})$

Answer (B)

Solution .

$$V = \frac{\pi}{3} l^3 . sin^2\theta . \cos\theta \text{ .....(1)}$$

Differentiating equa. (1) both sides with respect to θ,

$$\frac{dV}{d\theta} = \frac{\pi}{3} l^3 [2 \sin\theta \cos\theta \cos\theta - sin^2\theta \sin\theta]$$

$$\frac{dV}{d\theta} = \frac{\pi}{3} l^3 [2 \sin\theta \, cos^2\theta - sin^2\theta \sin\theta]$$

The volume of cone becomes maximum ,when

$$\frac{dV}{d\theta} = 0$$

Therefore,

$$\frac{\pi}{3} l^3 [2 \sin\theta \, cos^2\theta - sin^2\theta \sin\theta] = 0$$

$$\therefore \quad [2 \sin\theta \, cos^2\theta - sin^2\theta \sin\theta] = 0$$

$$\text{Or} \quad 2cos^2\theta - sin^2\theta = 0$$

$$\text{Or} \quad 2cos^2\theta - 1 + cos^2\theta = 0 \qquad [\text{since } sin^2\theta + cos^2\theta = 1]$$

$$\text{Or} \quad 3cos^2\theta = 1$$

$$\therefore \cos\theta = \frac{1}{\sqrt{3}}$$

$$\therefore \quad \theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

Q 54. The direction of gradient vector at a point (1,1,2) on a surface S (x, y, z) = $x^2 + y^2 - z$

(A) $\frac{1}{3}(2\hat{\imath} - 2\hat{\jmath} + \hat{k})$ **(B)** $\frac{1}{3}(-2\hat{\imath} + 2\hat{\jmath} + \hat{k})$

(C) $\frac{1}{3}(2\hat{\imath} - 2\hat{\jmath} + \hat{k})$ **(D)** $\frac{1}{3}(2\hat{\imath} + 2\hat{\jmath} - \hat{k})$

Answer (D)

Solution .

$$\nabla . S = \left(\mathrm{I}\frac{\partial}{\partial x} + \mathrm{J}\frac{\partial}{\partial y} + \mathrm{K}\frac{\partial}{\partial z}\right) . (x^2 + y^2 - z)$$

$$\nabla . S = \mathrm{I}\frac{\partial}{\partial x}(x^2 + y^2 - z) + \mathrm{J}\frac{\partial}{\partial y}(x^2 + y^2 - z) + \mathrm{K}\frac{\partial}{\partial z}(x^2 + y^2 - z)$$

$$\nabla.S = 2x\,\mathrm{J} + 2y\,\mathrm{J} - \mathrm{K}$$

At point (1,1,2)

$$\nabla.S = 2\mathrm{I} + 2\mathrm{J} - \mathrm{K}$$

Now, direction of the gradient vector $= \frac{2\mathrm{I} + 2\mathrm{J} - \mathrm{K}}{\sqrt{4+4+1}} = \frac{1}{3}(2\mathrm{I} + 2\mathrm{J} - \mathrm{K})$

Q 55. **The solution of the differential equation**

$$\frac{d^2y}{dx^2} + 3\frac{dy}{dx} - 4y = 0, \quad is$$

(A) $Y = c_1e^{4x}$ **(B)** $y = c_1e^{2x}$

(C) $y = c_1e^{x} + c_2e^{-4x}$ **(D)** $y = c_1e^{-x} + c_2e^{4x}$

Answer (C)

Solution .

Given differential equation is-

$$\frac{d^2y}{dx^2} + 3\frac{dy}{dx} - 4y = 0,$$

In symbolic form-

$$D^2y + 3Dy - 4y = 0$$

$$(D^2 + 3D - 4)y = 0$$

It's A.E. will be

$$D^2 + 3D - 4 = 0$$

$$D^2 + 4D - D - 4 = 0$$

$$\therefore (D+4).(D-1) = 0$$

$$\therefore D = 1, -4$$

Hence, solution will be-

$$y = c_1e^{x} + c_2e^{-4x}$$

Q 56. A force vector $= (2\hat{i} + 3\hat{j} - k)$ in N is acting on a point, whose position vector $r = (\hat{i} - \hat{j} - 6k)$ in m. The magnitude of the torque about the origin in Nm is

(A) 20.85 (B) 21.42 (C) 21.97 (D) 22.27

Answer (C)

Solution .

$$\vec{F} = 2\hat{i} + 3\hat{j} - \hat{k}$$

$$\vec{r} = \hat{i} - \hat{j} + 6\hat{k}$$

$\therefore$ Torque $= \vec{r} \times \vec{F}$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 6 \\ 2 & 3 & -1 \end{vmatrix}$$

$$= i\begin{vmatrix} -1 & 6 \\ 3 & -1 \end{vmatrix} - j\begin{vmatrix} 1 & 6 \\ 2 & -1 \end{vmatrix} + k\begin{vmatrix} 1 & -1 \\ 2 & 3 \end{vmatrix}$$

Torque $= -17\hat{i} + 13\hat{j} + 5\hat{k}$

Now, Magnitude of the torque $= \sqrt{(-17)^2 + (13)^2 + (5)^2}$

$= 21.97$ Nm

R_{max}

Q 57. If H is the maximum height attained by a projectile, the maximum horizontal range when fired at 45^0 inclination from the ground level is

(A) 4.0 H (B) 3.6 H (C) 3.2 H (D)2.7 H

Answer (A)

Solution .

We have,

$$R_{max} = \frac{u^2}{g} \text{.....(1)}$$

And $H_{max} = \frac{u^2 (\sin\theta)^2}{2g}$ .....(2)

From equation (1) & (2)

$$\frac{R}{N} = \frac{2}{(\sin\theta)^2}$$

$$\frac{R}{N} = \frac{2}{(\sin 45^0)^2}$$

$$\therefore R = 4N$$

Q 58. The local mean time at longitude $75^0 30'$ is 8 hr 45 min. The corresponding standard time with reference to $82^0 30'$ meridian is

(A) 8 hr 13 min (B) 9 hr 13 min (C) 9 hr 17 min (D) 10 hr 17 min

Answer (B)

Solution .

For every $15^0 \rightarrow 1$ hour

$\therefore 1^0 \rightarrow \frac{1}{15} \times 60 = 4$ min.

Now,

Change in meridian $= 82^0 30' - 75^0 30'$

$= 7^0$

$\therefore$ Change in time = 7 × 4 = 28 min.

Therefore,

Standard time with reference to $82^0 30$ Meridian :-

= 8 hr 45 min + 0 hr 28 min.

= 8 hr 73 min.

= 9 hr 13 min.

Q 59. Block economic values in 2D block model are shown below. Then based on the assumption of 1:1 slope angle. The blocks (identified by row and column numbers) that constitute the ultimate pit are

-1	-1	1	-1
-1	1	3	-1
-1	-1	-1	-1

(A) (1,2),(1,2),(1,3),(2,2)

(B) (1,2),(1,3),(1,4),(2,3)

(C) (1,3),(2,4)

(D) (1,3),(1,4),(2,4)

Answer (B)

Solution .

The following steps are used-

(1) The cone is floated from left to right along the top row of the blocks in the section, if there is a positive block it is removed.

	1	2	3	4	
1	-1	-1		-1	+1
2	-1	1	3	-1	
3	-1	-1	-1	-1	

(2) After traversing the first row the apex of the cone is moved to the second row, starting floats from left to right stopping when it encounters the first positive blocks. If the sum of all blocks falling within the cone is positive (or zero), these blocks are removed . if the sum is negative the blocks are left and thee cone floats to the next positive blocks on this row. The summing and mining or leaving process is repeated.

	1	2	3	4	
1				-1	-1-1+1= -1
2	-1		3	-1	
3	-1	-1	-1	-1	

	1	2	3	4
1	-1			
2	-1	1		-1
3	-1	-1	-1	-1

-1-1+3 = +1

(3) This floating cone process moving from left to right and top to bottom of the section continues until no more blocks can be removed.

(4) The profitability of the section is found by summing the value of the blocks removed.

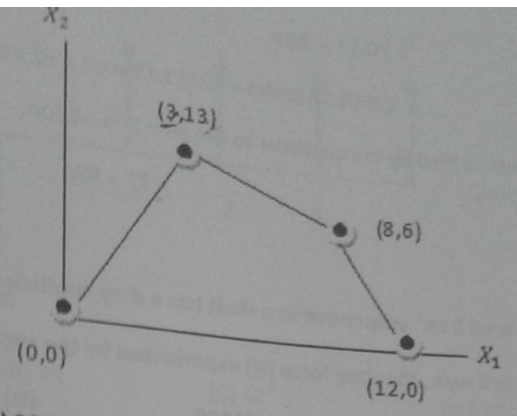
∴The optimum pit value of section $= +1 + 1 = +2$

ultimate pit limit

	1	2	3	4
1	-1	-1	1	-1
2	-1	1	3	-1
3	-1	-1	-1	-1

Therefore, Blocks (1, 2),(1, 3),(1, 4) and (2, 3) constitute a ultimate pit limit.

Q 60. The feasible region of an LP problem is shown as given below. The maximum value of the objective function $Z = 1600x_1 + 1200x_2$ is



(A) 20400 (B) 20000 (C) 19200 (D) 16800

Answer (A)

Solution .

We have,

$$Z = 1600X_1 + 1200X_2$$

Maximum value of objective function will be at point (3,13).

$$Z_{max} = 1600 \times 3 + 1200 \times 13$$

$$Z_{max} = 20400$$

Q 61. A conveyor of rated power 100 kW hauls up –dip at 30 kg/s along an inclination of 15^0 and distance 300 m. Heat added by the conveyor to the air in kW is

(A) 56.4 (B) 65.9 (C) 77.2 (D) 82.3

Answer (C)

Solution .

Component of weight along incline plane = mg sin θ

= 30×9.81× sin 15^0

= 76.17 N

and Work done = force × distance

$= 76.17 \times 300$

$= 22851.13$ joules $= 22851.13$ watt $= 22.85$ kW

Hence , Heat added by the conveyor to the air $= 100 - 22.85$

$= 77.2$ kW

Q 62. **A cage of floor area 5 m^2 suspended in a shaft has a drag coefficient of 2.5. if the velocity of air in the shaft is 6 m/s , the drag force (N) experienced by the cage is**

(A) 120 **(B) 170** **(C) 200** **(D) 270**

Answer (D)

Solution .

We have,

Drag force $= \frac{1}{2} \times \rho \times v^2 \times C_D \times A \times g$, N

Where, $\rho =$ density = 1.2 kg/m^3

V = velocity = 6 m/s

$C_D =$ Drag coefficient = 2.5

A = cross sectional area = 5 m^2

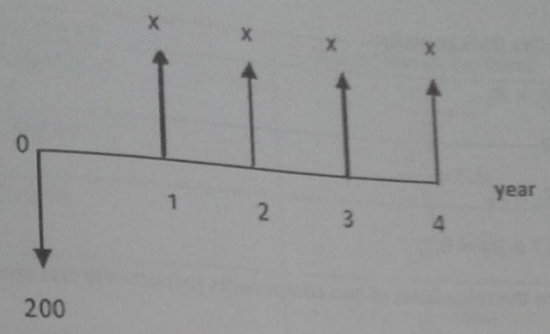
g = acceleration due to gravity = 9.81 m/s^2

Hence,

Drag force $= \frac{1}{2} \times 1.2 \times 6^2 \times 2.5 \times 5 \times 9.81$

Drag force = 270 N

Q 63. **A cash flow diagram is shown below. Based on NPV, at 10% rate of interest, the minimum annuity 'x' at which the instrument become viable**



(A) 63 (B) 54 (C) 42 (D) 35

Answer (A)

Solution .

We know,

$$\text{NPV} = -\text{ investment} + \text{annual payment } (X)\left[\frac{(1+i)^n-1}{i\,(1+i)^n}\right]$$

Investment would be acceptable ,when

$$\text{NPV} \geq 0$$

$$-200 + (X)\left[\frac{(1+0.1)^4-1}{0.1\,(1+0.1)^4}\right] \geq 0$$

$$\therefore -200 + (X).\,3.17 \geq 0$$

$$\therefore (X) \geq \frac{200}{3.17}$$

$$\therefore (X) = 63$$

Q 64. A system of two identical mine pumps connected in series has reliability 0.49. if the pump were to be connected in parallel, the system reliability would be

(A) 0.21 (B) 0.6 (C) 0.91 (D) 0.95

Answer (C)

Solution .

If R_1 and R_2 are the reliabilities of two components respectively and combined in series then

System reliability (R) is given by:-

$$R = R_1 \times R_2$$

$$\because R_1 = R_2$$

$$\therefore 0.49 = R_1 \times R_1$$

$$\therefore R_1 = 0.7 \ \& \ R_2 = 0.7$$

If R_1 and R_2 are the reliabilities of two components respectively and combined in parallel then System reliability (R') is given by:-

$$\therefore \quad R' = (1 - R_{1)} \times (1 - R_2)$$

$$R' = 1 - (1 - 0.7) \times (1 - 0.7)$$

$$\therefore \quad R' = 0.91$$

Q 65. **An SDL working at different faces gives the following performance:**

Operating faces	production per blast (tonne)	Muck clearance time (hrs)
Development face	16	1.25
Splitting face	17	1.20
Slicing faces	18	1.30
Heightening faces	20	1.50

In 5 hours operation maximum output is obtained from the

(A) Heightening faces **(B) Slicing faces**

(C) Development faces **(D) Splitting face**

Answer (B)

Solution .

Operating face	Output in 5 hours operation (tonnes)
Development face	$\frac{5 \times 16}{1.25} = 64$
Splitting face	$\frac{5 \times 17}{1.20} = 70.84$
Slicing face	$\frac{5 \times 18}{1.30} = 69.23$
Heighting face	$\frac{5 \times 20}{1.50} = 66.67$

∴ maximum output from from Splitting face.

Q 66. In a coal handling plant wagons of 8 m length are loaded at rake travel speed of 0.48 km/hr. The chute loading rate is 6000 tonne/hr. As the rake moves continuously, the chute stops for a total of 24 s in between two wagons. The quantity of coal in tonne loaded in each wagon is

(A) 52 (B) 60 (C) 76 (D) 94

Answer (B)

Solution .

$$\text{Speed} = \frac{distance}{time}$$

$$\therefore \quad \frac{0.48 \times 1000}{3600} = \frac{8}{time}$$

$$\therefore \text{ time} = 60 \text{ sec.}$$

Now, time taken to fill a wagon = 60 −24 = 36 sec.

But given chute loading rate = 6000 tonne/hr

Hence,

Quantity of coal loaded in each wagon = loading rate × time taken to fill a wagon

$$= 6000 \frac{tonne}{h} \times 36 \text{ sec}$$

$$= 6000 \frac{tonne}{3600\ sec} \times 36\ sec$$

$$= 60 \text{ tonnes}$$

Q 67. Match the following

Failure criteria	Relationship
P. Drucker-Prager	1. $\sigma_1 = \sigma_3 + \sqrt{m\,\sigma_3 + s^2}$
Q. Hoek-Brown	2. $\tau = c + \sigma_n \tan \emptyset$
R. Mohr-Coulomb	3. $\sqrt{\frac{2}{3}}\left[\left(\frac{\sigma_1-\sigma_2}{2}\right)^2 + \left(\frac{\sigma_2-\sigma_3}{2}\right)^2 + \left(\frac{\sigma_3-\sigma_1}{2}\right)^2\right]^{\frac{1}{2}} = A\,(\sigma_1 + \sigma_2 + \sigma_3) + B$

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

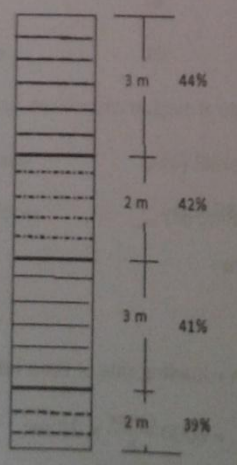
(B) P-3, Q-1, R-2

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

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

Answer (B)

Q 68. An assay value of alumina in a borehole from a bauxite deposit is shown in the figure. If the cut off grade is 40 %, the composite value of ore in the borehole in percent is



(A) 44.6 (B) 43.9 (C) 41.7 (D) 42.2

Answer (C)

Solution :

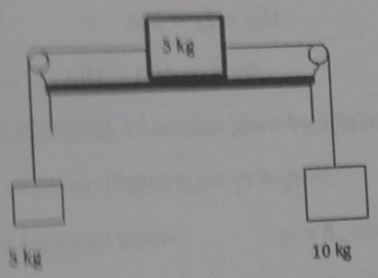
We have,

$$\text{Composite value of ore grade} = \frac{l_1g_1 + l_2g_2 + l_3g_3 + l_4g_4}{l_1+l_2+l_3+l_4}$$

$$= \frac{3 \times 44 + 2 \times 42 + 3 \times 41 + 2 \times 39}{3+2+3+2}$$

$$= 41.7\ \%$$

Common data for questions 69,70 and 71: Two blocks of mass 5 kg and 10 kg are connected with cords and frictionless pulley as shown. Friction coefficient between the 5 kg and table is 0.2

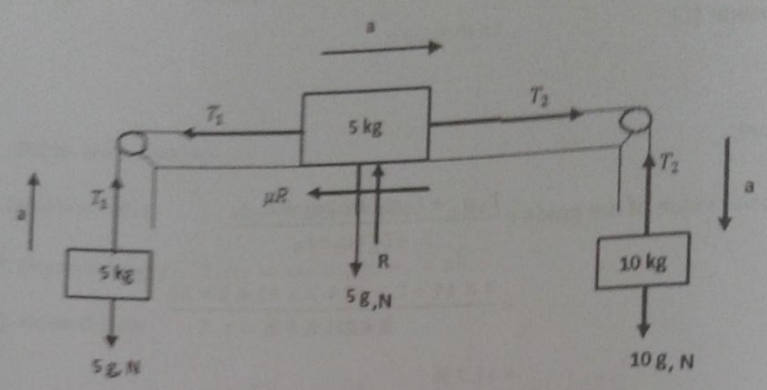


Q 69. The acceleration of the system when the blocks are released from rest ('g' is acceleration due to gravity)

(A) 5g (B) 2g (C) g/5 (D) g/10

Answer (C)

Solution :



From left hand side mass, applying F = ma, then

$$T_1 - 5g = 5a$$

Or $T_1 = 5a + 5g$ .....(i)

From right hand side mass, applying F = ma, then

$$10g - T_2 = 10a$$

Or $T_2 = 10g - 10a$ .....(ii)

From middle mass applying F = ma, then

$$T_2 - T_1 - \mu R = 5a$$

But when $\sum Y = 0$ then , R = 5g

$\therefore T_2 - T_1 - 5g \times 0.2 = 5a$

$\therefore T_2 - T_1 - g = 5a$ .....(iii)

Putting the value of T_1 & T_2 in equation (iii)

$10g - 10a - 5a - 5g - g = 5a$

$$\therefore a = \frac{g}{5}$$

Q 70. Tension (N) in the cord connected to the 10 kg block is

(A) 8g (B) 6g (C) 4g (D) 2g

Answer (A)

Solution .

From equation (2)

$$T_2 = 10\,g - 10 \times \frac{g}{5}$$

$$T_2 = 8\,g, N$$

Q 71. Tension (N) in the cord connected to the 5 kg block is

(A) 8g (B) 6g (C) 4g (D) 2g

Answer (B)

Solution .

From equation (1)

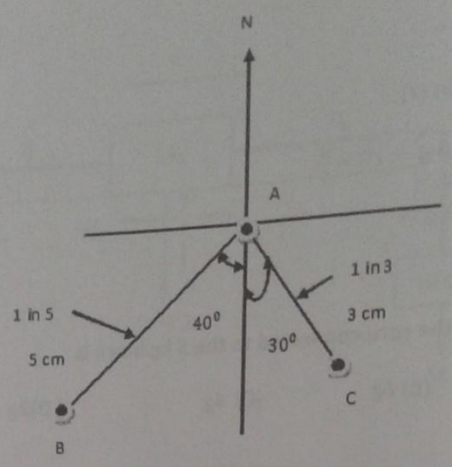
$$T_1 = 5\,a + 5\,g = 5 \times \frac{g}{5} + 5g$$

$$T_1 = 6\,g, N$$

Common data for questions 72 and 73: Three boreholes intersect a coal seam at a points A, B and C as shown (figure is drawn to scale)

The survey details are given below

Line	Bearing	Gradient
AB	$S40^0W$	1 in 5
AC	$S30^0E$	1 in 3

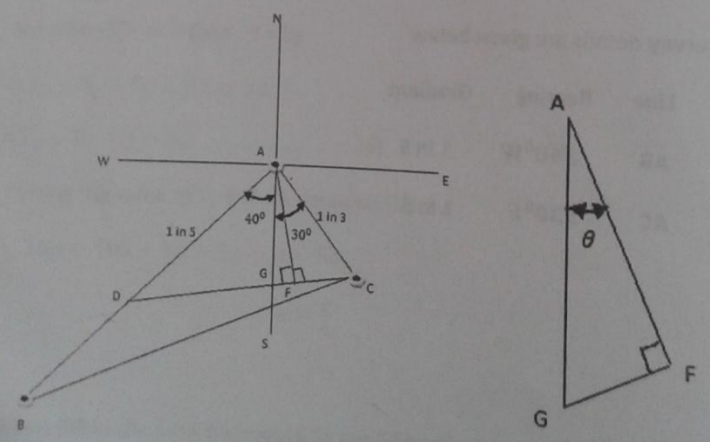


Q 72. The direction of the true dip of the seam is

(A) $S15^0W$ (B) $S\,25^0W$ (C) $S15^0E$ (D) $S\,30^0E$

Answer (C)

Solution .



θ - Direction of true dip

We have,

In ΔACD

$$\tan\frac{D-C}{2} = \frac{c-d}{c+d}\tan\frac{D+C}{2}$$

Now,

$$A + C + D = 180^0$$

But $\angle A = 70^0$

$$\therefore C + D = 110^0 \text{.....(1)}$$

Now,

$$\tan\frac{D-C}{2} = \frac{3-5}{3+5}\tan\frac{110^0}{2}$$

On solving, it is found that

$$D - C = -39^0 35' 91'' \text{.....(2)}$$

Solving (1) & (2)

$$\angle D = 35^0 12' 05''$$

$$\angle C = 74^0 47' 55.95''$$

In ΔAGC

$$A + C + G = 180^0$$

$$\angle G = 180^0 - 30^0 - 74^0 47' 55.95''$$
$$\angle G = 75^0 12' 4.44''$$

In ΔAGF

$$A + G + F = 180^0$$

$$\angle A = 180^0 - 90^0 - 75^0 12' 4.44''$$
$$\angle A = 14^0 47' 55.56''$$

Hence,

Direction of true dip of seam is S$14^0 47' 55.56''$E or S15^0E

Q 73. The gradient of the seam

(A) 1 in 2.7 (B) 1 in 3.7 (C) 1 in 4.7 (D) 1 in 5.7

Answer (A)

Solution ,

We know that,

Apparent dip = full dip × $\cos\alpha$

α- angle between full dip and apparent dip

$\frac{1}{5}$ = full dip × $\cos(40^0 + 14^0\ 47'55.56'')$

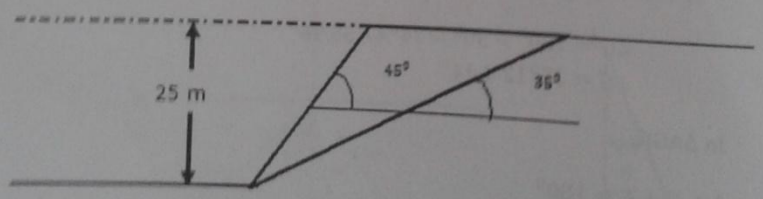
∴ full dip or gradient of the seam = $\frac{1}{2.7}$

Or

$\frac{1}{3}$ = full dip × $\cos(30^0 - 14^0\ 47'55.56'')$

∴ full dip or gradient of the seam = $\frac{1}{2.7}$

Statement for linked answer questions 74 and 75: An opencast mine bench has a potential failure plane as indicated below. The unit weight, cohesion, and angle of internal friction of the rock mass are 24 kN/m^3, 0.02 MPa and 30^0 respectively.

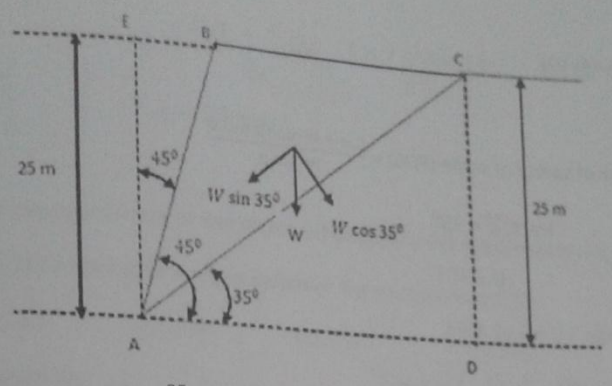


Q 74. The driving force for failure, on the potential failure plane is

(A) 187 N (B) 1.87 kN (C) 18.7 kN (D) 1.87 MN

Answer (D)

Solution ,



$$\tan 35^0 = \frac{25}{AD}$$

$$\text{Or } AD = \frac{25}{\tan 35^0} = 35.70\ m$$

Now, area of triangle ADC $= \frac{1}{2} \times 25 \times 35.70 = 446.25\ m^2$

Again $\tan 45^0 = \frac{EB}{25}$

$$EB = 25\ m$$

Now, area of triangle ABE$= \frac{1}{2} \times 25 \times 25 = 312.5\ m^2$

And area of rectangle ACDE $= 35.70 \times 25 = 892.5\ m^2$

$\therefore$ area of triangle ABC$= 892.5 - 446.25 - 312.5$

$$= 133.75\ m^2$$

Given that, unit weight $= 24.5\ kN/m^3$

So, weight of block (W) $= 24.5 \times 133.75 \times 1$

$$W = 3276.875\ kN$$

Now, driving force for failure is-

$$W \sin\beta = 3276.875 \times \sin 35^0$$

$$= 1.87\ MN$$

Q 75. The 'factor of safety' of slope under given condition is

(A) 0.7 (B) 0.9 (C) 1.1 (D) 1.3

Answer (D)

Solution .

Factor of safety of slope (FOS) = $\frac{C.A + W\ \cos\alpha \tan\emptyset}{W\ \sin\alpha}$

Here, $\alpha = 35^0$

$\emptyset = 30^0$

Cohesion = C = 0.02 MPa

Shear area (A) = $\left(\frac{25}{\sin 35^0}\right) \times 1, m^2$

W = 3276.88 kN = 3.28 MN

$\therefore$ FOS = $\frac{0.02 \times \left(\frac{25}{\sin 35^0}\right) \times 1 + 3.28 \times \cos 35^0 \times \tan 30^0}{3.28 \times \sin 35^0}$

$\therefore$ FOS = 1.3

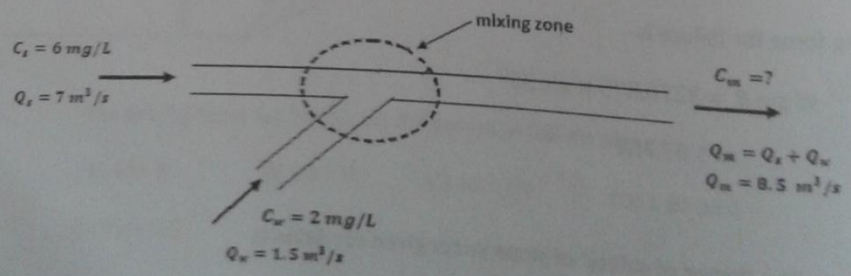
Statement for linked answer questions 76 and 77: Mine water flowing at 1.5 m^3/s with 2 mg/l dissolved oxygen, joins river water flowing at 7 m^3/s containing 6 mg/l dissolved oxygen

Q 76. The dissolved oxygen concentration of mixture in mg/l is

(A) 5.3 (B) 4.8 (C) 4.2 (D) 3.9

Answer (A)

Solution .



$$C_m = \frac{C_s Q_s + C_w Q_w}{Q_m} = \frac{6 \times 7 + 2 \times 1.5}{8.5}$$

$$C_m = 5.3\ mg/L$$

Q 77. **The saturated value of the dissolved oxygen in the mixture is given to be 9.3 mg/l. On this basis the initial oxygen deficit of the mixture in mg/l is**

(A) 2.4 **(B) 4.0** **(C) 6.8** **(D) 14.6**

Answer (B)

Solution .

Initial oxygen deficit of mixture = saturated value of dissolved oxygen in mixture−dissolved oxygen concentration of mixture

$= 9.3 - 5.3$

$= 4\ mg/l$

Statement for linked answer questions 78 and 79:

Unit cost matrix of a transportation problem is given below in certain monetary unit.

Destination

		1	2	3		
Source	1	2	2	8	15	Supply
	2	1	5	7	40	
	3	6	4	3	20	
		10	25	40		

Demand

Q 78. **The total cost of transportation based on the initial feasible solution obtained by the**

North- West corner rule is

(A) 250 (B) 290 (C) 330 (D) 360

Answer (C)

Solution .

2 (10)	2 (5)	8	15/5/0
1	5 (20)	7 (20)	40/20/0 supply
6	4	3 (20)	20/0
10/0	25/20/0	40/20/0	

Demand

Total cost of transportation $= 2 \times 10 + 2 \times 5 + 5 \times 20 + 7 \times 20 + 3 \times 20$

$= 330$

Q79. **The optimal solution for the transportation problem has allocation as shown below;**

Destination

Source	1	2	3	
1		15		15
2	10	10	20	40 Supply
3			20	20
	10	25	40	

Demand

When compared to initial basic feasible solution from the above, the optimal allocation

results in savings of

(A) 10 (B) 20 (C) 30 (D) 40

Answer (D)

Solution .

	15		15	
10	10	20	40	supply
		20	20	
10	25	40		

Demand

Here , Optimal cost of transportation $= 15 \times 2 + 10 \times 1 + 10 \times 5 + 20 \times 7 + 20 \times 3$

$= 290$

Hence , cost of saving $= 330 - 290 = 40$

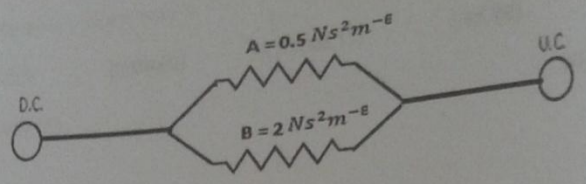
Statement for linked answer questions 80 and 81: In a mine ventilation system, the resistance of two splits A and B are 0.5 Ns^2m^{-8} and 2.0 Ns^2m^{-8} respectively. Combined resistance of two shafts and trunk roadways is 0.7 Ns^2m^{-8} .A quantity of 20 m^3/s of air passé through split A

Q 80. The total air quantity passing the mine in m^3/s

(A)30 (B) 27 (C) 25 (D) 7

Answer (A)

Solution .



$$\frac{1}{\sqrt{R_{AB}}} = \frac{1}{\sqrt{R_A}} + \frac{1}{\sqrt{R_B}}$$

$$\frac{1}{\sqrt{R_{AB}}} = \frac{1}{\sqrt{0.5}} + \frac{1}{\sqrt{2}}$$

$$\therefore R_{AB} = 0.223\ Ns^2m^{-8}$$

Now, total resistance = 0.7 + 0.223 = 0.923 Ns^2m^{-8}

And $P_A = P_B$

$$R_A(Q_A)^2 = R_B(Q_B)^2$$

$$0.5 \times (20)^2 = 2 \times (Q_B)^2$$

$$\therefore \quad Q_B = 10\ m^3/sec$$

Hence, total quantity = 20 + 10 = 30 m^3/sec

Q 81. The total air power of the ventilation system in kW is

(A) 82.9 (B) 48.9 (C) 24.9 (D)27.9

Answer (C)

Solution .

We have,

Air Power = $PQ \times 10^{-3}$, KW

Or Air Power = $RQ^3 \times 10^{-3}$, KW

$= 0.923 \times (30)^3 \times 10^{-3}$

Air Power = 24.9 KW

Statement for linked answer questions 82 and 83: A loco of mass 10000 kg has a coefficient of adhesion to the tracks as 0.25. the offers a rolling resistance equal to 10 % of its weight.

Q 82. The draw- bar- pull generated by the loco on a level ground in KN is

(A) 11.3 (B) 14.7 (C) 15.8 (D) 17.2

Answer (B)

Solution .

Mass of loco = 10000 kg = 10000×9.81= 98100 N

Tractive effort = coefficient of adhesion ×mass

= 0.25 × 98100

= 24524 N

And Running Resistance = $\frac{10}{100} \times 98100 = 9810$ N

Now, draw bar pull generated by the loco on a level gradient = Tractive effort – Running Resistance

= 24525 – 9810

= 14715 N

= 14.7 kN

Q 83. The draw-bar-pull generated by the loco when the upward gradient of the track is 5^0in kN is

(A) 6.16 (B) 7.9 (C) 9.5 (D) 1.5

Answer (A)

Solution .

Draw bar pull generated by loco, when the upward gradient of track is 5^0= Tractiveeffort–running resistance–component of force on inclined track

$= 24525 - 9810 - 1000 \times 9.81 \times \sin 5^0$

= 6.16 kN

Q . 1 If the slope of the diagonal of rectangular is m, the slope of the other diagonal is

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

Answer (D)

Solution . We know,

Product of slope of diagonals of rectangular is equal to (-1).

So,

$$m_1 \times m_2 = -1$$

Given that, $m_1 = m$

$$m \times m_2 = -1$$

$$\therefore \quad m_2 = \frac{-1}{m}$$

Q .2 if the rank of the matrix A is r, the rank of the matrix A^T is

(A) r , if and only if $A^T = A$ (B) r , for all A

(C) p , where $p \neq r$ (D) $r - 1$, $where\, r \geq 1$

Answer (D)

Solution .

Suppose, a matrix $(A) = \begin{bmatrix} 1 & 2 & 1 \\ 3 & 2 & 1 \\ 1 & 1 & 2 \end{bmatrix}$

Thus , rank of (A) = 3 , and

Transpose matrix of A matrix is given by-

$$A^T = \begin{bmatrix} 1 & 3 & 1 \\ 2 & 2 & 1 \\ 1 & 1 & 2 \end{bmatrix}$$

Thus , rank of (A^T) = 2

$\therefore$ r-1 , where $r \geq 1$

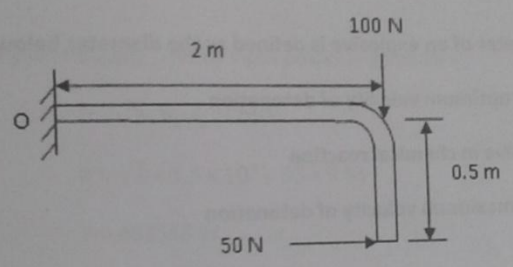
Q.3 Bulk modulus of rock defined as

(A) $\frac{shear\ stress}{volumetric\ strain}$ (B) $\frac{hydrostatic\ pressure}{shear\ strain}$

(C) $\frac{hydrostatic\ pressure}{volumetric\ strain}$ (D) $\frac{shear\ stress}{shear\ strain}$

Answer (C)

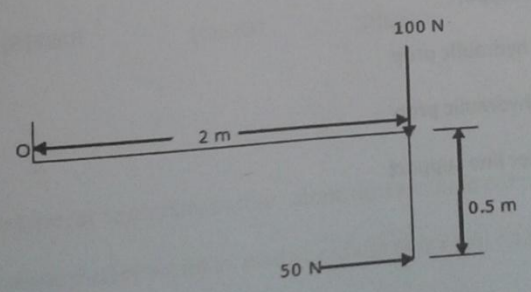
Q.4 The magnitude of the resultant moment about point O in Nm of two forces acting on the rod shown below is



(A) 25 (B)125 (C)175 (D)225

Answer (C)

Solution .



Magnitude of resultant moment about O :-

$M_O = 100\times 2 - 50\times 0.5$

$M_O = 175$ kN.m

Note - clock wise moment is taken (+) and anti clock wise (-)

Q 5. Radial stress on the excavation boundary of circular tunnel is

(A) always zero

(B) always positive

(C) always negative

(D)positive in some area and negative in some area

Answer (A)

Q .6 The critical diameter of an explosive is defined as the diameter below which it

(A) develops the optimum velocity of detonation

(B) does not involve in chemical reaction

(C) develops the maximum velocity of detonation

(D) deflagrates

Answer (D)

Q.7 Which one of the following supports does NOT require a power pack for its operation

(A) chock shield support

(B) open circuit hydraulic prop

(C) close circuit hydraulic prop

(D) Alpine breaker line support

Answer (C)

Q 8. In a centrifugal flow fan the conversion of velocity pressure to static pressure accomplished

with the help of

(A) impeller (B) curved blades

(C) hub (D)casing

Answer (D)

Q 9. A 3.3 kV, 3-phase AC motor having a PF of 0.85 draws current at 95 A . The motor input power in kW is

(A) 266.5 (B) 461.5 (C)543 (D) 799.5

Answer (B)

Solution :-

For three phase supply , motor input power is given by –

$$P = \sqrt{3} . V_L . I_L . \cos\emptyset$$

$$P = \sqrt{3} \times 3.3 \times 10^3 \times 95 \times 0.85$$

$$P = 461548 \text{ W}$$

$$P = 461.5 \text{ KW}$$

Q 10. The amount of total stone dust required in kg for a secondary heavy type stone dust barrier in a roadway of size $4.0\ m \times 3.0\ m$ is

(A) 1320 (B)4680 (C)5200 (D)6600

Answer (B)

Solution .

For heavy type or secondary barrier, stone dust required per m^2 is 390 kg.

So, Total stone dust required in roadway of size (4.0 × 3.0) = 12 × 390 kg = 4680 kg.

Q 11. In the Gaussian plume model, the dispersion coefficient are function of

(A) distance from the source and stability class

(B) stack height and distance from the source

(C) stability class and source coordinates

(D) source coordinates and distance from the source

Answer (A)

Q 12. The rachet-and- pawl arrangement in percussive drill machine helps in

(A) providing required rotational speed

(B) indexing at the bit rock interface

(C)regulating airflow in forward and return strokes of the piston

(D) engaging the bit with the rock between the blows

Answer (B)

Q 13. The measurement of distances from a position on the earth to artificial satellites is known as

(A) astronomical ranging (B) pseudo ranging

(C) satellite ranging (D) celestial ranging

Answer (B)

Q 14. In opencast mining, the width which is extracted from the working bench is termed as

(A) cut (B) bench width (C) bank width (D) bench face

Answer (A)

Q 15. Zener barriers are associated with

(A) increased safety apparatus

(B) statistically safe apparatus

(C) flame proof apparatus

(D) intrinsic safety apparatus

Answer (D)

Q 16. The most recent model of self- contained compressed oxygen breathing apparatus is

(A) Proto-IV (B) BG-174 (C) BG-4 (D) BG-174 A

Answer (C)

Q 17. The measure of dispersion are

(A) range, variance and standard deviation

(B) mean, median and variance

(C) mean, mode and skewness

(D) mean, range and variance

Answer (A)

Q 18. In a single server queueing model with constant arrival rate, which one of the following probability distribution is followed by the inter-arrival times of the costumers at the service facility?

(A) binomial (B) Poisson (C) Weibull (D) exponential

Answer (B)

Q 19. A company invested Rs. 4 lakh in a machine with an expected useful life of 12 years. The net income expected from the operation of the machine is Rs. 80,000 per annum. The payback period of the machine in years is

(A) 4 (B) 5 (C) 6 (D) 7

Answer (B)

Solution .

Machine earned per year = 80,000 rupees.

So, time (T) required to pay 4,00,000 rupees = $\frac{400000}{80000}$, year

T = 5 years.

Q 20. The angular (horizontal/vertical) observation made by a transite theodolite with the face of the vertical circle on the right side of the observer is called

(A) face right observation (B) face left observation

(C) normal observation (D) reciprocal observation

Answer (A)

Q 21. Two sides of a triangle are represented by vectors $a = \hat{\imath} + \hat{\jmath} + \hat{k}$ and $b = -\hat{\imath} - \hat{\jmath} + \hat{k}$. The area (magnitude) of the triangle is

(A) $1/\sqrt{2}$ (B) 1 (C) $\sqrt{2}$ (D) $2\sqrt{2}$

Answer (C)

Solution .

Let, $\vec{a} = \hat{\imath} + \hat{\jmath} + \hat{k}$

$\vec{b} = -\hat{\imath} - \hat{\jmath} + \hat{k}$

Now, $\vec{a} \times \vec{b} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 1 & 1 & 1 \\ -1 & -1 & 1 \end{vmatrix}$

$\vec{a} \times \vec{b} = \hat{\imath}(1+1) - \hat{\jmath}(1+1) + \hat{k}(-1+1)$

$\vec{a} \times \vec{b} = 2\hat{\imath} - 2\hat{\jmath}$

$\therefore$ Area of triangle $(A_T) = \frac{1}{2} |\vec{a} \times \vec{b}|$

$$A_T = \frac{1}{2}|2\hat{i} - 2\hat{j}|$$

$$\therefore \quad A_T = \frac{1}{2}\sqrt{4+4}$$

$$\therefore \quad A_T = \sqrt{2}$$

Q 22. The cost of diesel is Rs. $\left(25 + \frac{x}{90}\right)$ per km to drive a dump truck at a speed of x km/hour. The maintenance cost of the truck is Rs. 10 per hour. To minimize the cost per km, the truck speed in km/hour is

(A) 5 (B) 20 (C) 25 (D) 30

Answer (D)

Solution .

Cost of diesel = Rs. $(25 + \frac{x}{90})$ per km.

Maintenance cost = Rs. 10 per hour

Or maintenance cost = Rs. $\frac{10}{x}$ per Km

So, total cost (c) = $[\,(25 + \frac{x}{90}) + \frac{10}{x}\,]$ per Km

Now,

$$\frac{dc}{dx} = \frac{1}{90} - \frac{10}{x^2}$$

For minimum or maximum, $\frac{dc}{dx} = 0.$

$$\frac{1}{90} - \frac{10}{x^2} = 0$$

$$\frac{10}{x^2} = \frac{1}{90}$$

$$x^2 = 900$$

$$x = \sqrt{900} = 30 \text{ Km per hour}$$

Q 23. The function $f(x)$ and $g(x)$ satisfy $f(x=0) = 3, f'(x=0) = -5, g(x=0) = 2$ and

$g'(x=0) = -10$. The value of $\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right)_{x=0}$ is

(A) -35.0 (B) -5.0 (C) 0.5 (D) 5.0

Answer (D)

Solution .

Given that, $f(x=0) = 3$, $f'(x=0) = -5$, $g(x=0) = 2$ and $g'(x=0) = -10$

The value of –

$$\frac{d}{dx}\left\{\frac{f(x)}{g(x)}\right\}_{x=0} = \frac{\frac{d}{dx}f(x).\ g(x) - \frac{d}{dx}g(x).f(x)}{\{g(x)\}^2}$$

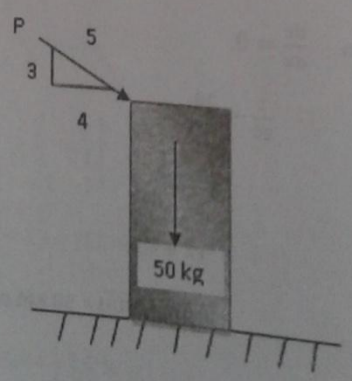
$$= \frac{f'(x).g(x) - g'(x).\ f(x)}{\{g(x)\}^2}$$

$$= \frac{-5\times 2 - (-10)\times 3}{2^2}$$

$$= \frac{-10+30}{4}$$

$$\frac{d}{dx}\left\{\frac{f(x)}{g(x)}\right\}_{x=0} = 5$$

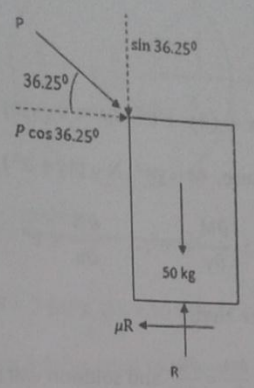
Q.24 **A wooden block of 50 kg rests on the floor (as shown in the figure below) for which the coefficient of friction is 0.5. The smallest magnitude of the force P in kg that will cause impending motion of the block is**



(A) 50 (B) 40 (C) 30 (D) 25

Answer (A)

Solution .



Here ,

$$\tan\theta = \frac{3}{4}$$

$$\theta = \tan^{-1}\frac{3}{4}$$

$$\therefore \quad \theta = 36.25^0$$

$$\text{Now, } \sum H = 0$$

$$P\cos 36.25^0 - \mu R = 0$$

$$\therefore R = \frac{P\cos 3.25^0}{\mu} = \frac{P\cos 36.25^0}{0.5} = 1.6\,P$$

$$\text{And } \sum V = 0$$

$$-P\sin 36.25^0 + R - 50 = 0$$

$$-0.6\,P + 1.6\,P - 50 = 0$$

$$P\,(1.6 - 0.6) = 50$$

$$\therefore \quad P = 50 \text{ kg}$$

Q 25. **The solution of $ye^x dx + (4y + e^x)dy = 0$ for y(0)= -1 is**

(A) $ye^x + 2y^2 - 1 = 0$ **(B) $e^x + xy^2 - 2 = 0$**

(C) $ye^x - y^2 = 0$ (D) $xe^x + y^2 - 1 = 0$

Answer (A)

Solution .

Given that,

$$ye^x.dx + (4y + e^x)dy = 0\ ,\ y(0) = -1$$

Here, $M = ye^x$, $N = (4y + e^x)$

$$\therefore \frac{\partial M}{\partial y} = e^x, \quad \frac{\partial N}{\partial x} = e^x$$

It is seen that,

$\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$ and solution will be

$\int M$(y - constant) dx + $\int N$(term of N not containing x) dy = C

$$\int ye^x dx + \int 4ydy = C$$

$$ye^x + 4\frac{y^2}{2} = C \quad \text{.....(1)}$$

putting $y = -1, x = 0$ in equation (1)

$$\therefore C = 1$$

Therefore from equation (1), solution will be

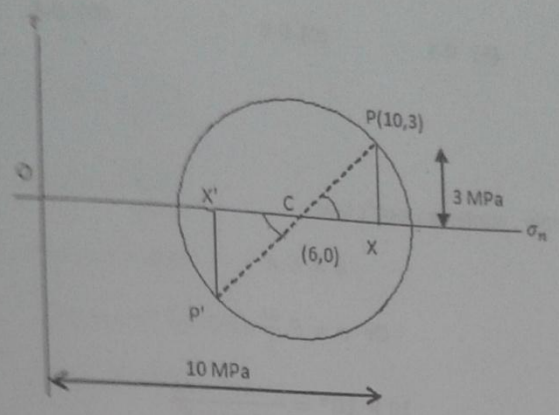
$$ye^x + 2y^2 - 1 = 0$$

Q 26. A point P (10,3) MPa on the Mohr's circle represents normal and shear stresses. If the centre of the Mohr's circle is C (6,0) MPa, the normal and shear stresses in MPa on the point diametrically opposite to P are

(A) (2,−3) (B) (4,−3) (C) (2, 3) (D) (4, 3)

Answer (A)

Solution .



Here , PX = 3 MPa, OX = 10 MPa, OC = 6 MPa

$\therefore P'X' = -3\ MPa$, (due to below of OX'X line)

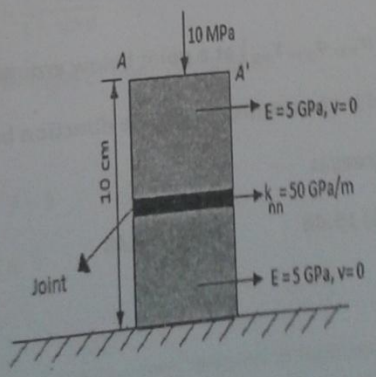
CX = 10 – 6 = 4 MPa

Also CX' = 4 MPa

∴ OX' = 6 – 4 = 2 MPa

So, normal and shear stresses on the point diametrically opposite to P is (2, –3).

Q.27. A rock sample with a horizontal joint is subjected to 10 MPa of normal pressure as shown in the figure. The elastic modulus and Poisson ratio of the rock are 0.5 GPa and 0 respectively. If the normal stiffness (k_{nn}) of the joint is 50 GPa/m, normal displacement of the top of the sample (AA' $line$) in mm is



(A) 0.2 (B) 0.4 (C) 0.6 (D) 0.8

Answer (B)

solution .

For rock sample , applying Hook's law-

$$\sigma = E.\varepsilon$$

$$\text{Or } \sigma = E.\frac{\Delta L}{L}$$

$$10 \times 10^6 = \frac{5 \times 10^9 \times \Delta L}{10 \times 10^{-2}}$$

$$\Delta L = \frac{1}{5 \times 10^3}, m$$

$$\Delta L = 0.2 \text{ mm}$$

For joint,

F = k.x , where x = displacement and k = stiffness;

$$10 \times 10^6 = 50 \times 10^9 \times x$$

$$x = \frac{1}{5 \times 10^3}, m$$

$$x = 0.2 \text{ mm}$$

$\therefore$ Normal displacement (D) = $\Delta L + x$

$$D = 0.2 + 0.2$$

$$D = 0.4 \text{ mm}$$

Q 28. The state of stress $(\sigma_{xx}, \sigma_{yy}, \tau_{xy})$ at a point below ground is found to be $(5, 15, -3)$ MPa. The angle measured in the counter clockwise direction between the x-axis and major principal axis in degrees is

(A) 9.52 (B) 15.48 (C) 150.48 (D) 164.52

Answer (B)

Solution .

We have,

$$\tan 2\alpha = \frac{2\,\tau_{xy}}{\sigma_{yy}-\sigma_{xx}}$$

$$\tan 2\alpha = \frac{-2 \times 3}{15-5}$$

$$\tan 2\alpha = -\,0.6$$

$$2\alpha = \tan^{-1}(-0.6)$$

$$\alpha = 15.48^0$$

Q 29. The unconfined compressive strength of a cylindrical rock sample is 90 MPa. The angle of internal friction of the rock is 30^0. If a confining pressure of 5 MPa is applied radially to the rock sample, the confined compressive strength in MPa is

(A) 92.88 (B) 95.00 (C) 105.00 (D) 110.0

Answer (C)

Solution .

Confined compressive strength (S) of rock sample is given by-

$$S = C_0 + \sigma_1 \tan\beta$$

Where, C_0 = uniaxial compressive strength = 90 MPa

σ_1= confining pressure = 5 MPa, and

$$\tan\beta = \frac{1+\sin\emptyset}{1-\sin\emptyset}$$

[angle β constant, Ø-angle of internal friction]

Therefore,

$$S = 90 + 3 \times 5$$

$$S = 105 \text{ MPa}$$

Q 30. A circular opening of radius a is made underground in hydrostatic condition. The radial

distance from the centre of the opening, where the tangential stress is twice the radial stress , is

(A) a (B) $\sqrt{2}a$ (C) $\sqrt{3}a$ (D) $2\sqrt{3}a$

Answer (C)

Solution .

Radial stress (σ_r)is given by:-

$$\sigma_r = \frac{1}{2}P_z \left\{(1+K)\left(1-\frac{a^2}{r^2}\right) + (1-K)(1-4\frac{a^2}{r^2}+3\frac{a^4}{r^4}\cos 2\theta)\right\}$$

Tangential stress is given by:

$$\sigma_\theta = \frac{1}{2}P_z \left\{(1+K)\left(1+\frac{a^2}{r^2}\right) + (1-K)(1+3\frac{a^4}{r^4})\cos 2\theta\right\}$$

In hydrostatic stress condition-

$$\sigma_x = \sigma_y\,; \quad K = \frac{\sigma_x}{\sigma_y} = 1;$$

But as per given condition:

$$\sigma_\theta = 2\sigma_r$$

$$\therefore \frac{1}{2}P_z \left\{(1+K)\left(1+\frac{a^2}{r^2}\right) + (1-K)\left(1+3\frac{a^4}{r^4}\right)\cos 2\theta\right\} = 2.\frac{1}{2}P_z \left\{(1+K)\left(1-\frac{a^2}{r^2}\right) + (1-K)\left(1-4\frac{a^2}{r^2}+3\frac{a^4}{r^4}\cos 2\theta\right)\right\};$$

Putting K = 1; we get

$$\frac{1}{2}P_z \left\{(1+1)\left(1+\frac{a^2}{r^2}\right)\right\} = 2.\frac{1}{2}P_z \left\{(1+1)\left(1-\frac{a^2}{r^2}\right)\right\}$$

$$\therefore \quad 1+\frac{a^2}{r^2} = 2-\frac{2a^2}{r^2}$$

$$\frac{3a^2}{r^2} = 1$$

$$3a^2 = r^2$$

$$\therefore \quad r = \sqrt{3}.a$$

Q 31. Coal pillar strength is represented by $S = S_1 h^{\alpha} w^{\beta}$, where S_1 =insitu strength of the pillar, h= mining height, and w= pillar width. Two bord and pillar panels are developed in similar geological conditions at depth D_1 and D_2 with mining heights h_1 and h_2 respectively. If the gallery width and the pillar width in both the panels remain the same, the ratio of pillar safety factors, SF_1/SF_2 is

(A) $\left(\frac{h_2}{h_1}\right)^{\alpha} \frac{D_1}{D_2}$ (B) $\left(\frac{h_2}{h_1}\right)^{\alpha} \frac{D_2}{D_1}$ (C) $\left(\frac{h_1}{h_2}\right)^{\alpha} \frac{D_1}{D_2}$ (D) $\left(\frac{h_1}{h_2}\right)^{\alpha} \frac{D_2}{D_1}$

Answer (D)

Solution.

For Panel – I

Strength of pillar = $S_1 \ (h^{\alpha})_1 \ W^{\beta}$

Load acting on pillar = $\gamma \ D_1 \ \frac{(a+b)^2}{a^2}$

$$\therefore FS_1 = \frac{S_1 . (h^{\alpha})_1 . W^{\beta}}{\gamma . \ D_1 . \frac{(a+b)^2}{a^2}} \quad \text{.....(1)}$$

For Panel – II

Strength of pillar = $S_1 \ (h^{\alpha})_2 W^{\beta}$

Load acting on pillar = $\gamma \ D_2 \ \frac{(a+b)^2}{a^2}$

$$\therefore FS_2 = \frac{S_1 . (h^{\alpha})_2 . W^{\beta}}{\gamma . \ D_2 . \frac{(a+b)^2}{a^2}} \quad \text{.....(2)}$$

From equation (1) & (2)

$$\frac{FS_1}{FS_2} = \frac{\frac{S_1 . (h^{\alpha})_1 . W^{\beta}}{\gamma . \ D_1 . \frac{(a+b)^2}{a^2}}}{\frac{S_1 . (h^{\alpha})_2 . W^{\beta}}{\gamma . \ D_2 . \frac{(a+b)^2}{a^2}}}$$

$$\frac{FS_1}{FS_2} = \left(\frac{h_1}{h_2}\right)^{\alpha} . \frac{D_2}{D_1}$$

Q 32. Match the following

Belt conveyor component	Function
P. Pull cord	1. Cleaning device
Q. Snub pulley	2. Discharging material on the side of the conveyor
R. Tripper	3. Safety stopping device
S. rotary brush	4. Increasing the angle of wrap

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

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

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

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

Answer (D)

Q 33. Match the following

Equipment	Action /Purpose
P. Dragline	1.Reaming
Q. Bucket wheel excavator	2. Key cut
R. Tunnel Boring Machine	3. Pulsating impact
S. Hydraulic monitor	4. Terracing

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

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

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

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

Answer (B)

Q 34. Match the following

Mining method	Face supporting system
P. Mechanizwd longwall	1. Cable bolting

Q. Blasting gallery

R. Steep seam mechanized longwall

S. Wangawilli

2. Shield type powered support

3. Alpine breaker line supports

4. Troika shield supports

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

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

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

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

Answer (B)

Q 35. A 15 yd^3 dragline is deployed in an overburden bench of an opencast mine. It works for 40 days at the rate of 6 hours per shift and 3 shifts a day. The cycle time, bucket fill factor, and operating efficiency of the dragline are respectively 50 s, 0.8, and 75%. The total volume of overburden in m^3 handled by the dragline is

$(1yd^3 = 0.765\ m^3)$

(A) 356918 (B) 634521 (C) 557685 (D) 991440

Answer (A)

Solution .

Total volume (A_m) handled by dragline is given by:-

$$A_m = \frac{3600 \times C_b \times F \times \alpha \times \eta}{t \times S},\ m^3/h$$

Where, $C_b =$ size of bucket in m^3 = 15 × 0.765 = 11.475 m^3

F = fill factor = 0.8

t = cycle time in seconds = 50 seconds

η = operating efficiency = 0.75

$$A_m = \frac{3600 \times 11.475 \times 0.8 \times 0.75}{50}$$

$$A_m = 495.72\ m^3/h$$

$$A_m = 495.72 \times 40 \times 3 \times 6 = 356918\ m^3$$

Q 36. The phenomenon of fretting (necking) of pillar in room and pillar stoping is common in the pillars formed in

(A) massive rock with very high pillar height to width ratio

(B) regularly jointed rock with high pillar height to width ratio

(C) massive rock with low pillar height to width ratio

(D) transversely jointed rock with low pillar height to width ratio

Answer (B)

Q 37. In an underground opening , the immediate roof strata consists of two rock layers with the following properties:

Property	Layer-I	Layer-II
Modulus of elasticity (GPa)	60	40
Modulus of rupture (MPa)	20	10
Unit weight (kN/m^3)	25	20
Thickness (m)	5	2.5

Considering a factor of safety of 4.0. the length of safe span in m is

(A) 27.82 (B) 34.06 (C) 36.54 (D) 39.34

Answer (B)

Solution .

We have,

$$L = \sqrt{\frac{2 \cdot R_0 \cdot t}{\gamma \cdot F_s}}, \text{m}$$

Where, L= length of the safe span in m

t = thickness in m

F_s = factor of safety = 4

γ = unit weight in kN/m^3

R_0 = modulus of rupture in MPa

Here, t = $\frac{t_1 + t_2}{2} = \frac{5 + 2.5}{2}$ = 3.75 m

$$\gamma = \frac{E_1 (t^2)_1 (\gamma_1 t_1 + \gamma_2 t_2)}{E_1 (t^3)_1 + E_2 (t^3)_2}$$

$$\gamma = \frac{60 \times 10^9 \times 5^2 [25 \times 10^3 \times 5 + 20 \times 10^3 \times 2.5]}{60 \times 10^9 \times 5^3 + 40 \times 10^9 \times 2.5^3}$$

$\therefore$ γ = 32.30 kN/m^3

And R_0 = 20 MPa = 20 × 10^3 kpa

$$\therefore \quad L = \sqrt{\frac{2 \times 20 \times 10^3 \times 3.75}{32.30 \times 4}}$$

$\therefore$ L = 34.07 m

Q 38. In an opencast mine, a centrifugal pump is required to lift water at a rate of 60 l/s to a height of 80 m above the pump level. The vertical suction head is 4 m. The total friction head including shock and energy loss is 10 m. If the pump runs at an efficiency of 80%, the brake power of motor in kW is

(A) 70.50 **(B) 67.50** **(C) 63.00** **(D) 57.55**

Answer (A)

Solution :-

Input power to motor = $\frac{P \times Q \times 10^{-3}}{pump\ efficiency}$, kw

P = pump pressure = $\rho . g . h$ = 1000 × 9.81 × (10 + 4 + 80) = 922140 Pa

Q = 60 l/s = 60× 10^{-3} m^3/s

$\therefore$ Input power (P) to motor = $\frac{922140 \times 60 \times 10^{-3} \times 10^{-3}}{0.80}$ kW

P = 69.2 kW

Q 39. Match the following

Support system	support principle
P. shotcrete	1. Reinforces rock mass by binding them together
Q. Backfill	2. Acts as link between two layers of rock to transfer load between them
R. Bolt	3. Imposes kinematics constraints on key pieces in a stope boundary
S. Prop	4. Prevents spatially progressive disintegration of near field rock mass

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

(B) P-2, Q-1, R-4, S-2

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

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

Answer (C)

Q 40. Match the following

Stope	Drill machine	Method of drilling
P. Shrinkage	I. Drill jumbo	1. Fan drilling
Q. Room-and-pillar	J. Down-the-hole-hammer	2. Overhand drilling
R. Sublevel	K. Hand held stopper	3.Parallel drilling
S. Sublevel caving	L. Mechanized fan drill	4. Frontal vertical/downward benching

(A) P-I-2, Q-K-4, R-L-3, S-J-1

(B) P-K-4, Q-I-3, R-J-2, S-L-1

(C) P-K-2, Q-I-4, R-J-3, S-L-1

(D) P-I-3, Q-K-4, R-J-1, S-L-2

Answer (C)

Q41. A coal seam of 12 m thickness is worked out by mechanized top coal caving syetem. The thickness of the bottom slice is 3 m, length of solid coal face is 120 m and the average depth of cut by the shearer (web) is 70 cm. The density of coal is 1300 kg/m^3 with the percentage of extraction in the slice at 95 and in the top coal at 70. The production of coal per cycle in tonne is

(A) 1008 (B) 999 (C) 688 (D) 311

Answer (B)

Solution .

$$\text{Production of coal in the slice} = \frac{3 \times 120 \times 0.7 \times 0.95 \times 1300}{1000}$$

$$= 311.22 \text{ tonnes}$$

$$\text{And production of coal in the top} = \frac{(12-3) \times 120 \times 0.7 \times 0.7 \times 1300}{1000}$$

$$= 687.96 \text{ tonne}$$

$$\therefore \text{Production of coal per cycle} = 311.22 + 687.96$$

$$= 999.18 \text{ tonne}$$

Q 42. Two reservoirs are connected by two equal length parallel pipe lines with diameter d and 2d. assuming similar resistance coefficient, if the discharge through the smaller diameter pipeline is 0.04 m^3/s, the discharge through the other pipelines in m^3/s is

(A) 0.226 (B) 0.426 (C) 1.130 (D) 1.280

Answer (A)

Solution.

We know,

$$\text{Pressure drop (P)} = \frac{K\,S\,Q^2}{A^3}$$

Or $P = \frac{K(\pi D L)Q^2}{\left(\frac{\pi D^2}{4}\right)^3}$

$\therefore \quad P = \frac{64 K L Q^2}{\pi^2 D^5}$

If P, K & L constant, then

$$Q^2 \propto Q^5$$

Or $\frac{(Q^2)_1}{(Q^2)_2} = \frac{(D^5)_1}{(D^5)_2}$

Or $Q_2 = Q_1 \times \sqrt{\left(\frac{D_2}{D_1}\right)^5}$

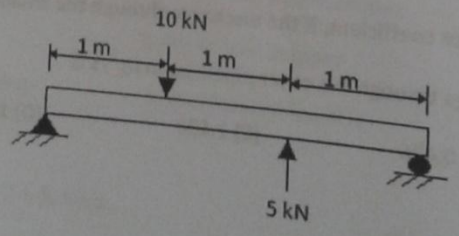
Now, putting $Q_1 = 0.04\ m^3/s$, $D_1 = d$, $D_2 = 2d$

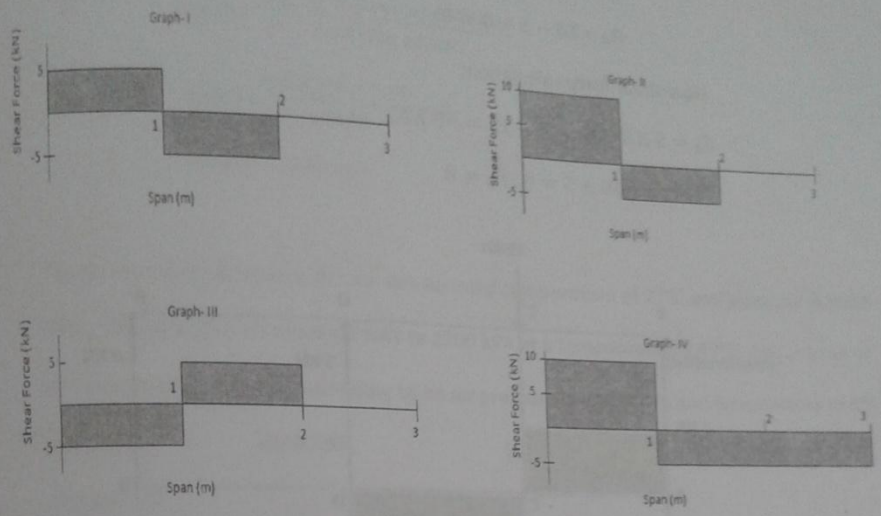
$$Q_2 = 0.04 \times \sqrt{\left(\frac{2d}{d}\right)^5}$$

$$Q_2 = 0.04 \times \sqrt{2^5}$$

$$Q_2 = 0.226\ m^3/s$$

Q 43. The shear force diagram for the shaft shown below resembles which one of the following graphs?

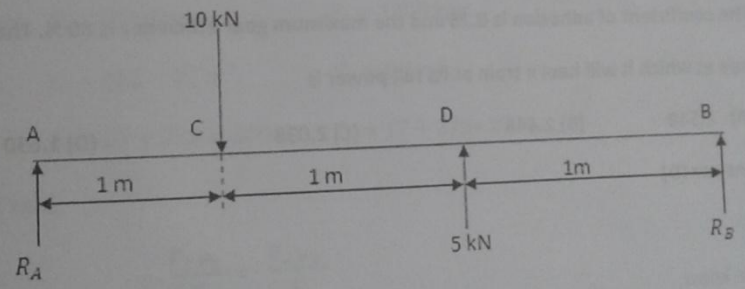




(A) Graph-I (B) Graph-II (C) Graph-III (D) Graph-I V

Answer (A)

Solution .



Now , $\sum M_B = 0$

$$R_A \times 3 - 10 \times 2 + 5 \times 1 = 0$$

$$\therefore R_A = \frac{20-5}{3} = 5 \text{ KN}$$

Now, $\sum V = 0$

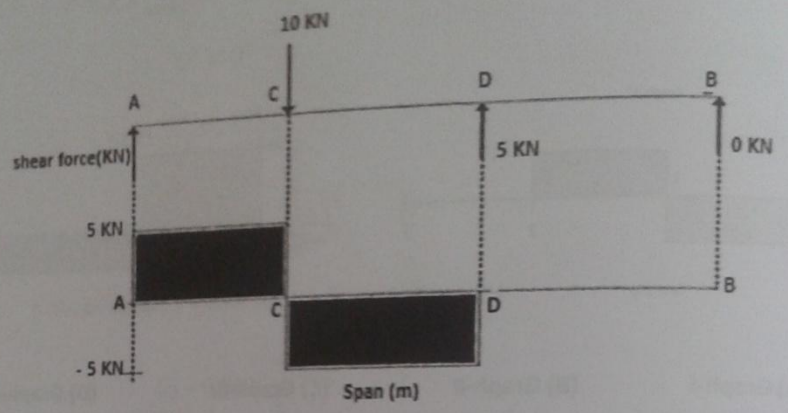
$$R_A + R_B - 10 + 5 = 0$$

$$R_B = 10 - 5 - 5 = 0$$

Now shear force calculation:

$$F_A = 5\ KN\ ,\ F_C = 5 - 10 = -5\ KN$$

$$F_D = 5 - 10 + 5 = 0,\ F_B = 0$$



Q 44. A 12 tonne diesel locomotive of 60 kW is employing in an underground haulage roadway. The coefficient of adhesion is 0.25 and the maximum gear efficiency is 80 %. The speed in m/s at which it will haul a train at its full power is

(A) 2.548 (B) 2.448 (C) 2.038 (D) 1.630

Answer (D)

Solution :

We know,

Tractive effort = coefficient of adhesion × mass

$= 0.25 \times 12 \times 1000 \times 9.81$

$= 29430$ N

Now,

$$\text{Power} = \frac{tractive\ effort \times speed}{gear\ efficiency}$$

Or $\quad$ Speed = $\frac{power \times gear\ efficiency}{tractive\ effort}$

$\therefore$ $\quad$ Speed = $\frac{60 \times 10^3 \times 0.80}{29430}$,m/s

$\therefore$ $\quad$ Speed = 1.630 m/s

Q 45. **An air reservoir of volume 0.2 m^3 has an intial temperature of 27°C and pressure of 1800 kPa. After use, the air pressure falls to 1200 kPa at a temperature of 17°C. The volume of air consumed in m^3 corresponding to an air pressure of 101.3 kPa and temperature of 0°C is**

(A) 0.693 $\quad$ **(B) 0.895** $\quad$ **(C) 1.002** $\quad$ **(D) 1.251**

Answer (C)

Solution .

Let V is the volume of air used at 1800 kpa and 27°C

$\therefore$ (0.2 – V) volume of air remaining in the receiver.

Here, P_1 = 1800 kpa, $\quad$ $P_2 = 1200\ kpa$

$V_1 = (0.2 - V)\ m^3$, $\quad$ $V_2 = 0.2\ m^3$

$T_1 = 27 + 273 = 300k$, $\quad$ $T_2 = 17 + 273 = 290$ k

We have,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{1800 \times (0.2 - V)}{300} = \frac{1200 \times 0.2}{290}$$

$\therefore$ V = 0.0620 m^3

Now, $\frac{P\ V}{T} = \frac{P_S V_S}{T_S}$

Here, P = 1800 kpa ; $\quad$ P_S = 101.3 kpa

T = 300 k ; $\quad$ T_S = 273 k

$V = 0.0620\ m^3$; $V_s = ?$

$$\therefore \frac{180 \times 0.0620}{300} = \frac{101.3 \times V_s}{273}$$

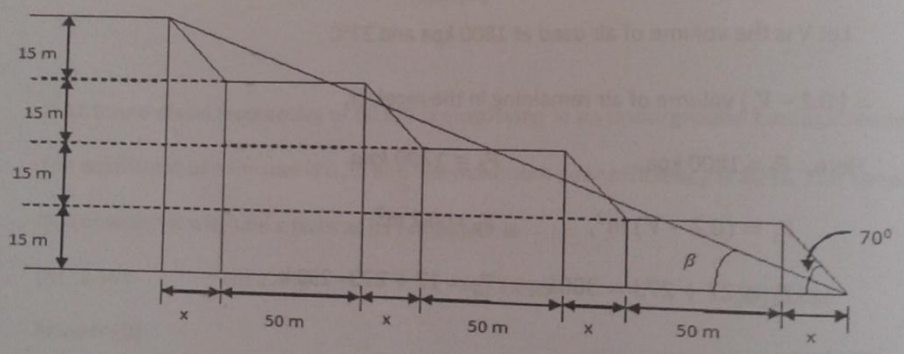
$$\therefore V_s = 1.002\ m^3$$

Q 46. Four benches are being worked by the opencast mining system. Height, width and face angle for each bench are 15 m, 50 m and 70^0 respectively. The overall slope angles of the benches in degrees is

(A) 15.45 (B) 19.25 (C) 32.65 (D) 36.25

Answer (B)

Solution .



Where, β *is* overall slope angle

Now, $\tan 70^0 = \frac{H}{x}$

Or $x = \frac{15}{\tan 70^0} = 5.46\ m$

And $\tan\beta = \frac{15\times4}{5.46\times4+50\times3}$

$\therefore \beta = 19.25^0$

Q 47. Match the following

Rock mass condition	Shaft sinking method	Limiting depth (m)
P. Water bearing strata of Loose sand or gravel	I. Freezing	1. 40
Q. Competent rock with Fissures and cracks filled With water	J. Depression of ground water level	2. 150
R. highly permeable coarse Solid or gravel with heavy water flow	K. Cement grouting	3. 1000
S. All types of water bearing rocks	L. Caisson	4. > 600

(A) P-L-4, Q-K-1, R-J-2, S-I-3

(B) P-L-1, Q-K-4, R-J-2, S-I-3

(C) P-L-2, Q-K-4, R-J-3, S-I-1

(D) P-L-4, Q-K-3, R-J-2, S-I-1

Answer (B)

Q 48. Match the following

System	device/Safety device
P. Drum winding	1. Taper guide
Q. Koepe winding	2. Detaching safety hook
R. Inclined Haulage	3. Rider
S. Winding in sinking shaft	4.Back catch

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

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

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

(C) P-4, Q-1, R-3, S-4

Answer (B)

Q 49. A closed container with 10 kg of air at ambient pressure and specific heat 1024 J/kg°C is cooled from 35°C. If the removal of 200 kJ of heat resulted in the saturation of air, the corresponding dew point temperature in °C is

(A) 33.0 (B) 27.3 (C)15.4 (D)12.6

Answer (C)

Solution :

We have,

$$H = Q.S.\Delta t$$

And given that, $H = 200kJ = 200 \times 10^3$ J

$Q = 10$ kg

$S = 1024$ J/kg°C

So,

$$200 \times 10^3 = 10 \times 1024 \times \Delta t$$

$$\therefore \Delta t = \frac{200 \times 10^3}{10 \times 1024}$$

$$\therefore \Delta t = 19.6°C$$

∴ dew point temperature(T) is :

$$T = 35°C - 19.6°C$$

$$T = 15.4°C$$

Q 50. Identify the INCORRECT statement

(A) Evasee is meant to minimise exit shock loss

(B) Evasee efficiency is primarily a function of divergence angle and area ratio

(C) Evasee produces an inevitable in friction losses

(D) Evasee installation leads to reduction in the fan total pressure

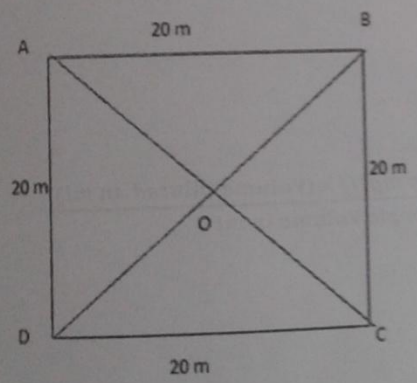
Answer (D)

Q 51. A single lamp placed centrally at the roof provides 40 lux illumination vertically below, at the floor of an underground workshop. The workshop is of dimensions $20\ m \times 20\ m$ with height 4 m. Assuming uniform spherical dispersion of luminous intensity, the floor level illumination in lux at any corner of the workshop is

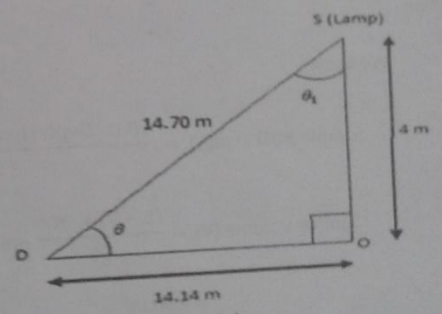
(A) 23.2 (B) 10.9 (C) 3.0 (D) 0.8

Answer (D)

Solution .



Top view



Sectional view

By calculation, we find that,

BD = 28.29 m, DO = OB = 14.14 m

And $\theta = \tan^{-1}\frac{4}{14.14} = 15.80^0$

Also, $\theta_1 = 180^0 - 15.80^0 - 90^0 = 74.25^0$

We know,

Illumination at point = (candle of source) $\times \frac{\cos\theta_1}{(distance)^2}$

Here, candle of source = 40 lux = $40 \times 4 \times 4 = 640$ lumens

$\therefore$ illumination at corner point D is = $\frac{640 \times \cos 74.25^0}{14.70^2} = 0.8$ lux

Q 52. An effluent sample is diluted with fresh water to make a solution of 300 ml. The DO of the solution initially is 8.0 mg/l and the value falls to 3.0 mg/l after 5 days. If the 5-day BOD of the original effluent is known to be 50 mg/l, the amount of fresh water added in ml to the solution is

(A) 270 (B) 160 (C) 54 (D)30

Answer (A)

Solution .

We know,

Sample BOD in mg/L = $\frac{(D.O.\ Depletion\ in\ mg/l) \times (Volume\ Diluted\ \ in\ ml)}{Sample\ Volume\ in\ ml}$

$\therefore$ Sample Volume (V) = $\frac{(8-3) \times 300}{50}$,ml

$\therefore$ V = 30 ml

Therefore ,

Amount of fresh water (V') added to the solution in ml = ($300 - 30$) ml

$V' = 270$ ml

Q 53. With respect to stack emission the phenomenon of fumigation is noticed in case of

(A) Atmospheric lapse rate being lower than the adiabatic lapse rate

(B) Atmospheric lapse rate being higher than the adiabatic lapse rate

(C)Temperature inversion in the atmosphere above the stack height

(D)Temperature inversion in the atmosphere below the stack height

Answer (C)

Q 54. At a fan pressure of 450 Pa , 50 m^3/s of air flows through a mine. When fan stops, 10 m^3/s of air still flows in the same direction. The mine resistance in Ns^2m^{-8} is

(A) 0.1731 (B) 0.1800 (C) 0.1875 (D) 0.2372

Answer (C)

Solution .

When fan running

$(450 + N) = R \times 50^2$ $[P = RQ^2]$

Or $R = \frac{450 + N}{50^2}$ .....(1)

And when fan stopped

$N = R_1 \times 10^2$ [N = N.V.P]

Or $R_1 = \frac{N}{10^2}$ .....(2)

Resistance of the mine is same whether fan is running or stopped

$\therefore$ $R = R_1$

$\frac{450 + N}{50^2} = \frac{N}{10^2}$

$\therefore$ N = 18.75 Pa

From equation (1)

$R = \frac{450 + 18.75}{2500}$

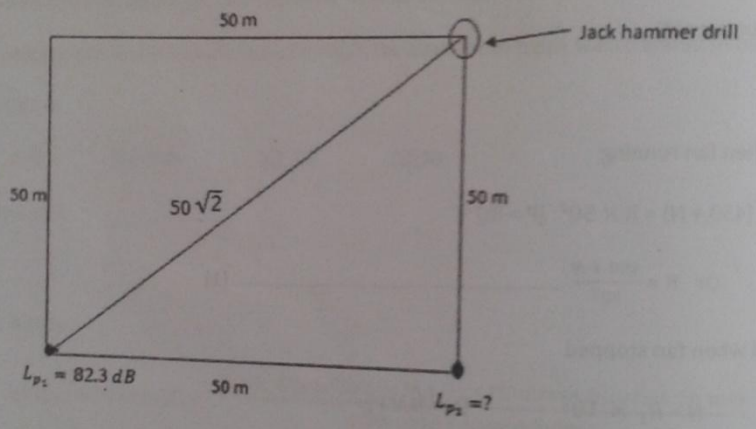
$R = 0.1875\ Ns^2m^{-8}$

Q 55. A jackhammer operates at a corner of a square field of side 50 m. At the diagonally opposite corner , the SPL sensed is 82.3 dB. The SPL at any of the other two corners of the field in dB is

(A) 86.3 (B) 85.3 (C) 83.6 (D) 81.2

Answer (B)

Solution .



If the sound pressure level , L_{p_1} , in dB is known at a distance r_1(m) from a point source, the sound pressure level, L_{p_2} , in dB at a distance r_2(m) from the same source can be calculated using the relationship : -

$$L_{p_2} = L_{p_1} - 20\ \log\left(\frac{r_2}{r_1}\right)$$

$$\therefore \quad L_{p_2} = 82.3 - 20\ \log\left(\frac{50}{50\sqrt{2}}\right)$$

$$\therefore \quad L_{p_2} = 85.3\ \text{dB}$$

Q 56. Consider the following data for the grade of iron ore from a working bench over past 5 weeks

Week	1	2	3	4	5
Grade (%)	62.1	61.0	60.5	62.5	62.0

The 3 - week moving average forecast for the grade , in % Fe , in the 6th week is

(A) 61.66 (B) 61.90 (c) 62.20 (D) 62.50

Answer (A)

Solution -

The 3- week moving average forecast for the grade (G), in the 6th week is:

$$G = \frac{0.62 + 0.625 + 0.605}{3}$$

$$G = 0.6166$$

$$G = 61.66\ \%$$

Q 57. The random variable X has the following probability mass fnction

$P(4) = \frac{1}{4}$, $P(8) = \frac{1}{4}$, $P(12) = \frac{1}{4}$, $P(16) = \frac{1}{4}$

The expected value of X

(A) 1 (B) 3 (C) 10 (D) 12

Answer (C)

Solution .

Suppose random variable X can take value x_1 with probability P_1 , value x_2 with probability P_2 and so on, then expectation of random variable X is defined as –

$$E[X] = x_1 P_1 + x_2 P_2 + x_3 P_3 + \ldots\ldots$$

$$\therefore E[X] = 4 \times \frac{1}{4} + 8 \times \frac{1}{4} + 12 \times \frac{1}{4} + 16 \times \frac{1}{4}$$

$\therefore$ E[X] = 10

Q.58. The time between successive failure (in hours) of a side discharge loader operating in a mechanized underground coal mine are as follow

62 , 58 , 54 , 50 , 52 , 60 , 58 , 57 , 50 , 53

If the failure data follows an exponential distribution, then reliability of the equipment for a period of 50 hours s

(A) 0.25 (B) 0.40 (C) 0.60 (D) 1.00

Answer (B)

Solution .

Mean time between failure (m) = $\frac{62+58+54+50+52+60+58+57+50+53}{10}$

m = 55.4 hours

Reliability of the equipment run for a period of t hours is given by:

$$R(t) = e^{\frac{-t}{m}}$$

Here, t = 50 hours and m = 55.4 hours

$\therefore$ $R(t) = e^{\frac{-50}{55.4}}$

$\therefore$ R(t) = 0.40

Q.59. Three jobs A,B and C are to be assigned to three machines X, Y and Z. The processing costs are given below

		Machine		
		X	Y	Z
	A	19	28	31
Job	B	11	17	16
	C	12	15	13

The minimum cost of assigning the jobs to the machine is

(A) 60 **(B) 54** **(C) 51** **(D) 49**

Answer (D)

Solution .

		Machine		
		X	Y	Z
	A	0	9	12
Job	B	0	6	5
	C	0	3	1

Machine

Job	X	Y	Z
A	0	6	11
B	0	3	4
C	0	11	0

Machine

Job	X	Y	Z
A	0	3	8
B	0	0	1
C	0	0	0

∴ Minimum total cost of assigning the job to the machine is : 19 +17+ 13 = 49

Q.60 An underground coal mine employing 1200 persons experienced 12 roof fall injuries during the year 2005. The roof fall injury rate per 1000 persons employed during the period 2005, as per the DGMS norms, is

(A) 6 (B) 8 (C) 10 (D) 12

Answer (C)

Solution.

Roof fall injury rate per 1000 persons employed = $\frac{12}{1200} \times 1000$

= 10

Q 61. Consider the following linear programming problem:

Maximize $Z = 6X_1 + 4X_2$

Subject to $2X_1 \leq 8$

$2X_2 \leq 12$

$3X_1 + 2X_2 \leq 18$

$X_1 \geq 0, X_2 \geq 0$

The multiple optimal solutions lie on the line joining the corner points

(A) (0, 0),(0, 6) (B) (0, 6),(2, 6) (C) (2, 6),(4, 3) (D) (4, 3),(4, 0)

Answer (C)

Solution .

Multiple optimal solution – linear programming having more than one such point give maximum value among all remaining points.

Here, points (2, 6), (4, 3) give multiple optimal solution i.e.

When (2,6), $Z_1 = 6 \times 2 + 4 \times 6 = 36$

And when (4,3), $Z_2 = 6 \times 4 + 4 \times 2 = 36$

$\therefore \quad Z_1 = Z_2 = 36$

Q 62. . Match the following

Problem	Technique
P. Queueing	1. Time series models
Q. Project scheduling and monitoring	2.Linear programming models
R. Transportation	3. Waiting line models
S. Forecasting of production	4.PERT and CPM

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

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

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

Answer (A)

Q 63. The net present value in Rs. of a 3 – year annuity of Rs. 10,000 discounted at 10% is

(A) 9,091 (B) 17,355 (C) 24,869 (D) 26,446

Answer (C)

Solution .

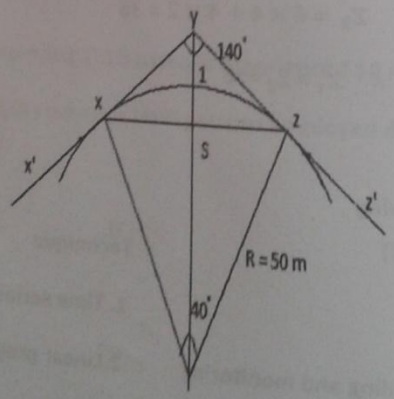
We have,

$$\text{Net present value} = \frac{R_1}{(1+i)} + \frac{R_2}{(1+i)^2} + \cdots + \frac{R_n}{(1+i)^n}$$

$$\text{NPV} = \frac{10000}{(1+0.1)} + \frac{10000}{(1+0.1)^2} + \frac{10000}{(1+0.1)^3}$$

NPV = 24869 rupees

Q 64. For a track gauge of 1.05 m and a speed of 10 km/hour, the super-elevation in cm from the following figure is



(A) 1.65 (B) 2.76 (C) 5.54 (D)6.64

Answer (A)

Solution .

We have,

$$\text{Super elevation (E)} = \frac{a \cdot v^2}{g \cdot r} \text{ m}$$

Given that, a = 1.05 m, v = 10 km =2.8m/s,

r = 50 m, g = 9.81 m/s^2

$$E = \frac{1.05 \times 2.8^2}{9.81 \times 50}, \text{ m}$$

E = 0.0167 m

E = 1.67 cm

Q 65. **In the bubble tube of a dumpy level, the bubble moves 5 mm for a change of inclination of 40''. The sensitivity in mm and the radius of the bubble tube in m are (1 radian= 206265'')**

(A) 0.125, 12.89 (B) 0.063, 26.78 (C) 0.125, 25.78 (D) 0.063, 12.89

Answer (C)

Solution .

Since , 40'' = 5 mm

$$1'' = \frac{5}{40} \text{ mm}$$

1'' = 0.125 mm

Sensitivity of the dumpy level = 0.125 mm

And we have

$$\alpha = \frac{n}{R}$$

Or $$R = \frac{n}{\alpha}$$

$$R = \frac{5 \times 206265}{40}, \text{ mm}$$

$$R = \frac{5 \times 206265}{40 \times 1000}, \text{ mm}$$

$\therefore \quad R = 25.78$ m

Q 66. The value of $A.B$, if $A+B=\begin{bmatrix}1 & -1\\3 & 0\end{bmatrix}$ and $A-B=\begin{bmatrix}3 & 1\\1 & 4\end{bmatrix}$, is

(A) $-4\begin{bmatrix}1 & 1\\0 & 3\end{bmatrix}$ (B) $-2\begin{bmatrix}1 & 1\\0 & 3\end{bmatrix}$

(C) $\begin{bmatrix}1 & 1\\0 & 3\end{bmatrix}$ (D) $-\frac{1}{2}\begin{bmatrix}1 & 1\\0 & 3\end{bmatrix}$

Answer (B)

Solution .

$$A+B=\begin{bmatrix}1 & -1\\-3 & 0\end{bmatrix} \text{.....(1)}$$

$$A-B=\begin{bmatrix}3 & 1\\1 & 4\end{bmatrix} \text{.....(2)}$$

Solving (1) & (2), it is found that

$$A=\begin{bmatrix}2 & 0\\2 & 2\end{bmatrix} \quad \& \quad B=\begin{bmatrix}-1 & -1\\1 & -2\end{bmatrix}$$

Now, $$A.B = \begin{bmatrix}2 & 0\\2 & 2\end{bmatrix}.\begin{bmatrix}-1 & -1\\1 & -2\end{bmatrix}$$

$$A.B=\begin{bmatrix}-2+0\times 1 & -2+(-2)\times 0\\-2+2 & -2-4\end{bmatrix}$$

$$\therefore \quad A.B = -2\begin{bmatrix}1 & 1\\0 & 3\end{bmatrix}$$

Q 67. The values of $f(x)$ at x_0, x_1 and x_2 are 9.0, 12.0 and 15.0 respectively. Using the Simpson's 1/3 rule, the value of $\int_{x_0}^{x_1} f(x)$, considering an interval of 0.1 is

(A) 1.2 (B) 2.4 (C) 1.6 (D) 1.8

Answer (B)

Solution .

Simpson's 1/3 rule,

$$\int_{x_0}^{x_0+nh} f(x)\ dx = \frac{h}{3}\ [(y_0 + y_n) + 4\ (y_1 + y_3 + \cdots + y_{n-1}) + 2\ (y_2 + y_4 + \cdots + y_{n-2})]$$

Given that, $h = 0.1, x_0 = 9, x_1 = 12, x_2 = 15;$

$$\int_{x_0}^{x_2} f(x)\ dx = \frac{0.1}{3}\ [9 + 15 + 4 \times 12]$$

$$\therefore \quad \int_{x_0}^{x_2} f(x)\ dx = 2.4$$

Q 68. **From the following page of the leveling field book, the missing values in F.S. and B.S. respectively**

Station	B.S.	I.S.	F.S.	Rise	Fall	Remarks
1.	4.550					Starting point
2.	2.125		?		0.750	Change point
3.		2.225				
4.	?		1.975			Change point
5.		2.445		1.500		

(A) 3.804, 0.945 **(B) 3.804, 3.945** **(C) 5.300,0.945** **(D) 5.300,3.945**

Answer (D)

Solution .

$\therefore$ Fore Sight = back sight + fall

= 4.550 + 0.750

= 5.300

And Back Sight = intermediate reading + rise

= 2.445 + 1.500

= 3.945

Station	B.S	I.S	F.S	Rise	Fall	Remarks
1.	4.550					starting point
2.	2.125		5.300		0.750	change point
3.		2.225				
4.	3.945		1.975			change point
5.		2.445		1.500		

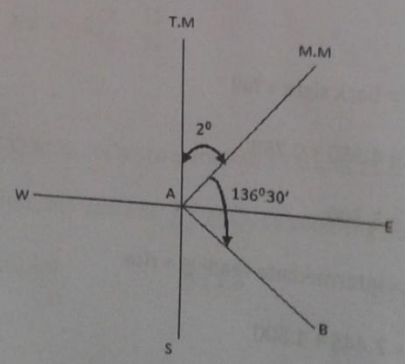
Q 69. The magnetic bearing and declination of a line were recorded in the year 1906 as $S48^0 30'E$ and $2^0 00'E$ respectively. If the declination in the year 2006 is $3^0 00W$, the magnetic bearing of the line is

(A) $S48^0 30'E$ (B) $S45^0 30'E$ (C) $S41^0 30'E$ (D) $S38^0 30'E$

Answer (D)

Solution .

In the year 1906 -



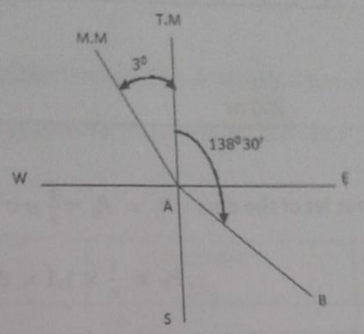
Magnetic bearing of line (AB) = S $40^0 30'$E

= $136^0 30' 0''$

Declination = $2^0 0' 0''$E

True bearing of line (AB) = $136^0 30' 0'' + 2^0 0' 0'' = 138^0 30' 0''$

In the year 2006 -



Magnetic bearing of line (AB) = $138^0 30' 0'' + 3^0 = 141^0 30' 0''$

= S $38^0 30'$ E

<u>Common Data for Questions 70 ,71,72 :-</u>

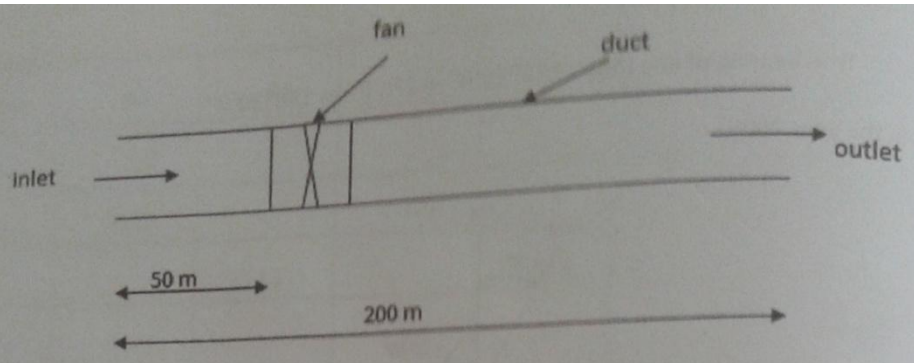
In a straight duct of length 200 m a fan operates 50 m away from the inlet such that the mean air velocity in the duct is 8 m/sec at a density of 1.1 kg/m^3. The friction pressure loss per m length of the duct is 3.0 Pa and the entry shock factor is 1.2. Answer the following in terms of gauge pressure values in Pa

Q 70. The total pressure at the outlet of the duct is

(A) −35.2 (B) 35.2 (C) 192.2 (D) 635.2

Answer (B)

Solution .



Total pressure at the out let of the duct = $P_T = P_v = \frac{1}{2}\rho v^2$

$$P_T = \frac{1}{2} \times 1.1 \times 8^2$$

$$\therefore \quad P_T = 35.2\ Pa$$

Q 71. **The total pressure at the inlet side of the fan is**

(A) – 192.2 **(B) –150.0** **(C) 150.0** **(D) 192.2**

Answer (A)

Solution .

Total pressure(P′) at inlet side of the fan = –[shock pressure + friction pressure]

P′ = –[shock factor × velocity pressure + friction pressure]

$$P' = -[1.2 \times 35.2 + 3 \times 50]$$

P′ = –192.24 Pa

Q 72. **The total pressure generated by the fan is**

(A) 600 **(B) 635.2** **(C) 677.4** **(D)682.2**

Answer (C)

Solution .

Total pressure (P'')generated by fan = velocity pressure + shock pressure + friction pressure

$$P'' = 35.2 + 1.2 \times 35.2 + 200 \times 3$$

$$P'' = 677.44 \text{ Pa}$$

Common data for Questions 73,74 : A bauxite deposit has been intersected by 5 drill holes. The values of alumina (% by weight) and silica (% by weight) in these holes are as follows:

Drill hole number	Alumina (%)	Silica (%)
1	46	1
2	42	5
3	45	2
4	43	4
5	44	3

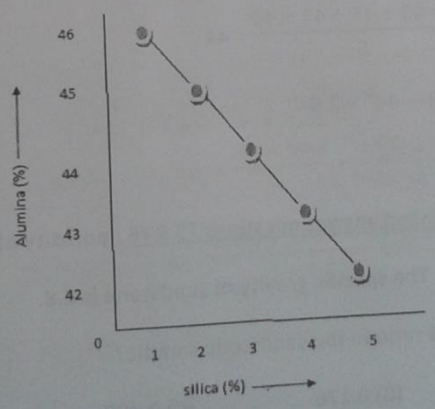
Q 73. The relationship between alumina and silica is

(A) positive linear **(B) exponential**

(C)negative linear **(D) random**

Answer (C)

Solution.



∴ Relationship between alumina and silica is negative linear

Q 74. The unbiased estimate of variance of alumina and silica $(\%)^2$ respectively are:

(A) 2.5, 2.5 (B) 2.0, 2.5 (C) 2.5, 2.0 (D) 2.0, 2.0

Answer (D)

Solution .

We know,

Variance of random variable X ia given by :

$$\text{Var } (X) = E[X^2] - (E[X])^2$$

For silica;

$$E[X^2] = \frac{1^2+5^2+2^2+4^2+3^2}{5} = 11$$

$$E[X] = \frac{1+5+2+4+3}{5} = 3$$

$$\therefore \text{Var } (X) = 11-3^2 = 2.0$$

For alumina;

$$E[X^2] = \frac{46^2+42^2+45^2+43^2+44^2}{5} = 1938$$

$$E[X] = \frac{46+42+45+43+44}{5} = 44$$

$$\therefore \text{Var } (X) = 1938 - 44^2 = 2.0$$

Statement for linked answer questions 75 &76 : porosity of coarse grain sandstone sample is 15 %. The specific gravity of sandstone is 2.8.

Q 75. What is the void ratio in the sandstone sample?

(A) 0.150 (B) 0.176 (C) 0.850 (D) 1.176

Answer (B)

Solution 74.

We know,

$$\text{Porosity} = \frac{void\ ratio}{1+void\ ratio}$$

$$0.15 = \frac{void\ ratio}{1+void\ ratio}$$

$\therefore$ void ratio = 0.176

Q 76. **If the sandstone sample is fully saturated in water, the saturated density of sample in kg/m^3 is**

(A) 1590 **(B) 2234** **(C) 2438** **(D) 2531**

Answer (D)

Solution .

We have ,

$$\text{Saturated density} = \frac{mass\ of\ solid + mass\ of\ water}{volume\ of\ solid + volume\ of\ water}$$

$$\text{Or Saturated density} = \frac{volume\ of\ solid \times density\ of\ solid + density\ of\ water \times volume\ of\ water}{volume\ oF\ solid\ + volume\ of\ water}$$

$$\text{Saturated density} = \frac{\frac{volume\ of\ solid}{volume\ of\ solid} \times specific\ gravity\ of\ solid \times density\ of\ water + density\ of\ water \times \frac{volume\ of\ water}{volume\ of\ solid}}{\frac{volume\ of\ solid}{volume\ of\ solid} + \frac{volume\ of\ water}{volume\ of\ solid}}$$

$$\therefore \text{Saturated density} = \frac{2.8 \times 1000 + 1000 \times void\ ratio}{1 + void\ ratio}$$

$$\text{Saturated density} = \frac{2800 + 1000 \times 0.176}{1 + 0.176}$$

$\therefore$ Saturated density = 2531 kg/m^3

Statement for linked answer questions 77 &78 : A double outboard chain stranded conveyor is installed in an underground coal mine to transport coal. The mass of the chain and associated flight is 40 kg/m, the coefficient of kinematics friction are 0.33 between chain and the span and 0.5 between conveyed coal and the span. The motor efficiency is 80%. Coal is to be conveyed at the rate of 120 t/hour over a length of 120 m at a chain Speed of 0.9 m/s. The bulk density of coal is 900 kg/m^3.

Q 77. The power requirement of the motor of the chain conveyor in kW is

(A) 33.16 (B) 37.53 (C) 42.00 (D) 45.94

Answer (C)

Solution .

Power required to move empty belt :-

$\because$ Power (E) = force × velocity

Or E = mass × acceleration × velocity

$\therefore$ E = 40 × 120 × 0.33 × 9.81 × 0.9

$\therefore$ E = 13985 W = 13.985 kW

Power required to move load :-

$$H = \frac{120 \times 120 \times 1000 \times 9.81 \times 0.5}{60 \times 60}$$

$\therefore$ H = 19620 W = 19.620 kW

$\therefore$ Power requirement (P) of motor of the chain conveyor :-

$$\therefore \quad P = \frac{13.985 + 19.620}{0.80} = 42.00 \text{ kW}$$

Q 78 . The power requirement of the motor of the chain conveyor in kW , if it moves in the uphill direction at a gradient of 1 in 10, is

(A) 46.91 (B) 42.00 (C) 38.53 (D) 30.16

Answer (A)

Solution .

Power required to move load vertically up :-

$$V = \frac{120 \times 1000 \times 9.81 \times 120 \times 1}{60 \times 60 \times 10}$$

$$V = 3924 \text{ W} = 3.924 \text{ kW}$$

∴ Power requirement of motor to convey in uphill:

$$P' = \frac{13.985 + 19.620 + 3.924}{0.80} = 46.91 \text{ kW}$$

Statement for linked answer questions 79 & 80 :-

The observed total time of drilling a face in an underground coal mine is 18 min. The rating of the drill screw performance, expressed in percentage is 90. Following allowances are recommended by the mine management

(i) Personal need allowance : 5% of the basic time

(ii) Fatigue allowance : 4% of the basic time

(iii) Contingency delay allowance : 1% of basic time

Q 79. The basic time required for drilling job by the crew in min is

(A) 16.2 (B) 17.4 (C) 18.0 (D) 20.0

Answer (A)

Solution .

∴ Basic time (B.T) required for drilling Job = 18 × 0.9 = 16.2 minutes

Q 80. The standard time required for the same drilling job by the crew in min is

(A) 15.50 (B) 17.01 (C) 17.82 (D) 18.90

Answer (C)

Solution.

Standard time (S.T) required for the same drilling Job :-

$$S.T = B.T + \frac{5}{100} \times (B.T) + \frac{4}{100} \times (B.T) + \frac{1}{100} \times (B.T)$$

$$S.T = 16.2 + \frac{5}{100} \times 16.2 + \frac{4}{100} \times 16.2 + \frac{1}{100} \times 16.2$$

$\therefore$ S.T = 17.82 minutes

<u>Statement for linked answer Questions 81 & 82 :</u> The result of a theodolite survey are given below:

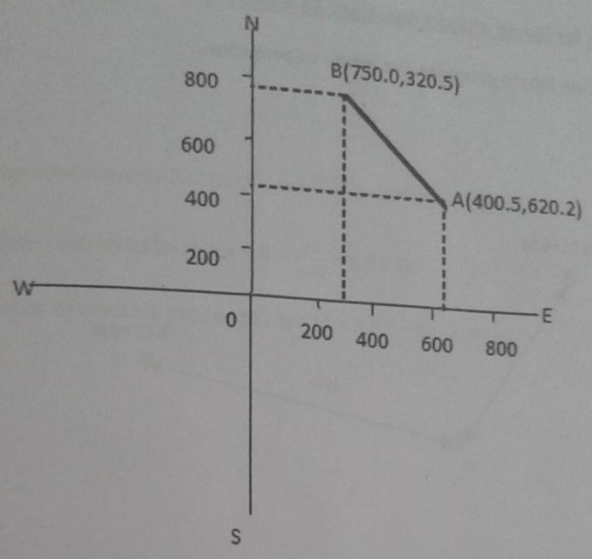
Points	North coordinate, in m	East coordinate, in m
A	400.5	620.2
B	750.5	320.5

Q 81. The length of line AB in m is

(A) 460.78 (B) 349.70 (C) 106.60 (D) 50.30

Answer (A)

Solution .



Latitude of line AB = $L_{AB} = 750.5 - 400.5 = 350\ m$

Departure of line AB = $D_{AB} = 620.2 - 320.5 = 299.7\ m$

∴ Length of line AB = $\sqrt{L^2{}_{AB} + D^2{}_{AB}}$

$= \sqrt{350^2 + 299.7^2}$

= 460.7 m

Q 82. The bearing of the line AB in degrees

(A) 23.17 NE (B) 23.17NW (C) 40.57NW (D) 40.57NE

Answer (C)

Solution .

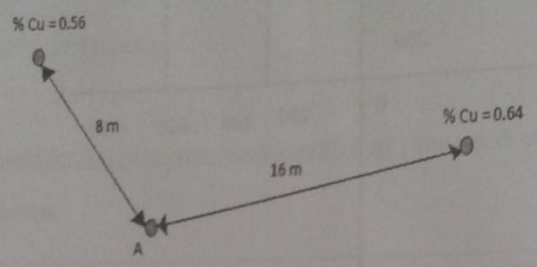
Bearing of line AB $= \tan^{-1}\left(\frac{departure\ of\ AB}{latitude\ of\ AB}\right)$

$= \tan^{-1}\left(\frac{299.7}{350}\right)$

$= 40.57^{\circ}$ NE

Statement for linked answer questions 83 & 84 :-

The following figure provides the grade information.



Q 83. The grade of copper (%) at a point A using inverse distance weighting method is

(A) 0.47 (B) 0.58 (C) 0.61 (D) 1.20

Answer (B)

Solution .

Grade of copper at point A :-

$$g_A = \frac{\sum_{i=0}^{n} \frac{g_i}{d^2_i}}{\sum_{i=0}^{n} \frac{1}{d^2_i}}$$

$$g_A = \frac{\frac{0.56}{64} + \frac{0.64}{256}}{\frac{1}{64} + \frac{1}{256}}$$

$$g_A = 0.58\ \%$$

Q 84. Assume the grade at A to be the average grade of the copper , mill recovery to be 85% and the smelting & refining losses to be 1.0 kg of copper per tonne of ore. The amount of saleable copper in kg/tonne of ore is

(A) 2.93 (B) 3.93 (C) 4.93 (D)5.93

Answer (B)

Solution .

Copper content per tonne of ore = $\frac{0.58}{100} \times 1000 = 5.8$ kg

Copper recovered by mill = $5.8 \times \frac{85}{100} = 4.93$ kg

$\therefore$ Amount of saleable copper per tonne = 4.93 −1 = 3.93 kg

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