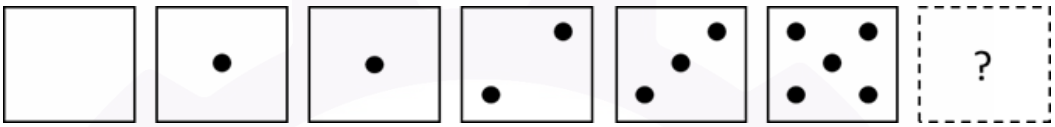
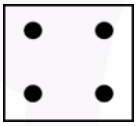
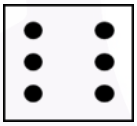
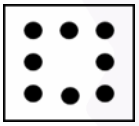
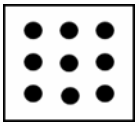
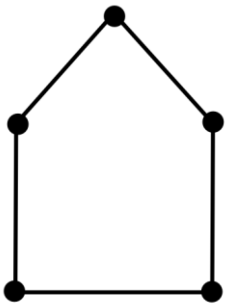
General Aptitude (GA)

Q.1 – Q.5 Carry ONE mark Each

Q.1	Suresh said, “I did it yesterday.” Which one of the following options is the correct form of this sentence in indirect speech?
(A)	Suresh said that I did it yesterday.
(B)	Suresh says I did it yesterday.
(C)	Suresh says that he did it the day before.
(D)	Suresh said that he had done it the day before.

Q.2	To continue the sequence of tiles shown, the tile indicated by the question mark should be 
(A)	
(B)	
(C)	
(D)	

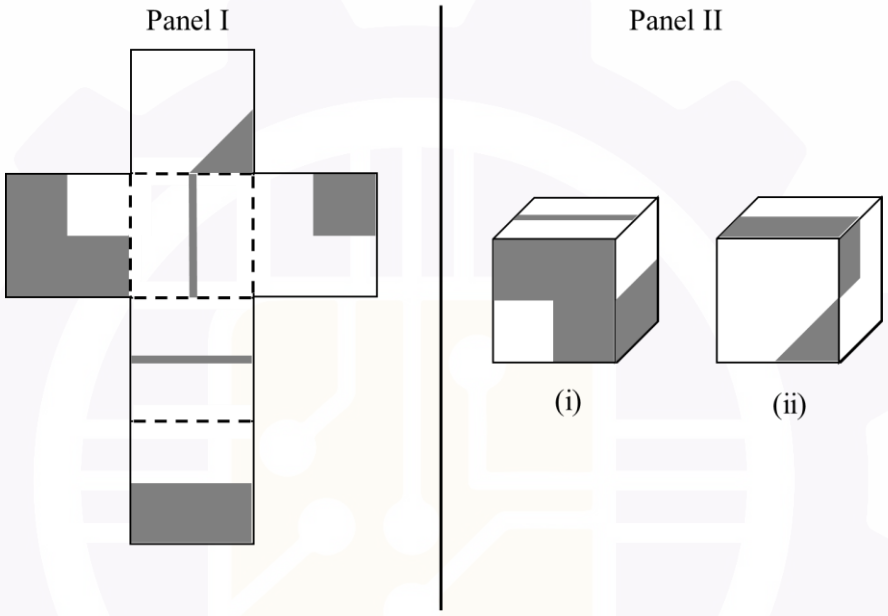
Q.3	Consider an art gallery whose walkways are shown as lines in the diagram. A black dot represents a junction of two walkways. A guard may be placed at a junction to watch over the walkways that join at that junction. The minimum number of guards needed to watch all the walkways is _____. 
(A)	2
(B)	3
(C)	4
(D)	5

Q.4	The 2nd of June is a Thursday in a certain year. Which day of the week is the 3rd of July in that year?
(A)	Thursday
(B)	Friday
(C)	Saturday
(D)	Sunday

Q.5	A coin with heads facing up is shown as (H) and a coin with tails facing up is shown as (T) . Six coins are placed in the Starting Arrangement, as shown in the figure below. A "step" is defined as interchanging a pair of adjacent coins without flipping them. The minimum number of steps needed to go from the Starting Arrangement to the Final Arrangement, as shown in the figure, is _____. Starting Arrangement  Final Arrangement 
(A)	3
(B)	6
(C)	9
(D)	12

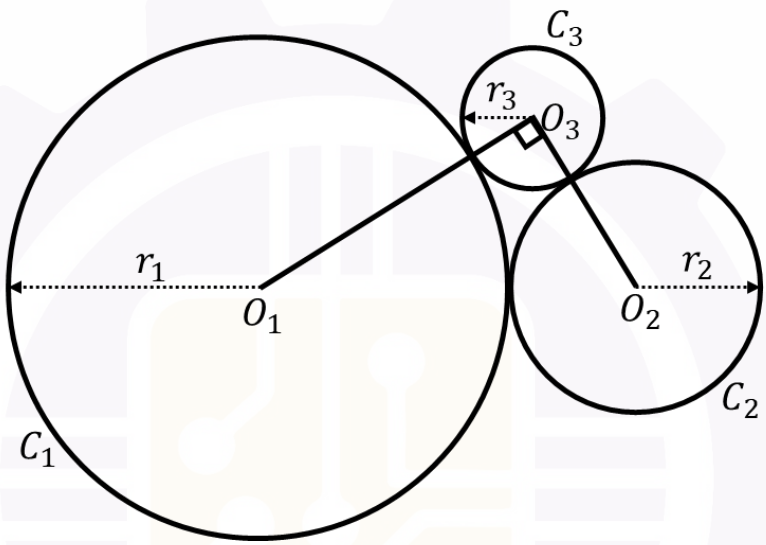
Q.6 – Q.10 Carry TWO marks Each

Q.6	Exacerbate : Mitigate :: _____ Choose the option with the correct pair of words to fill the blank.
(A)	Aggravate : Alleviate
(B)	Alleviate : Precipitate
(C)	Aggravate : Precipitate
(D)	Emancipate : Exonerate

Q.7	A paper shown in Panel I is folded along the dashed lines (- - -) to construct a cube. The shaded regions shown in Panel I appear on the outer surface of the cube. Referring to cubes shown in Panel II, which one of the options is correct? 
(A)	Only (i) can correspond to the unfolded cube in Panel I.
(B)	Only (ii) can correspond to the unfolded cube in Panel I.
(C)	Both (i) and (ii) can correspond to the unfolded cube in Panel I.
(D)	Neither (i) nor (ii) can correspond to the unfolded cube in Panel I.

Q.8	In a population, patients who have high cholesterol also have high blood-pressure (BP). Some patients with high BP also have diabetes. There are no patients who have both high cholesterol and diabetes. Furthermore, 1. the total number of patients with at least one of these conditions is 75, 2. the number of patients with high cholesterol is 10, 3. the number of patients with high BP is 45, and 4. the number of patients with only high BP and no other conditions is 20. Then the number of patients who have both diabetes and high BP is _____
(A)	0
(B)	15
(C)	20
(D)	10

Q.9	Four people P, Q, R, and S, of different ages, make the following observations. P – I am younger than S. Q – I am neither the youngest nor the oldest. R – P is older than me. Based on these observations, the youngest person is _____.
(A)	P
(B)	Q
(C)	R
(D)	S

Q.10	Circles C_1, C_2, and C_3, with centers O_1, O_2, and O_3 , and radii r_1 , r_2, and r_3, respectively, touch each other as shown in the following figure. Given $r_1 = 2$ cm, $r_2 = 1$ cm and the angle $\angle O_1O_3O_2$ is 90°, r_3 = _____ cm. 
(A)	$\frac{1}{2}(-3+\sqrt{17})$
(B)	$\frac{1}{2}(3+\sqrt{17})$
(C)	$\frac{1}{2}(-2+\sqrt{17})$
(D)	$\frac{1}{2}(-3+2\sqrt{17})$

Q.11 – Q.35 Carry ONE mark Each

Q.11	If I is an identity matrix, the polynomial equation that satisfies the Cayley-Hamilton theorem for the matrix $P=\begin{bmatrix}2 & 1\\ 0 & 3\end{bmatrix}$ is
(A)	$P^2-5P+6I=0$
(B)	$P^2-5P+5I=0$
(C)	$P^2-6P+5I=0$
(D)	$P^2-4P+3I=0$

Q.12	Let $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$ are the unit vectors in the x and y direction, respectively. The divergence $\left(\nabla.\vec{F}\right)$ of $\vec{F}=x^2y\,\hat{\mathbf{i}}+y^3x\,\hat{\mathbf{j}}$ at the point $(3,2)$ is
(A)	12
(B)	24
(C)	36
(D)	48

Q.13	Which one of the following is a non-linear, second-order, and first-degree differential equation?
(A)	$\frac{d^2y}{dx^2}+\cos x\frac{dy}{dx}+e^x y=0$
(B)	$\frac{d^2y}{dx^2}+\cos y=0$
(C)	$\frac{d^2y}{dx^2}+\sin x=0$
(D)	$\left(\frac{dy}{dx}\right)^2+3y=0$

Q.14	As per the Mohs scale of hardness, the correct sequence is
(A)	Topaz > Quartz > Calcite > Talc
(B)	Quartz > Topaz > Calcite > Talc
(C)	Quartz > Topaz > Talc > Calcite
(D)	Topaz > Calcite > Quartz > Talc

Q.15 Match the distribution with its corresponding probability density/mass function.

Distribution type	Probability density/mass function
(P) Binomial Distribution	(1) $f(x)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right), \sigma>0$
(Q) Poisson Distribution	(2) $f(x)=\binom{n}{x}p^x(1-p)^{n-x}, \quad x=0,1,2,...,n$
(R) Normal Distribution	(3) $f(x)=\frac{\mu^x}{x!}\exp(-\mu), \qquad x=0,1,2,...$
(S) Exponential Distribution	(4) $f(x)=\lambda\exp(-\lambda x), \qquad x>0$

(A) P $\rightarrow$ 2, Q $\rightarrow$ 3, R $\rightarrow$ 1, S $\rightarrow$ 4

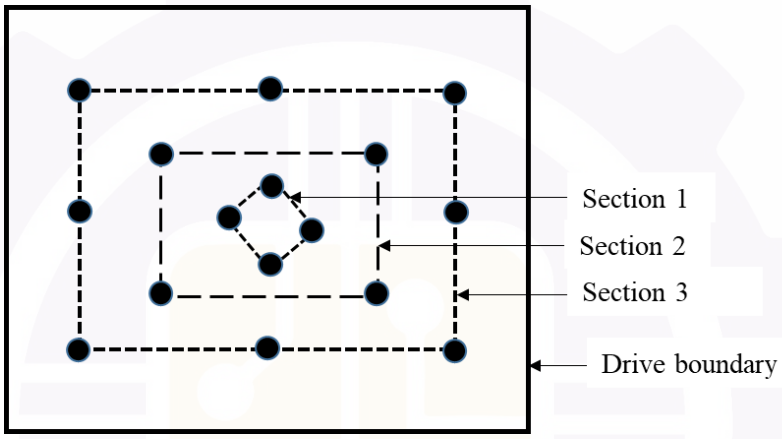
(B) P $\rightarrow$ 1, Q $\rightarrow$ 3, R $\rightarrow$ 2, S $\rightarrow$ 4

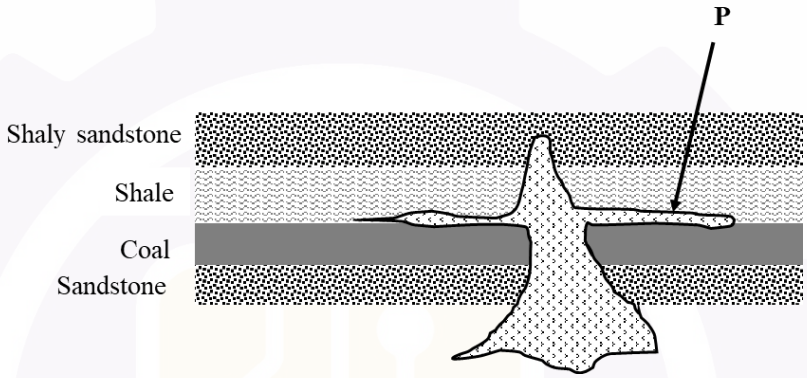
(C) P $\rightarrow$ 3, Q $\rightarrow$ 2, R $\rightarrow$ 1, S $\rightarrow$ 4

(D) P $\rightarrow$ 2, Q $\rightarrow$ 4, R $\rightarrow$ 3, S $\rightarrow$ 1

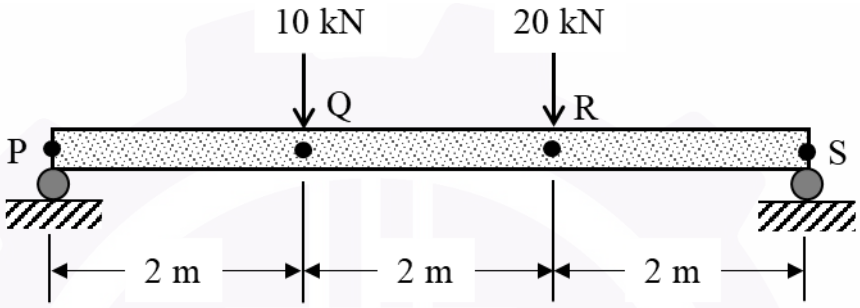
Q.16	As per the UNFC mineral resources classification system, the highest category of resource is indicated by
(A)	111
(B)	122
(C)	333
(D)	334

Q.17	The best combination of explosive and initiation system for underwater blasting for rock breakage is
(A)	ANFO and electric detonator
(B)	emulsion and non-electric detonator
(C)	HANFO and safety fuse
(D)	PETN and electronic detonator

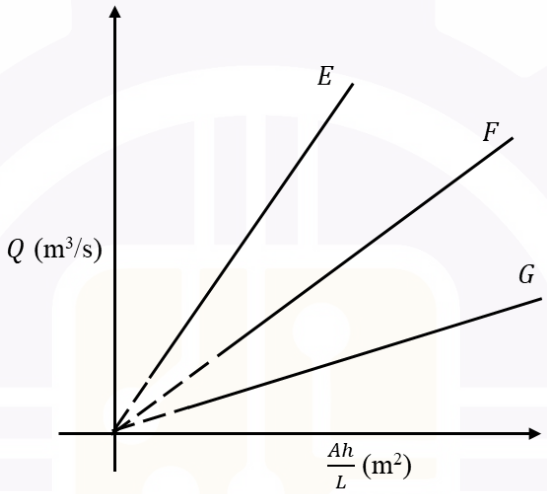
Q.18	The firing sequence in a drivage is shown. The charge per hole for Sections 1, 2, and 3 are 2.0 kg, 3.0 kg, and 1.0 kg, respectively, and the delay between each section is 25 milliseconds. The maximum charge per delay, in *kg*, is 
(A)	8.0
(B)	12.0
(C)	20.0
(D)	28.0

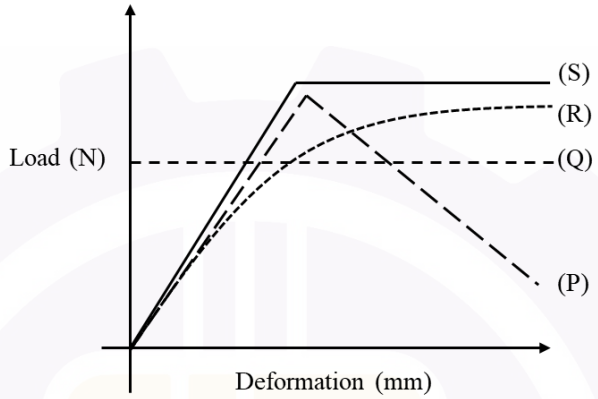
Q.19	The igneous intrusion along the bedding plane of the coal seam, as indicated by P, is known as 
(A)	dyke
(B)	washout
(C)	sill
(D)	seam split

Q.20	In remote sensing, the order of the wavelength bands of electromagnetic radiation used for data acquisition is
(A)	Visible < Near Infrared < Thermal Infrared < Microwave
(B)	Thermal Infrared < Near Infrared < Visible < Microwave
(C)	Microwave < Near Infrared < Thermal Infrared < Visible
(D)	Near Infrared < Thermal Infrared < Microwave < Visible

Q.21	A simply supported beam is shown. The location at which the zero shear force is acting on the beam is 
(A)	P
(B)	Q
(C)	R
(D)	S

Q.22	In a Slake Durability Index (SDI) test, a rock sample of 500 g undergoes two standard cycles of wetting and drying. The mass of the sample retained after the test is 400 g. The SDI of the sample, in %, is
(A)	10
(B)	40
(C)	20
(D)	80

Q.23	Results from the permeability test of rock samples, *E*, *F*, and *G* are shown. The correct order of hydraulic conductivity (*k*) of the rock samples is  Note: Q is water flow rate, A is area of cross-section of the sample, h is water head, L is length of the sample
(A)	$k_E > k_F > k_G$
(B)	$k_E < k_F < k_G$
(C)	$k_E = k_F = k_G$
(D)	$k_F > k_G > k_E$

Q.24	The ideal load – deformation characteristic curve of a hydraulic prop is 
(A)	P
(B)	Q
(C)	R
(D)	S

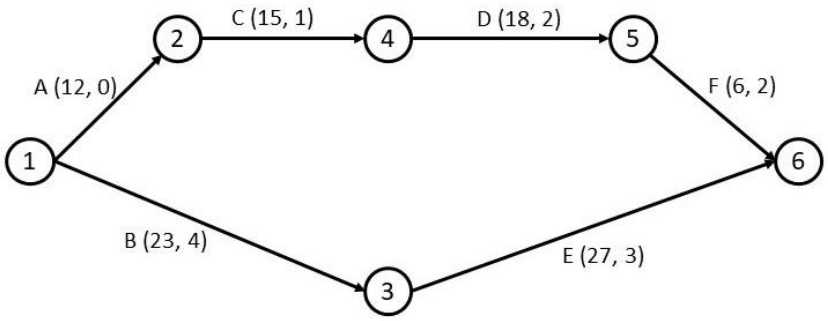
Q.25	A 20 m thick orebody is dipping at an angle of 75°. The orebody and host rock are strong. It is proposed to deploy a 150-200 mm diameter drill for production. The suitable stoping method is
(A)	block caving
(B)	long hole stoping
(C)	shrinkage stoping
(D)	post and pillar stoping

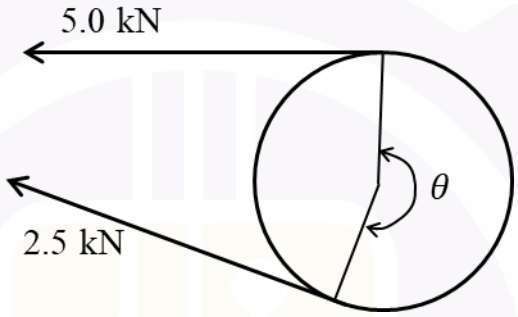
Q.26	A gradually expanding duct fitted to the outlet of an exhaust fan is known as
(A)	chimney
(B)	diffuser
(C)	evasee
(D)	equivalent orifice

Q.27	The cobweb-like appearance in the radiograph of the lung of a miner can be diagnosed as
(A)	silicosis
(B)	asbestosis
(C)	talcosis
(D)	coal workers' pneumokoniosis

Q.28	In firedamp explosion, the methane concentration in the stoichiometric methane-air mixture, in % by volume, is Assume the air contains 79 % nitrogen and 21 % oxygen, by volume.
(A)	5.4
(B)	9.5
(C)	10.8
(D)	14.8

Q.29	Which of the following statements about Fourier series is/are correct?
(A)	The Fourier series of an even function contains only cosine terms
(B)	The Fourier series of an odd function contains only cosine terms
(C)	The Fourier series of an odd function contains only sine terms
(D)	The Fourier series of an even function contains only sine terms

Q.30	A circular curve having radius of curvature 1000 m is set out by connecting two straights with a deflection angle of 60°. The apex distance, in *m*, is _____. (*rounded off to three decimal places*)
Q.31	The expected time (P days) and standard deviation (Q days) of the different activities (A to F) in a project are indicated in the network diagram as (P, Q). The standard deviation of the project completion time, in *days*, is _____. (*rounded off to one decimal place*) 
Q.32	The shaft of a motor rotating at 50 rev s^{-1} is uniformly retarded to 20 rev s^{-1} in 15 s. The number of complete rotations the shaft makes in the given time is _____. (*answer in integer*)
Q.33	In an underground mine, an airflow of 30 m^3 s^{-1} is delivered through a circular opening having a diameter of 5 m and a length of 500 m. Assuming that there is no change in the surface characteristics, the diameter of the opening, in *m*, required to double the quantity of airflow at same pressure loss is _____. (*rounded off to two decimal places*)
Q.34	In an underground mine atmosphere, the alcohol of a Kata thermometer took 60 s to fall from 38 °C to 35 °C. The Kata factor of the thermometer is 480 milli-calories cm^{-2}. The Kata cooling power, in $W\ m^{-2}$, is _____. (*rounded off to one decimal place*)

Q.35	A belt is wrapped around a pulley as shown. The coefficient of friction between the belt and pulley is 0.3. If there is no slippage between the belt and pulley, the angle of wrap (θ), in *degrees*, is _____. (*rounded off to two decimal places*) 

Q.36 – Q.65 Carry TWO marks Each

Q.36	The value of the determinant of the Hessian of $f(x,y)=x^2+y^2+xy-8x-7y$ at its stationary point is
(A)	2
(B)	3
(C)	4
(D)	5

Q.37	Given the data in the following Table, Newton's divided difference interpolation polynomial is $$y = b_0 + b_1(x-2) + b_2(x-2)(x-2.5).$$ If the values of b_0 and b_1 are 3 and 1, respectively, then the value of b_2 is x: 2.0, 2.5, 3.0 y: 3.0, 3.5, 5.0
(A)	2
(B)	3
(C)	4
(D)	5

Q.38	Given $\mathbf{x}=\begin{bmatrix}1\\2\\1\end{bmatrix}$, $\mathbf{b}=\begin{bmatrix}-16\\-3\\7\end{bmatrix}$, $\mathbf{P}^{-1}=\begin{bmatrix}e & -6 & -7\\ f & 9 & 11\\ -1 & -2 & g\end{bmatrix}$ and $\mathbf{P}\mathbf{x}=\mathbf{b}$ If $\mathbf{P}\mathbf{y}=\mathbf{d}$ with $\mathbf{y}=\begin{bmatrix}y_1\\y_2\\y_3\end{bmatrix}$ and $\mathbf{d}=\begin{bmatrix}-16\\0\\7\end{bmatrix}$, the value of y_2 is
(A)	29
(B)	27
(C)	25
(D)	5

Q.39 Match the type of rock with its metamorphic form.

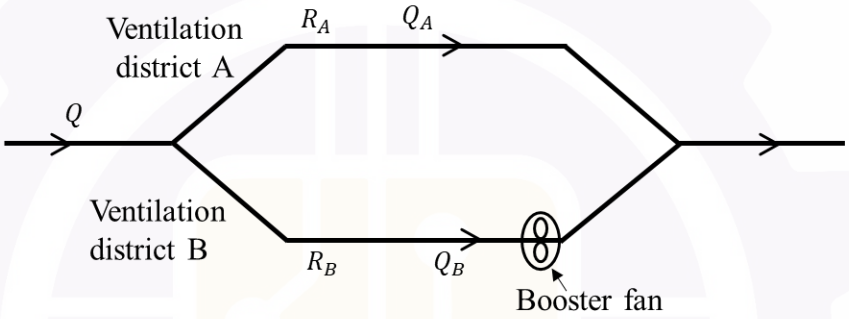
Igneous/Sedimentary rock	Metamorphic rock
(P) Shale	(1) Gneiss
(Q) Limestone	(2) Quartzite
(R) Granite	(3) Marble
(S) Sandstone	(4) Slate

(A) $P \rightarrow 4, Q \rightarrow 3, R \rightarrow 1, S \rightarrow 2$

(B) $P \rightarrow 3, Q \rightarrow 1, R \rightarrow 4, S \rightarrow 2$

(C) $P \rightarrow 4, Q \rightarrow 3, R \rightarrow 2, S \rightarrow 1$

(D) $P \rightarrow 3, Q \rightarrow 4, R \rightarrow 2, S \rightarrow 1$

Q.40	In an underground coal mine, the air quantities Q_A and Q_B passes through ventilation districts A and B, respectively as shown, with a pressure drop of ΔP across them. The air quantity in district B is to be increased to Q'_B by installing a booster fan, as shown, without affecting the air quantity in ventilation district A. The capacity of booster fan (P_B) can be expressed as 
(A)	$P_B = \Delta P\left(\frac{Q_B}{Q'_B}\right)^2 - \Delta P$
(B)	$P_B = \Delta P\left(\frac{Q'_B}{Q_B}\right)^2 - \Delta P$
(C)	$P_B = \Delta P - \Delta P\left(\frac{Q'_B}{Q_B}\right)^2$
(D)	$P_B = \Delta P + \Delta P\left(\frac{Q'_B}{Q_B}\right)^2$

Q.41 Match the shaft sinking method with its applicability.

Shaft sinking method	Applicability
(P) Piling system	(1) Strata consisting of alternate strong and loose soil, and drum sinks down by its own weight
(Q) Caisson method	(2) Sinking through the loose ground near the surface
(R) Cementation	(3) Heavily watery strata, including quick sand
(S) Freezing	(4) Fissured water bearing strata without running sand

(A) P $\rightarrow$ 2, Q $\rightarrow$ 3, R $\rightarrow$ 4, S $\rightarrow$ 1

(B) P $\rightarrow$ 4, Q $\rightarrow$ 1, R $\rightarrow$ 2, S $\rightarrow$ 3

(C) P $\rightarrow$ 2, Q $\rightarrow$1, R $\rightarrow$ 4, S $\rightarrow$ 3

(D) P $\rightarrow$ 4, Q $\rightarrow$ 3, R $\rightarrow$ 2, S $\rightarrow$ 1

Q.42 A shovel needs to be selected from four models of different capacities, S1 to S4, for loading of dumpers. The operational data for the shovel-dumper combination are provided. The mean arrival rate of the dumpers at the loading point is 5 per hour and the waiting cost of dumper is ₹ 200 per hour. The inter-arrival time of dumpers and loading time of shovel follows exponential distribution. Ignoring the shovel hiring cost, the shovel type that will have minimum total cost (waiting and operating cost) is

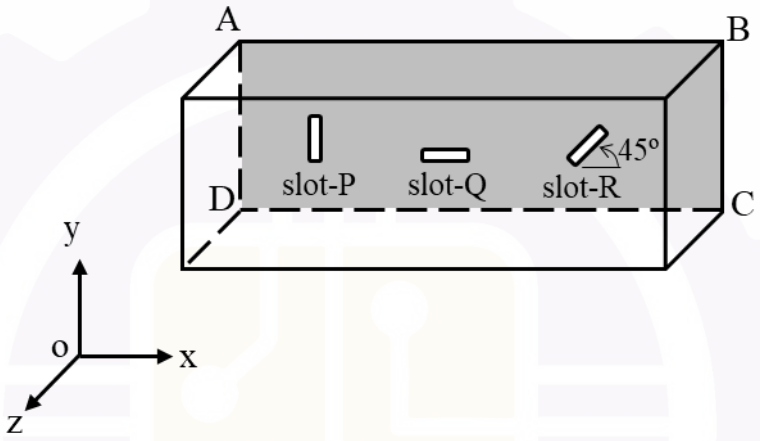
Model	Operating cost of shovel (₹ per hour)	Mean loading rate of shovel (number of dumpers per hour)
S1	800	8
S2	850	9
S3	920	10
S4	1000	11

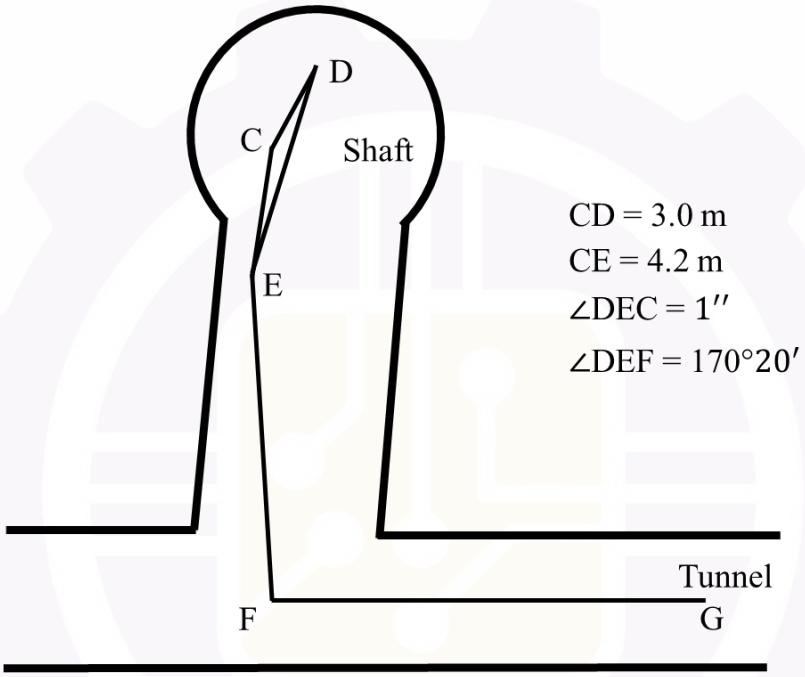
(A) S1

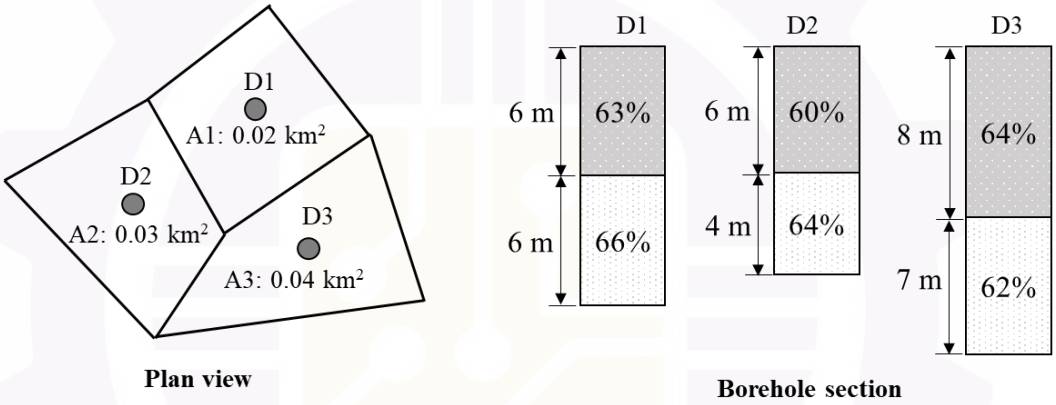
(B) S2

(C) S3

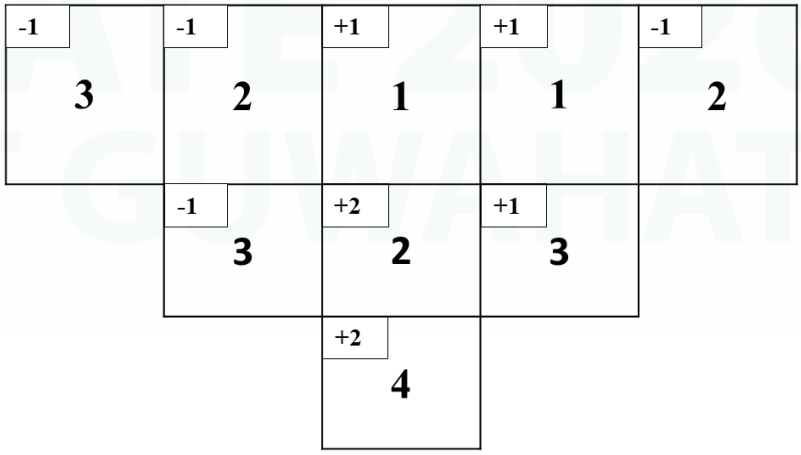
(D) S4

Q.43	The *in-situ* stresses are determined by Flat-jack method by making three slots (P, Q, and R) on the wall (ABCD) of a mine gallery as shown. The *in-situ* stresses σ_P, σ_Q, and σ_R are determined at slot-P, slot-Q, and slot-R, respectively. If $\sigma_P > \sigma_Q$, and $\sigma_R = 0$, the shear stress on the wall is 
(A)	$\frac{\sigma_P + \sigma_Q}{2}$
(B)	$\frac{\sigma_P - \sigma_Q}{2}$
(C)	$-\left(\frac{\sigma_P + \sigma_Q}{2}\right)$
(D)	$-\left(\frac{\sigma_P - \sigma_Q}{2}\right)$

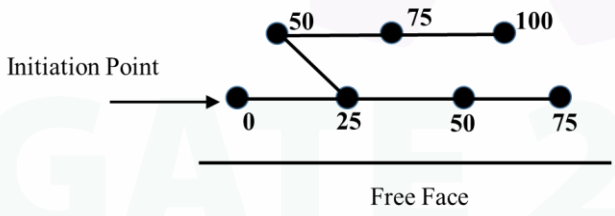
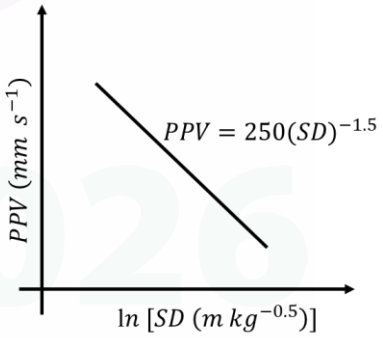
Q.44	The observations from a correlation survey are shown. If the coordinates of points C and D are (East: 375 m, North: 1120 m) and (East: 376 m, North: 1121 m), respectively, the whole circle bearing of the line EF is 
(A)	215°19′59.6″
(B)	35°19′59.6″
(C)	215°20′1.4″
(D)	35°20′1.4″

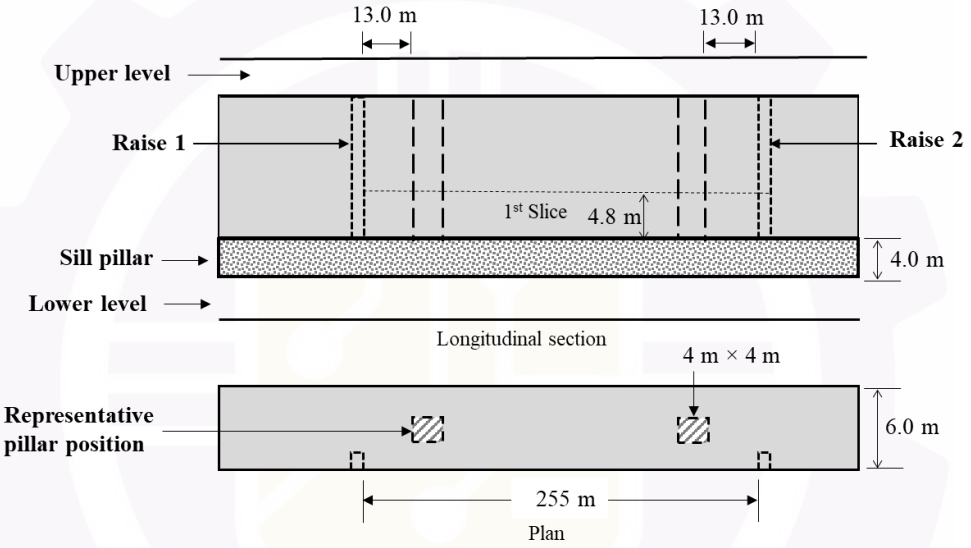
Q.45	A closed-circuit self-contained breathing apparatus (SCBA) contains 2 liters of O_2 at 200 bar. If a miner consumes O_2 at a rate of 2 liters min^{-1}, the maximum duration that the apparatus can supply O_2, in *min*, is _____. (*answer in integer*)
Q.46	The borehole data for resource estimation for an iron ore deposit are shown. The average grade of the deposit, in %, is _____. (*rounded off to two decimal places*)  Index: D1 to D3: Exploratory Borehole ID A1 to A3: Corresponding Polygonal Area
Q.47	A mine workshop needs to assign 4 jobs to 4 service engineers. The cost for performing a job by an individual service engineer is given. A typical job can be assigned to only one service engineer. If the service engineer S1 cannot perform the job J3, and S3 cannot perform the job J4, the optimal cost for completion of jobs is _____. (*answer in integer*)

Service Engineer	Job			
	J1	J2	J3	J4
S1	50	50	---	20
S2	70	40	20	70
S3	90	30	50	---
S4	70	20	60	30

Q.48	Using linear regression (least squares), the best-fit line for the given dataset is $y = 2.2x + 2.3$. Given the residual sum of squares is 25.8, the coefficient of determination (r^2), is _____ . (*rounded off to two decimal places*) | x | 2 | 3 | 4 | 5 | | y | 8 | 9 | 7 | 16 |
Q.49	A plug dam is to be constructed in a mine gallery of size 3.5 m × 2.5 m. The interfacial shear strength between the surrounding rock and plug dam is 1.0 MPa. The minimum thickness of the dam, in *m*, to withstand a water pressure of 10.0 MPa, is _____. (*rounded off to two decimal places*)
Q.50	A shovel costing (P) ₹ 20 crores has a salvage value (S) of ₹ 2 crores with a useful life (n) of 10 years. The annual depreciation is evaluated using declining balance method as given by $$Depreciation\ rate = 1 - (S/P)^{1/n}$$ The depreciated cost of the shovel, in *crores*, in its 2nd year is ₹ _____. (*rounded off to two decimal place*)
Q.51	An economic block model along with extraction sequence is shown. The numbers given at the centre of the block represent the year of extraction, and that at the corners represent the block economic value in ₹ (lakhs). If the discount rate is 10%, the net present value (NPV), in *lakhs*, is ₹_____. (*rounded off to two decimal place*) 

Q.52	A main mechanical ventilator installed for an underground mine develops a pressure of 25 mm wg. A natural ventilation pressure (NVP) of 15 mm wg acting in the mine aids the ventilator, and a total 500 $m^3\ min^{-1}$ of air is circulated in the mine. Considering the same NVP aiding the ventilator, the pressure required, in *mm wg*, to be generated by the ventilator to circulate 1000 $m^3\ min^{-1}$ of air, is _____. (*answer in integer*)
Q.53	Dust particles from a blasting operation rise up in the atmosphere to a height of 500 m. The viscosity of air is 1.80×10^{-5} kg $m^{-1}\ s^{-1}$. Assume the particles have quiescent settling (no turbulence) in atmosphere. Neglecting air density, the settling time, in *days*, of a dust particle of 2.5 µm diameter and 3600 kg m^{-3} density is _____. (*rounded off to two decimal places*)
Q.54	In a biochemical oxygen demand (BOD) test, 15 ml of wastewater sample was diluted with distilled water to completely fill a 300 ml BOD bottle and incubated at 20 °C for 5 days. The dissolved oxygen (DO) level before and after incubation are 9.2 mg $liter^{-1}$ and 4.4 mg $liter^{-1}$, respectively. The BOD of the sample, in *mg* $liter^{-1}$, is _____. (*answer in integer*)
Q.55	A rake of wagons, with inter-wagon gap of 100 cm, is moving at a speed of 0.4 km per hour under a silo loading system. The dimensions of the wagon are 8 m (L) × 3 m (W) × 3 m (H). The silo stops discharging the material between the wagons. Considering the fill factor of the wagon as 0.95 and the bulk density of coal as 1.2 tonne per cubic meter, the loading rate of the silo, in *tonne per hour*, is _____. (*rounded off to nearest integer*)
Q.56	A turbine pump is designed to generate water head of 60 m. The impeller speed of the pump is 2000 rpm and the manometric efficiency is 70%. Neglecting the impeller blade curvature, the impeller diameter of the pump, in *cm*, is _____. (*rounded off to two decimal places*)

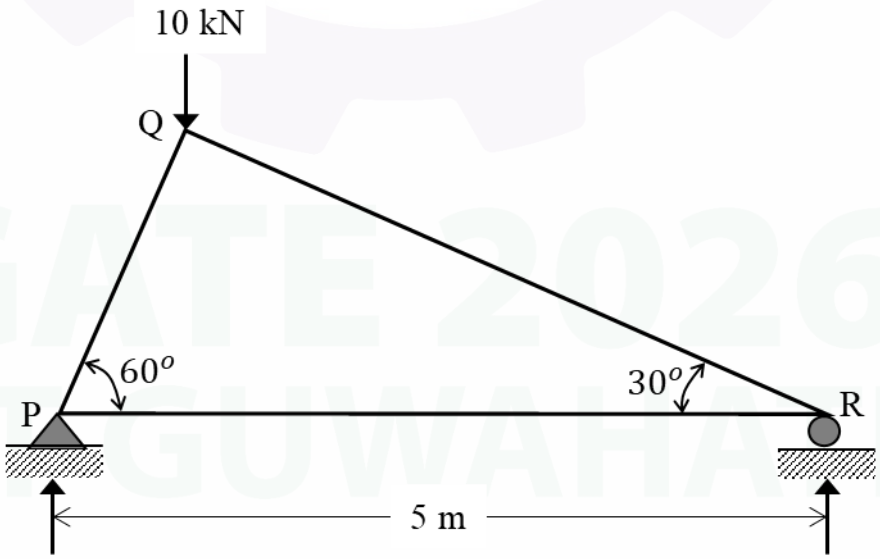
Q.57	The information for a dragline operation is given: Bucket capacity: 20 m^3 Bucket fill factor: 0.9 Digging and filling time: 20 s Swinging (to and fro) time: 32 s Dumping time: 10 s Dragline utilization: 90% The output of the dragline, in $m^3\ h^{-1}$, is _____. (*rounded off to one decimal place*)
Q.58	In a bench blasting, as shown, 49 kg of explosive is put in each hole. The detonation time of holes, in millisecond, and the associated scale distance (*SD*) vs. peak particle velocity (*PPV*) plot for the given blast pattern is shown. The *PPV* at a distance of 100 m, in $mm\ s^{-1}$, is _____. (*rounded off to two decimal places*)  

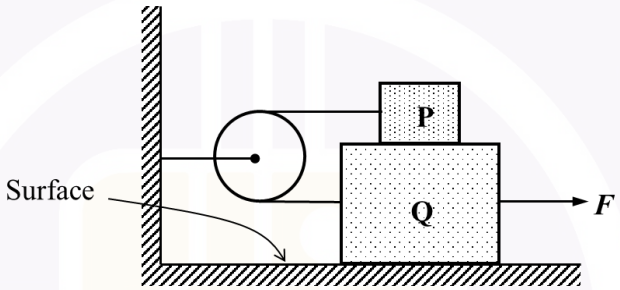
Q.59	A regular shaped cut and fill stope is shown. Pillars of size 4 m × 4 m are left at an interval of 13 m along the length of the stope. If the density of the mined ore is 2.5 tonne m^{-3}, and slices are extracted to the full stope width, the total tonnage of ore recovered from the 1st slice of the stope is _____ $\times 10^3$. (*rounded off to one decimal place*) 
Q.60	A coal seam of 2.4 m thickness is mined with a DERD shearer at a cutting speed of 0.6 km h^{-1} . The web depth of the cut is 0.5 m. The average cross-sectional area of coal on the AFC during transportation is 0.24 m^2. For the evacuation of cut coal from the face with 10% spillage, the required minimum velocity of the AFC, in $m\ s^{-1}$, is _____. (*rounded off to two decimal places*)
Q.61	A bord and pillar panel has 24 developed pillars of size 40 m × 40 m (centre to centre) under extraction. The following information is given: Gallery width = 4 m Extraction height = 3 m Extraction ratio during depillaring = 80% Specific gravity of coal = 1.4 Incubation period = 6 months Average working days per month = 25 In order to extract the panel within the incubation period, the minimum rate of production, in *tonne per day*, is _____. (*rounded off to one decimal place*)

Q.62 Following observations were taken using a Tacheometer with staff held vertical. The additive and multiplying constants of the instrument are 0 and 100, respectively. The reduced level (RL) of the staff station R, in *m*, is _____. (*rounded off to two decimal places*)

Instrument station	Staff station	Staff reading (m)	Vertical angle	Remarks
P	Q	1.4, 2.7, 3.9	7°	RL of Q = 102 m
	R	2.1, 2.8, 3.6	5°	

Q.63 A truss PQR carries vertical load of 10 kN at Q as shown. The force in member PR, in *kN*, is _____. (*rounded off to two decimal places*)



Q.64	Two blocks P and Q weighing 100 kN and 200 kN, respectively, are connected by a string passing through a massless and frictionless pulley as shown. The friction coefficient between blocks P and Q is 0.4, and that between block Q and surface is 0.3. The minimum force, ***F***, in *kN*, required to pull the block Q, is _____. (*answer in integer*) 
Q.65	In a uniaxial compressive strength test, a 120 Ω strain gauge of gauge factor 2.0 is pasted on the rock sample as shown. At the end of the test, the change in resistance of the strain gauge is 0.5 Ω. The longitudinal deformation of the sample, in *mm*, is _____. (*rounded off to two decimal places*)