## Q. 1 – Q. 5 carry one mark each.

Q.1 The volume of a sphere of diameter 1 unit is _____ than the volume of a cube of side 1 unit.

(A) least (B) less (C) lesser (D) low

Q.2 The unruly crowd demanded that the accused be _____ without trial.

(A) hanged (B) hanging (C) hankering (D) hung

Q.3 Choose the statement(s) where the underlined word is used correctly:

(i) A prone is a dried plum.
(ii) He was lying prone on the floor.
(iii) People who eat a lot of fat are prone to heart disease.

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

Q.4 **Fact:** If it rains, then the field is wet.

Read the following statements:
(i) It rains
(ii) The field is not wet
(iii) The field is wet
(iv) It did not rain

Which one of the options given below is **NOT** logically possible, based on the given fact?

(A) If (iii), then (iv). (B) If (i), then (iii).

(C) If (i), then (ii). (D) If (ii), then (iv).

Q.5 A window is made up of a square portion and an equilateral triangle portion above it. The base of the triangular portion coincides with the upper side of the square. If the perimeter of the window is 6 m, the area of the window in $m^2$ is _____.

(A) 1.43 (B) 2.06 (C) 2.68 (D) 2.88

## Q. 6 – Q. 10 carry two marks each.

Q.6 Students taking an exam are divided into two groups, **P** and **Q** such that each group has the same number of students. The performance of each of the students in a test was evaluated out of 200 marks. It was observed that the mean of group **P** was 105, while that of group **Q** was 85. The standard deviation of group **P** was 25, while that of group **Q** was 5. Assuming that the marks were distributed on a normal distribution, which of the following statements will have the highest probability of being **TRUE**?

(A) No student in group **Q** scored less marks than any student in group **P**.

(B) No student in group **P** scored less marks than any student in group **Q**.

(C) Most students of group **Q** scored marks in a narrower range than students in group **P**.

(D) The median of the marks of group **P** is 100.

Q.7 A smart city integrates all modes of transport, uses clean energy and promotes sustainable use of resources. It also uses technology to ensure safety and security of the city, something which critics argue, will lead to a surveillance state.

Which of the following can be logically inferred from the above paragraph?

(i) All smart cities encourage the formation of surveillance states.
(ii) Surveillance is an integral part of a smart city.
(iii) Sustainability and surveillance go hand in hand in a smart city.
(iv) There is a perception that smart cities promote surveillance.

(A) (i) and (iv) only (B) (ii) and (iii) only

(C) (iv) only (D) (i) only

Q.8 Find the missing sequence in the letter series.

B, FH, LNP, _ _ _ _.

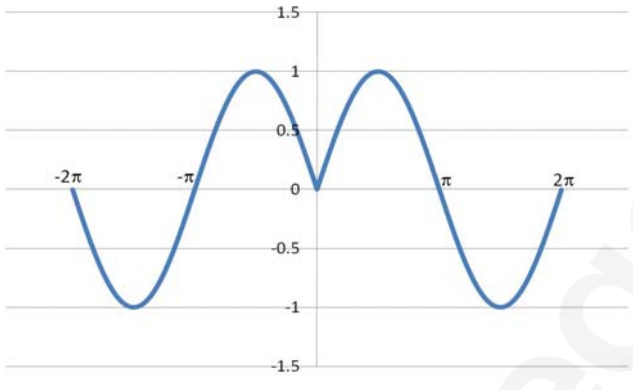
(A) SUWY (B) TUVW (C) TVXZ (D) TWXZ

Q.9 The binary operation □ is defined as $a \square b = ab+(a+b)$, where $a$ and $b$ are any two real numbers. The value of the identity element of this operation, defined as the number $x$ such that $a \square x = a$, for any $a$, is _____.

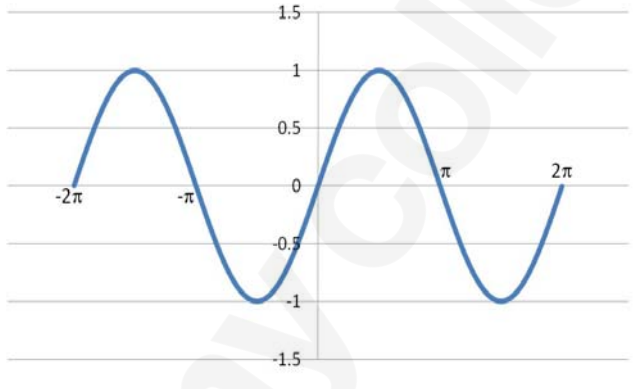
(A) 0 (B) 1 (C) 2 (D) 10

Q.10 Which of the following curves represents the function $y = \ln(|e^{[|\sin(|x|)|]}|)$ for $|x| < 2\pi$? Here, $x$ represents the abscissa and $y$ represents the ordinate.

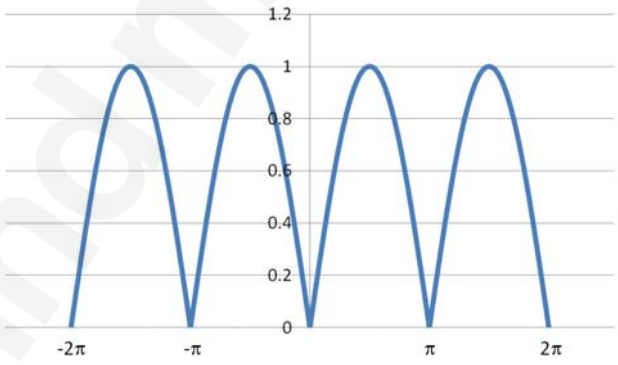
(A)



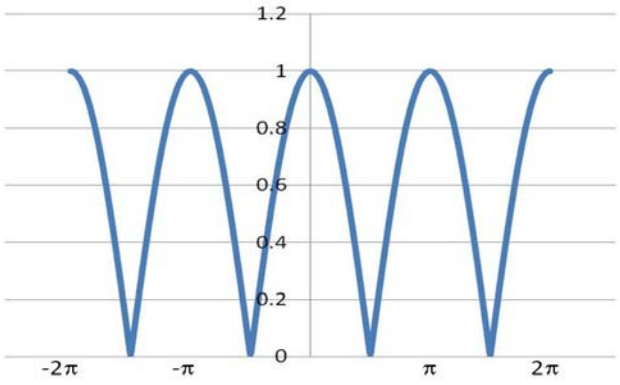

(B)




(C)




(D)




**END OF THE QUESTION PAPER**

## Q. 1 – Q. 25 carry one mark each.

Q.1 The differential of the equation, $x^2 + y^2 = 1$, with respect to $x$ is

(A) $-x/y$ (B) $x/y$ (C) $-y/x$ (D) $y/x$

Q.2 If $[A][B] = [I]$ then

(A) $[B] = [A]^T$ (B) $[A] = [B]^T$ (C) $[B] = [A]^{-1}$ (D) $[B] = [A]$

Q.3 $X^4 + C$ is the general integral of

(A) $3\int x^3 dx$ (B) $\frac{1}{4}\int x^3 dx$ (C) $\int x^3 dx$ (D) $4\int x^3 dx$

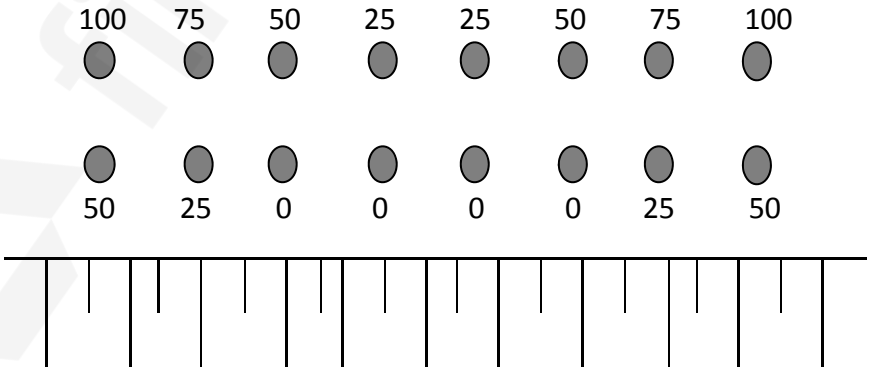
Q.4 *Sinh* (*x*) is

(A) $\frac{e^x - e^{-x}}{4}$ (B) $\frac{e^x - e^{-x}}{2}$ (C) $\frac{e^x + e^{-x}}{2}$ (D) $\frac{e^x + e^{-x}}{4}$

Q.5 Identify the correct statement.
NONEL is used for surface connection of the blast holes in order to

(A) achieve better water resistance over detonating fuse
(B) have a precise delay timing
(C) provide noiseless shock front movement
(D) avoid deflagration

Q.6 Identify the pattern of surface blasting given in the figure. The values of delay time, in ms, are given against each blasthole.




(A) V- cut
(B) extended V- cut
(C) row to row
(D) en echelon

Q.7 Identify the initiation sequence which is NOT possible for surface blasting.

(A) Detonating fuse →Nonel→Electronic detonator
(B) Electric detonator→Nonel→Detonating fuse
(C) Electric detonator→ Detonating fuse → Nonel
(D) Electronic detonator→ Detonating fuse → Nonel

Q.8 Parallel holes at right angles to the face with some holes uncharged are associated with the following shot hole pattern

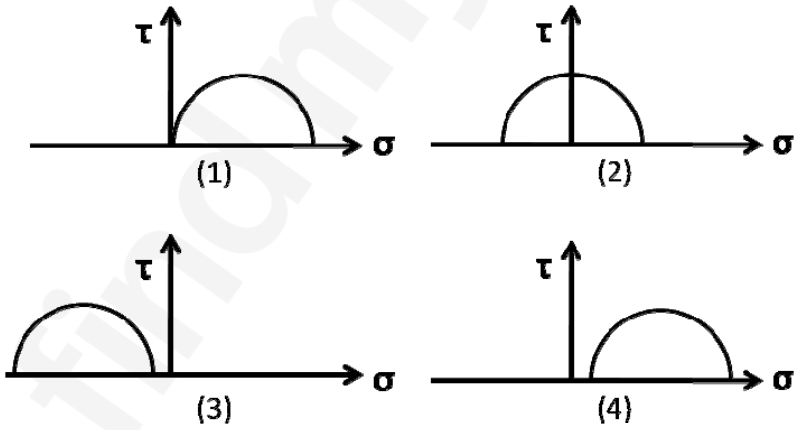
(A) drag cut (B) wedge cut (C) pyramid cut (D) burn cut

Q.9 Bieniawski's Rock Mass Rating considers the parameters: RQD, spacing of joints, condition of joints, ground water condition, and

(A) tensile strength
(B) uniaxial compressive strength
(C) shear strength
(D) buckling strength

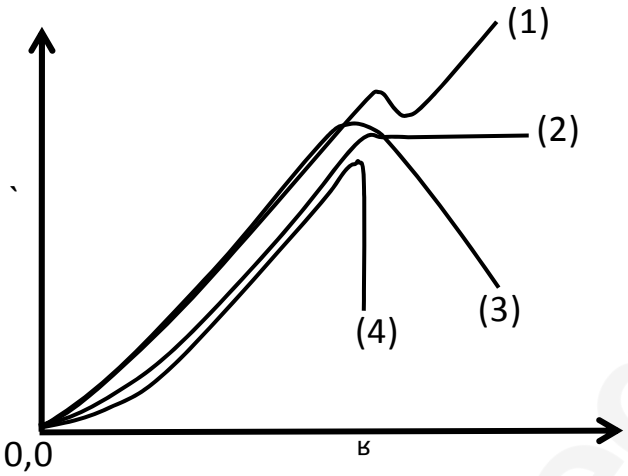
Q.10 A rockmass is subjected to hydrostatic pressure of 6 MPa. If each of the measured strains $\varepsilon_{xx} = \varepsilon_{yy} = \varepsilon_{zz}$, is 2.0 mm/m, then the bulk modulus, in GPa, is _____

Q.11 Identify the uniaxial compressive loading condition from the following four Mohr circles.




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

Q.12 Out of the given stress-strain curves, identify the rock type that is most prone to rock burst.




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

Q.13 A longwall panel of width 120 m is extracted at a depth of 200 m. Critical subsidence is reached when the panel length becomes 150 m. If the seam were to be worked at a depth of 300 m, critical subsidence would be observed at a panel length, in m, of _____.

Q.14 The support system followed along the goaf edge in a depillaring panel is

(A) rope stitching
(B) cable bolting
(C) wooden/steel chock
(D) hydraulic prop

Q.15 Which one of the following ropes CANNOT be an effective cable bolt?

(A) locked coil wire rope
(B) Langs lay wire rope
(C) ordinary lay wire rope
(D) bird-caged wire rope

Q.16 In metalliferous mines, the sublevel interval does NOT depend on

(A) capacity of drilling equipment
(B) capacity of loading equipment
(C) strength of rib pillar
(D) strength of wall rock

Q.17 Jack hammer does NOT contain

(A) pawl and ratchet
(B) gear box
(C) rifle bar
(D) piston

Q.18 At the inlet of a mine roadway, the dry and wet bulb temperatures of air are $38^0C$ and $29^0C$, respectively. At the outlet, the corresponding temperatures are $32^0C$ and $29^0C$, respectively. The process of heat transfer in the airway is described as

(A) evaporative cooling
(B) sensible cooling
(C) sensible heating
(D) dehumidification

Q.19 Underground coal mines are in principle ventilated by exhausting system, so that

(A) spontaneous heating risk is reduced
(B) fumes can be quickly removed in case of an underground fire
(C) build-up of methane concentration is decreased
(D) cool and fresh intake air can enter underground

Q.20 Identify the WRONG statement.
Pit bottom air lock

(A) prevents the short circuiting of air when the flow is reversed in coal mines
(B) has at least three doors
(C) has at least one door that has provision for latching
(D) all doors are in principle designed to open towards high pressure side of the air

Q.21 Identify the WRONG statement.
The 'temperature inversion' of the atmosphere in surface mines aggravates the problem of

(A) airborne dust
(B) noise
(C) ground vibrations
(D) visibility

Q.22 In a CO self rescuer, the purpose of the calcium bromide and lithium chloride mixture is to

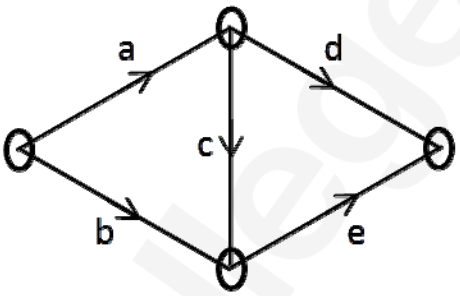
(A) dry the incoming air
(B) convert the CO catalytically to $CO_2$
(C) absorb and thereby neutralise CO
(D) cool the inhaled air from excess exothermic heat due to chemical reaction

Q.23 IRR of a project is the discount rate at which

(A) profit after tax is zero
(B) written down value of the project is zero
(C) revenue from the project is zero
(D) NPV is zero

Q.24 For the critical path network shown, the slack for the activity 'b', in months, is

| Activity | Duration (months) |
|---|---|
| a | 4 |
| b | 3 |
| c | 5 |
| d | 4 |
| e | 7 |




(A) 4 (B) 6 (C) 9 (D) 13

Q.25 The three axes comprising the numerical codification of resources, as per the UNFC, are

(A) Economic Viability, Geological Assessment, Geotechnical Assessment
(B) Geological Assessment, Environmental Assessment, Feasibility Assessment
(C) Feasibility Assessment, Geological Assessment, Mining Assessment
(D) Economic Viability, Geological Assessment, Feasibility Assessment

## Q. 26 – Q. 55 carry two marks each.

Q.26 Equations of two planes are $z = 4$ and $z = 4 + 3x$. The included angle between the two planes in degrees, is _____

Q.27 A force $\vec{P} = 2\hat{i} - 5\hat{j} + 6\hat{k}$ acts on a particle. The particle is moved from point A to point B, where the position vectors of $\vec{A}$ and $\vec{B}$ are $6\hat{i} + \hat{j} - 3\hat{k}$ and $4\hat{i} - 3\hat{j} - 2\hat{k}$ respectively. The work done is _____

Q.28 The value of $x$ in the simultaneous equations is _____

$$3x + y + 2z = 3$$
$$2x - 3y - z = -3$$
$$x + 2y + z = 4$$

Q.29 Two persons *P* and *Q* toss an unbiased coin alternately on an understanding that whoever gets the head first wins. If *P* starts the game, then the probability of *P* winning the game is _____

Q.30 Data pertaining to a surface bench blast is given below:

Burden = 3.0 m
Spacing = 4.0 m
Bench height = 10.0 m
Density of rock = 2000 $kg/m^3$
Sub-grade drilling = 1.0 m
Collar stemming = 4.0 m
Air decking length = 1.0 m
Linear charge concentration = 10 kg/m

The powder factor of the blast, in kg/tonne, is _____

Q.31 Match the following for a typical slurry explosive.

| | **Chemical** | | **Purpose** |
|---|---|---|---|
| P. | Calcium nitrate | 1. | Cross linking agent |
| Q. | Potassium dichromate | 2. | Gelling agent |
| R. | TNT | 3. | Oxidiser |
| S. | Starch | 4. | Fuel |

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

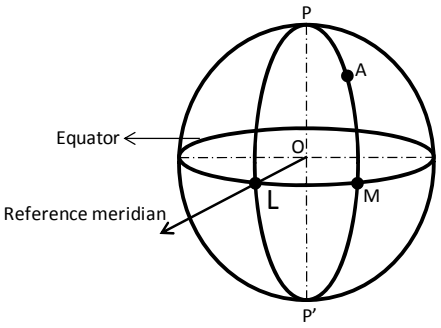
Q.32 A 10 m thick coal block is excavated by a contractor at a cost of Rs. 40 per $m^3$. The excavated area, measured in the mine plan, is found to be $50\ cm^2$. If the mine plan has been drawn to a scale of 1:1000, the payment to be made to the contractor, in lakhs of Rs., is _____

Q.33 Two vertical shafts of a mine have the following parameters:

| Shaft | ShaftπA | ShaftπB |
|---|---|---|
| Collar RL (m) | 0.0 | 0.0 |
| Depth (m) | 250 | 200 |
| Northing (m) | 200 | 100 |
| Easting (m) | 100 | π100 |

The gradient of the drift connecting the shaft bottoms, in degrees, is_____

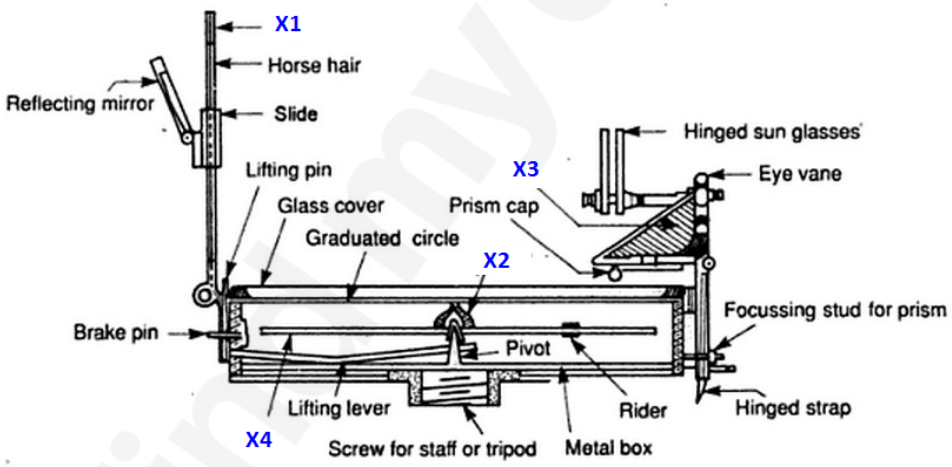
Q.34 For a station 'A' on the Earth's surface, as shown in the figure, match the following




| Arc | Description |
|---|---|
| Q. MA | 1. Longitude |
| R. LM | 2. Co-latitude |
| S. PA | 3. Latitude |

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

Q.35 Match the following for the prismatic compass shown below

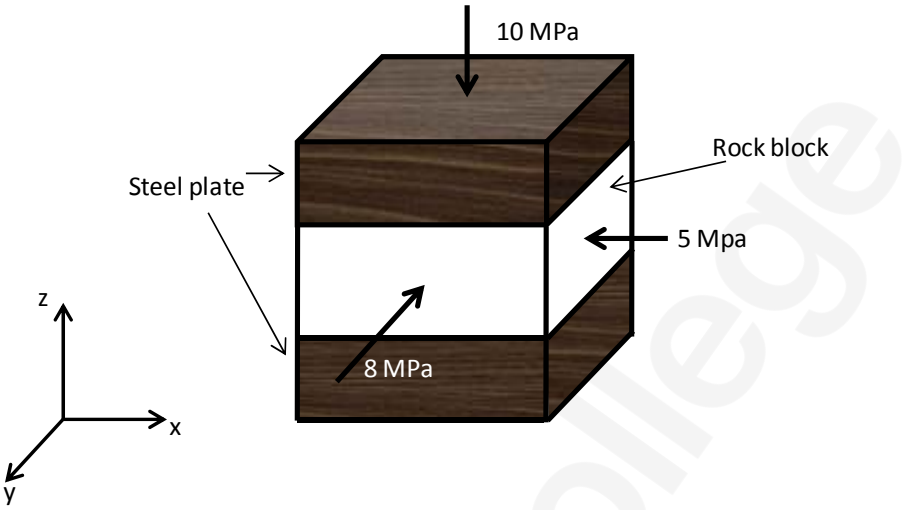



| Component | | Name |
|---|---|---|
| P. | X1 | 1. Agate bearing |
| Q. | X2 | 2. Object vane |
| R. | X3 | 3. Magnetic needle |
| S. | X4 | 4. Prism |

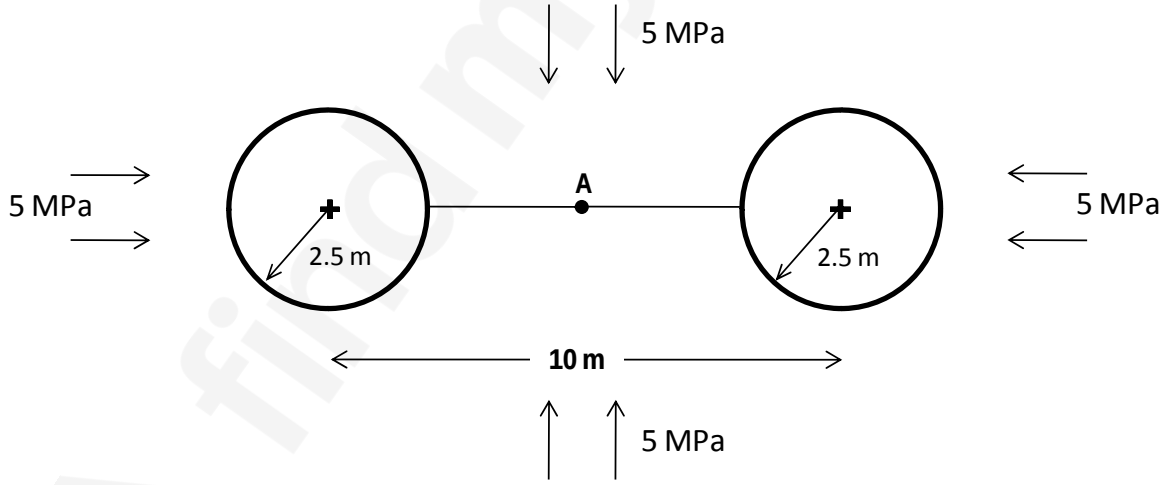
(A) P-1, Q-2, R-3, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-1, R-4, S-2

Q.36 A ladder placed against a frictionless wall at an inclination of $60^0$ with horizontal, is in a state of limiting equilibrium. The ladder has a length of 13 m and a uniform mass of 4 kg/m. The coefficient of friction between the ladder and the floor is _____

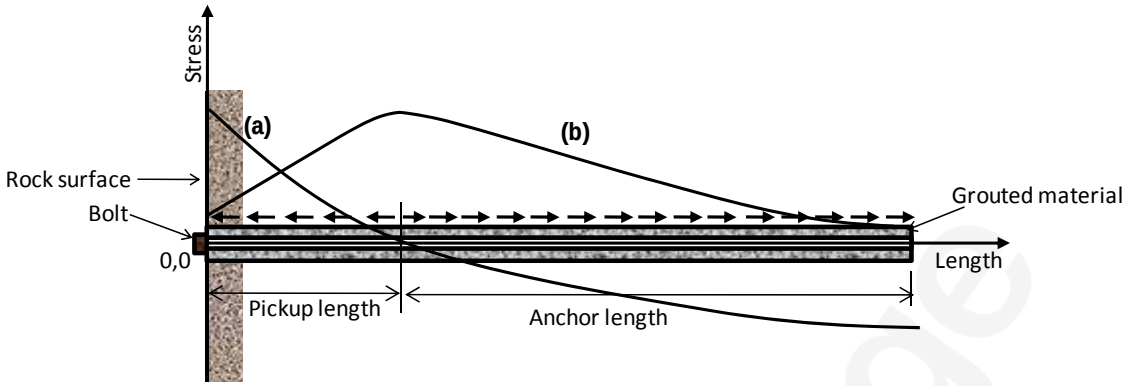
Q.37 A cubical rock sample is enclosed between two fixed hard steel plates as shown in the figure below. The modulus of elasticity and Poisson's ratio of the rock are 2 GPa and 0.25, respectively. If the rock is subjected to the stresses as shown in the figure, the strain in x-direction, in mm/m, is _____.




Q.38 In a hydrostatic stress field, point A is in the middle of two circular openings as shown in the figure. The radial stress, in MPa, at point A is _____.



Q.39 Curves (a) and (b) represent the stress distributions along the length of a 'full column grouted bolt' shown in the figure. Curves (a) and (b) are




(A) Tensile stress, Compressive stress
(B) Axial stress, Shear stress
(C) Compressive stress, Tensile stress
(D) Shear stress, Axial stress

Q.40 Match the following mechanical properties with the formulae

| Mechanical property | Formula |
|---|---|
| P. Modulus of elasticity | 1. $c + \sigma_n \tan\varphi$ |
| Q. Compressive strength | 2. $\varepsilon_{lateral} / \varepsilon_{longitudinal}$ |
| R. Shear Strength | 3. $\sigma / \varepsilon$ |
| S. Poisson's ratio | 4. $F_n / \pi r^2$ |

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

Q.41 A skip of 10 tonne capacity hoists ore through a 1000 m deep shaft at a speed of 20 m/s. The skip accelerates and decelerates at 2.0 $m/s^2$. The loading and unloading times for the skip are 2.5 min and 1.5 min, respectively. The maximum hourly capacity of the hoisting system, in tonnes, is

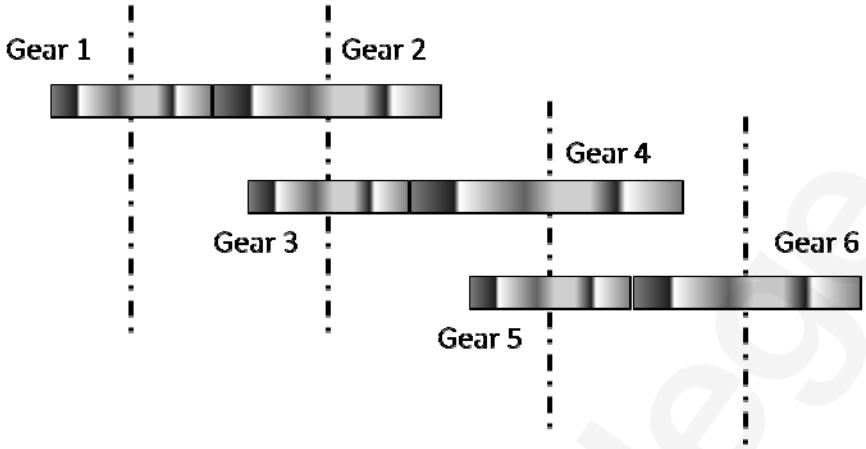
_____

Q.42 Match the following:

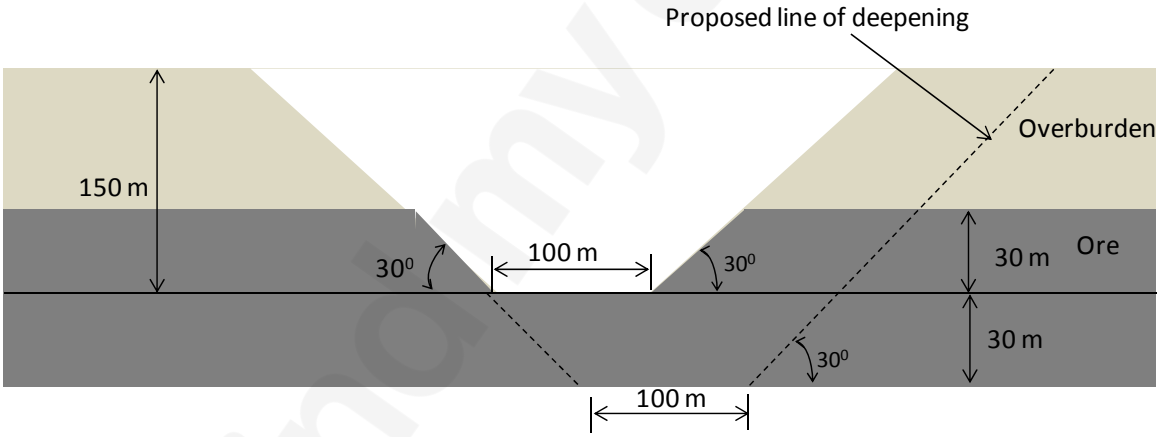
| Haulage unit | Safety device |
|---|---|
| P. Friction winder | 1. Run-away switch |
| Q. Drum winder | 2. Lilly controller |
| R. Direct rope haulage | 3. Regenerative braking |
| S. Endless rope haulage | 4. Monkey/back catch |

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

Q.43 In the gear assembly shown, the rpm of Gear 1 is 600. The number of teeth in Gear 1, Gear 2, Gear 3, Gear 4, Gear 5 and Gear 6 is 30, 45, 15, 20, 10 and 30, respectively. The rpm of Gear 6 is _____




Q.44 An operating surface mine is proposed to be deepened by 30 m as shown in the figure. If the density of the ore is 2.4 $tonne/m^3$, the incremental stripping ratio for the deepening, in $m^3/tonne$, is _____.



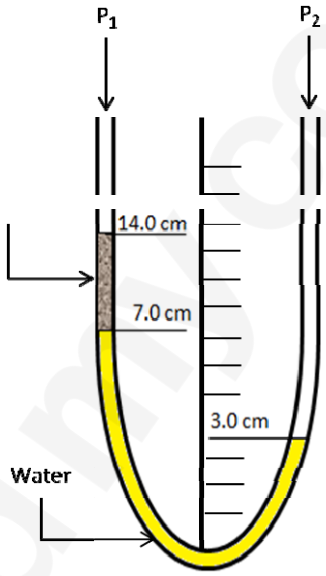

Q.45 From an openpit sump, mine water is lifted using a 250 m long straight pipeline laid along a gradient of $34^0$. The pumping rate is 500 gpm (1 gallon = 3.8 litres). Additional head loss due to pipe friction can be considered to be 10% of head lifted. At an overall efficiency of 70%, the electric power consumed by the pump, in kW, is _____.

Q.46 With reference to Coward diagram, match the following in the context of explosibility of a mixture of 'normal air' and 'methane'.

| **($O_2$ %, $CH_4$ %)** | **Mixture status** |
|---|---|
| P. 20.5, 2.4 | 1. Impossible mixture |
| Q. 19.0, 9.5 | 2. Non-explosive |
| R. 17.0, 19.0 | 3. Potentially explosive |
| S. 20.0, 19.5 | 4. Explosive |

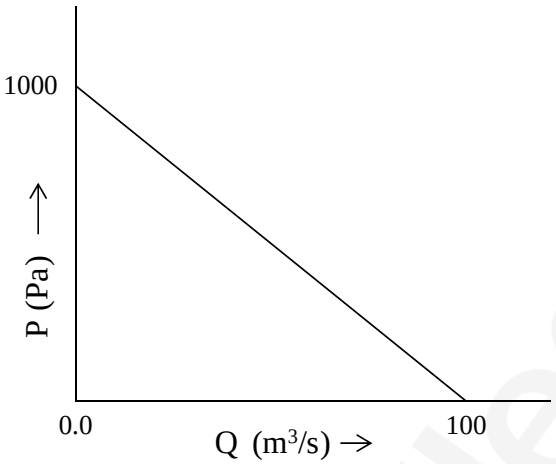
(A) P-2, Q-4, R-3, S-1
(B) P-2, Q-3, R-1, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-2, R-1, S-4

Q.47 A U-tube manometer is subjected to differential pressure as shown. If specific gravity of kerosene is 0.8, the value of $\left(P_1 - P_2\right)$, in Pa, is_____.




Q.48 An air stream having an enthalpy of 100 kJ/kgda, is flowing at 20 kgda/s. It is cooled by water at temperature $10^0C$ circulating in a cooling coil at a flow rate of 10.0 l/s. If the return temperature of water is $20^0C$, the enthalpy of the cooled air, in kJ/kgda, is _____.
(Specific heat of water: 4.18 $kJ/kg\,^0C$; kgda: kg of dry air).

Q.49 The static pressure characteristic of a mine fan is as shown. If the mine resistance is 0.3 $Ns^2/m^8$, the quantity generated by the fan, in $m^3/s$, is _____.




Q.50 In the context of ventilation plan symbols, match the following:

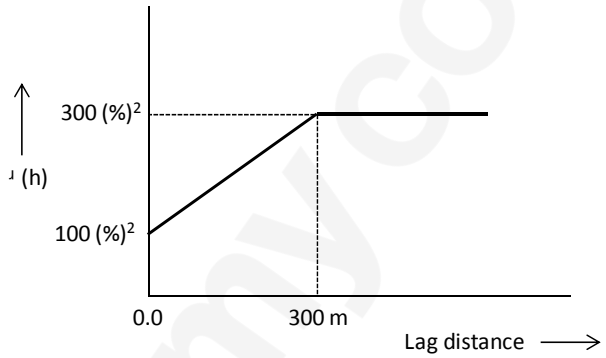
| Symbol | | Description |
|---|---|---|
| P. | | 1. Temporary stopping |
| Q. | | 2. Regulator |
| R. | | 3. Air-crossing |
| S. | | 4. Ventilation stopping |

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

Q.51 A mill concentrate, having 25% copper, is proposed to be sold at Rs. 1,25,000 per tonne. The grade of the deposit is 0.8% Cu and the overall cost of mining and milling is Rs. 2,520 per tonne of ore. At a recovery of 75%, the estimated profit, in Rs./tonne of concentrate, is _____.

Q.52 Copper grade distribution in an ore body has the probability density function, $f(x)$, as shown in the figure. The average grade of the deposit, in % Cu, is _____.

Q.53 The semivariogram shown belongs to a bauxite deposit. The expected difference in the $Al_2O_3$ (%) values between two boreholes separated by a distance of 200 m is _____.




Q.54 A surface mine has 15 identical dumpers and two shovels. For shovel 1, the dumper cycle time is 30 min and the shovel loading time is 5 min. For shovel 2, the dumper cycle time is 32 min and the shovel loading time is 4.0 min. Based on match factor optimisation (equitable match factor), the ideal allocation of dumpers to shovel 1 and shovel 2, respectively is

(A) 6, 9 (B) 7, 8 (C) 9, 6 (D) 8, 7