Q. 1 – Q. 25 carry one mark each.

Q.1 Out of the 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

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

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

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

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

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

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 atmosphere is

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

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

(A) reduction in 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

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

Q.9 In a triangle ABC, the bearings of the sides AB, BC, and CA are 60°, 130°, and 270° 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

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

(A) $np\lambda$ (B) $n\lambda$ (C) $p\lambda$ (D) λ

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 _____

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

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

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 the wastewater, in mg/l, is

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

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 _____
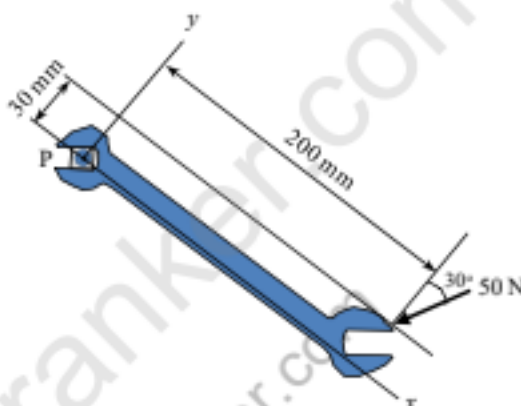
Q.15 Dilatancy of rock is associated with

(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

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 _____

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

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

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

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

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

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 5.0%, 3.3% and 4.2% respectively. The lower explosibility limit of the gas mixture, in percentage, is _____

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 _____

Q.22 In a fully mechanised 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

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 _____

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

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

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 _____

Q. 26 – Q. 55 carry two marks each.

Q.26 In a 4.2 m wide and 3.0 m high gallery in a coal seam, twelve shot holes are blasted per round. The holes are charged with 2 explosive cartridges 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

Q.27 The stadia readings with horizontal sight on a vertical staff held at 50 m from a tacheometer are 1.285 m 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 _____

Q.28 In a shortwall panel, coal is extracted from the face by a continuous miner having rate of production 30 tonne/h. 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

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 _____

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

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

Q.32 A rectangular field of area 20000 m^2 is to be divided into 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 _____
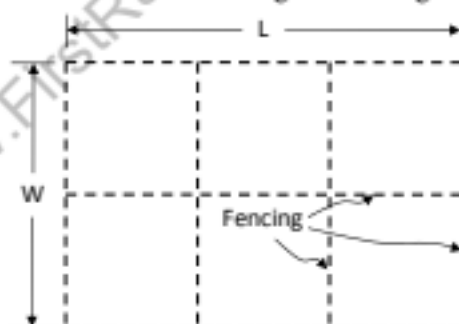

Q.33 Match the following for a drilling system.

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 into 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

Q.34 For the ventilation system shown, the combined resistance of the trunk airways and the shafts is 2.2 Ns^2m^{-8}. The resistances of splits 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 _____
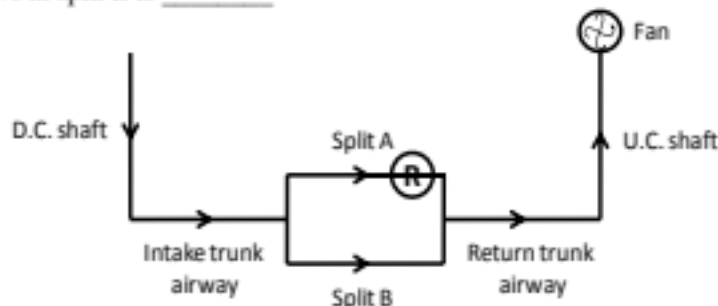
Q.35 A mine fan running at 300 rpm delivers 150 m^3/s of air at a pressure of 900 Pa. Fan and motor efficiencies are 75% and 90% respectively. If the fan speed is reduced to 250 rpm, the saving in electric power input to the motor in kW is _____

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

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

where x = distance (m) from the inflection point and D = depth (m) of the 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 _____

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 _____

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 _____

Q.39 Match the method of mining with strength of orebody, type of support and orebody 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

Q.40 A mine air sample 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 _____

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 _____

Q.42 Given the following linear programming problem,

Maximise $z = 3x_1 + 4x_2$
    Subject to
    $2x_1 + x_2 \leq 6$
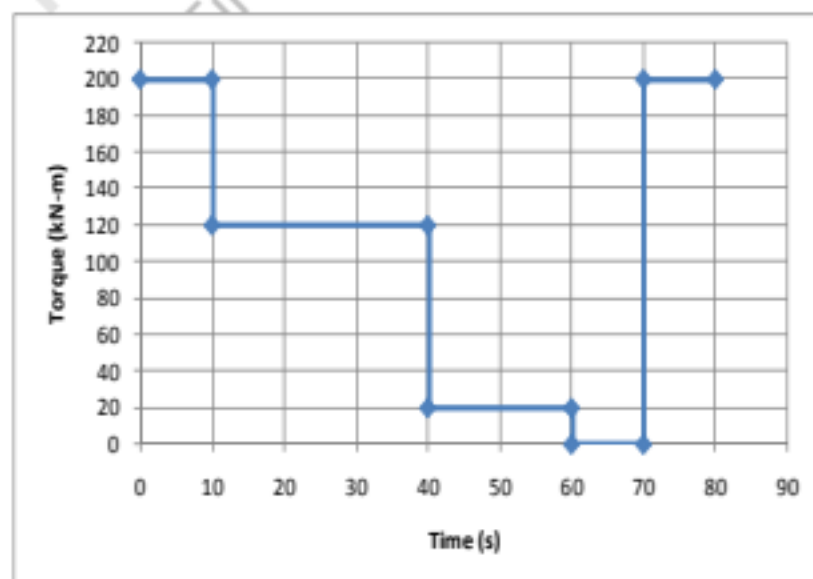 $2x_1 + 3x_2 \leq 9$
    $x_1 \geq 0, x_2 \geq 0$

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)

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

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

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 $\mu g\ m^{-3}$ is _____

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 _____

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

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

$$f(x) = \begin{cases} \frac{1}{4}(1-3x), & \text{if } -2 \le x \le 2 \\ 0, & \text{otherwise} \end{cases}$$

If 95% of the bolt lengths (L) lie in the interval $150 - c$ cm to $150 + c$ cm, the value of c is _____

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

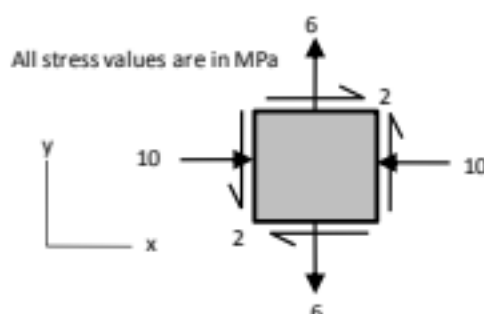$$E(X) = 24,\ E(Y) = 36,\ E(X^2) = 702,\ E(Y^2) = 1524,\ E(XY) = 1004$$

The correlation coefficient between X and Y is _____

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

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.
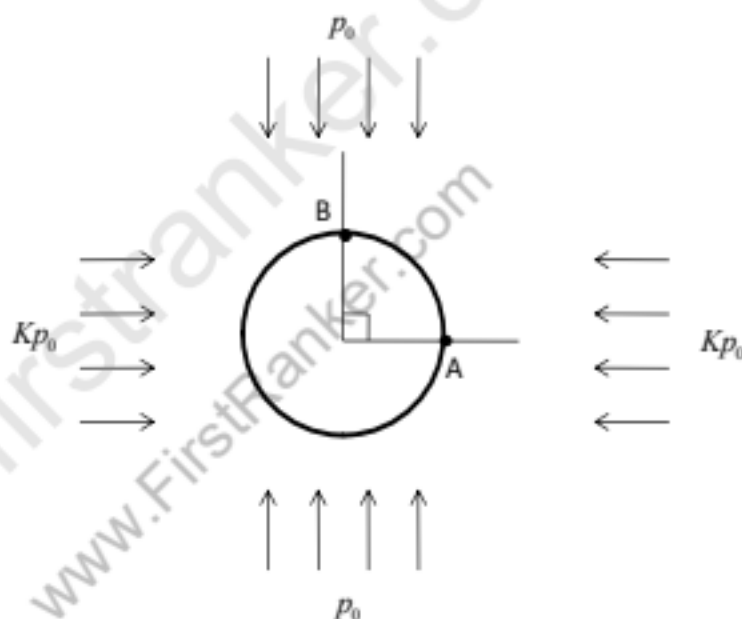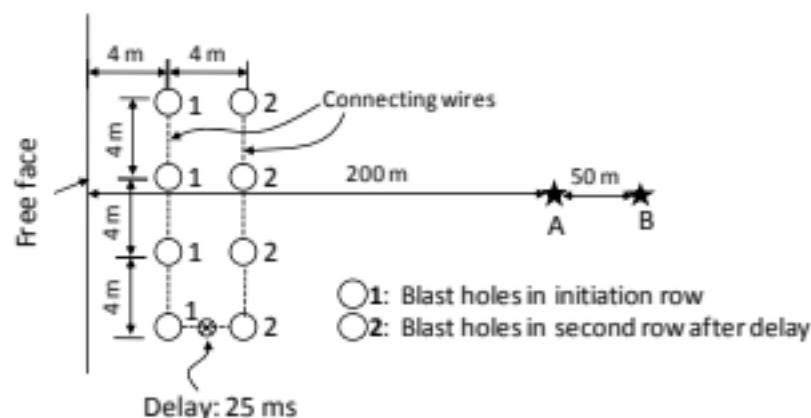

If the ratio of the tangential stress measured at the boundary points A and B is 3:1, the value of K is _____

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 explosives per hole in the 1st row   : 500 kg
Amount of explosives 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 constants K and n respectively are

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

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

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 _____

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 the 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 _____

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 _____

END OF THE QUESTION PAPER