Q. 1 – Q. 5 carry one mark each.

Q.1   John Thomas, an _____ writer, passed away in 2018.

(A) imminent   (B) prominent
(C) eminent   (D) dominant

Q.2   _____ I permitted him to leave, I wouldn't have had any problem with him being absent,
_____ I?

(A) Had, wouldn't   (B) Have, would
(C) Had, would   (D) Have, wouldn't

Q.3   A worker noticed that the hour hand on the factory clock had moved by 225 degrees during
her stay at the factory. For how long did she stay in the factory?

(A) 3.75 hours   (B) 4 hours and 15 mins
(C) 8.5 hours   (D) 7.5 hours

Q.4   The sum and product of two integers are 26 and 165 respectively. The difference between
these two integers is _____.

(A) 2   (B) 3   (C) 4   (D) 6

Q.5   The minister avoided any mention of the issue of women's reservation in the private sector.
He was accused of _____ the issue.

(A) collaring   (B) skirting
(C) tying   (D) belting

Q. 6 – Q. 10 carry two marks each.

Q.6   Under a certain legal system, prisoners are allowed to make one statement. If their
statement turns out to be true then they are hanged. If the statement turns out to be false
then they are shot. One prisoner made a statement and the judge had no option but to set
him free. Which one of the following could be that statement?

(A) I did not commit the crime
(B) I committed the crime
(C) I will be shot
(D) You committed the crime

Q.7   A person divided an amount of Rs. 100,000 into two parts and invested in two different schemes. In one he got 10% profit and in the other he got 12%. If the profit percentages are interchanged with these investments he would have got Rs.120 less. Find the ratio between his investments in the two schemes.

(A) 9 : 16   (B) 11 : 14   (C) 37 : 63   (D) 47 : 53

Q.8   Congo was named by Europeans. Congo's dictator Mobuto later changed the name of the country and the river to Zaire with the objective of Africanising names of persons and spaces. However, the name Zaire was a Portuguese alteration of *Nzadi o Nzere*, a local African term meaning 'River that swallows Rivers'. Zaire was the Portuguese name for the Congo river in the 16th and 17th centuries.
Which one of the following statements can be inferred from the paragraph above?

(A) Mobuto was not entirely successful in Africanising the name of his country
(B) The term *Nzadi o Nzere* was of Portuguese origin
(C) Mobuto's desire to Africanise names was prevented by the Portuguese
(D) As a dictator Mobuto ordered the Portuguese to alter the name of the river to Zaire

Q.9   A firm hires employees at five different skill levels P, Q, R, S, T. The shares of employment at these skill levels of total employment in 2010 is given in the pie chart as shown. There were a total of 600 employees in 2010 and the total employment increased by 15% from 2010 to 2016. The total employment at skill levels P, Q and R remained unchanged during this period. If the employment at skill level S increased by 40% from 2010 to 2016, how many employees were there at skill level T in 2016?

Percentage share of skills in 2010
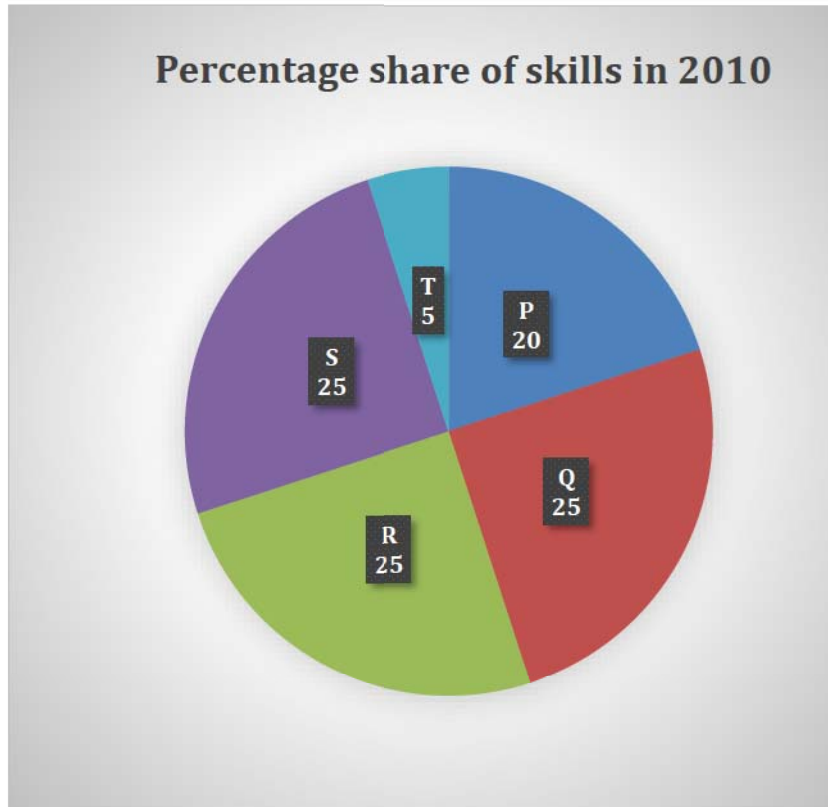
(A) 30   (B) 35   (C) 60   (D) 72

Q.10 M and N had four children P, Q, R and S. Of them, only P and R were married. They had children X and Y respectively. If Y is a legitimate child of W, which one of the following statements is necessarily FALSE?

(A) M is the grandmother of Y
(B) R is the father of Y
(C) W is the wife of R
(D) W is the wife of P

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 Shear strength of rock joint is NOT dependent on

(A) applied normal stress   (B) applied shear stress
(C) friction angle of the joint plane   (D) cohesion of the joint plane

Q.2 If $f(x)$ is a polynomial function that passes through origin, and $g(x) = f'(x)$, then

(A) $g'(a) = f(a)$ (B) $g'(a) = f'(a)$

(C) $\int_0^a g(x)dx = f(a)$ (D) $\int_0^a f(x)dx = g(a)$

Q.3 A flat longwall panel is mined out at an area having subsidence factor a. The measured maximum subsidence on the surface is S for a mining height of m. The subsidence is subcritical if

(A) $S = am$ (B) $S = m/a$ (C) $S > am$ (D) $S < am$

Q.4 The PV diagram of four explosives is given below. The preferred explosive for adequate fragmentation in hard and brittle rock is
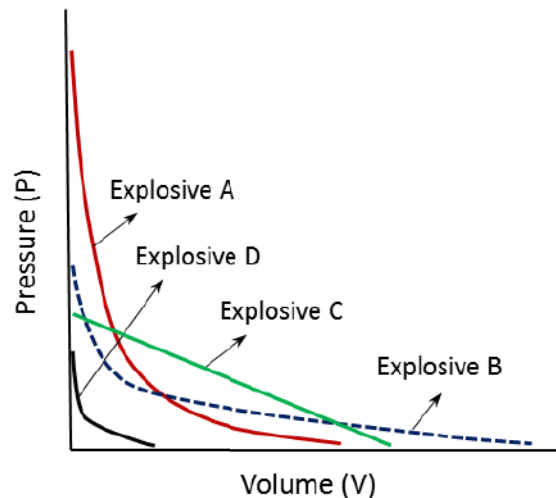

(A) Explosive A   (B) Explosive B
(C) Explosive C   (D) Explosive D

Q.5 As per classification of mineral resources "reserve" means

(A) Identified resources
(B) Identified and techno-economically viable resources
(C) Hypothetical resources
(D) Inferred resources

Q.6 If the sample statistic $\bar{X}$ is an unbiased estimator of the parameter μ, then

(A) $E(\mu - \bar{X}) = 0$ (B) $E(\mu + \bar{X}) = 0$

(C) $E(\mu - \bar{X})^2 = 0$ (D) $E(\mu + \bar{X})^2 = 0$

Q.7 The vector sum of all the external forces acting on a rigid body is expressed as $\sum \mathbf{F}$ and the vector sum of moments of the external forces about a point is given as $\sum \mathbf{M}$. The rigid body is in equilibrium if

(A) $\sum \mathbf{F} - \sum \mathbf{M} = 0$ (B) $\sum \mathbf{F} + \sum \mathbf{M} = 0$

(C) $\sum \mathbf{F} = 0$ and $\sum \mathbf{M} = 0$ (D) $\sum \mathbf{F} \neq 0$ and $\sum \mathbf{M} \neq 0$

Q.8 For a regionalized variable $Z(x)$, at a lag distance h, the empirical semi-variogram $\gamma(h)$ is given by

(A) $E[Z(x) - Z(x+h)]^2$

(B) $\dfrac{1}{2} E[Z(x) - Z(x+h)]^2$

(C) $\dfrac{1}{2} E\big[\{Z(x) - E(Z(x))\} \times \{Z(x+h) - E(Z(x+h))\}\big]$

(D) $E\big[\{Z(x) - E(Z(x))\} \times \{Z(x+h) - E(Z(x+h))\}\big]$

Q.9 The coefficient of variation of a dataset is defined as

(A) $\dfrac{\text{Mean}}{\text{Standard Deviation}}$ (B) $\dfrac{\text{Mean}}{\text{Variance}}$

(C) $\dfrac{\text{Variance}}{\text{Mean}}$ (D) $\dfrac{\text{Standard Deviation}}{\text{Mean}}$

Q.10 In project planning, the activity durations are calculated by PERT and CPM techniques assuming

(A) PERT: probabilistic, CPM: deterministic
(B) PERT: probabilistic, CPM: probabilistic
(C) PERT: deterministic, CPM: probabilistic
(D) PERT: deterministic, CPM: deterministic

Q.11 Respirable dust in an underground coal mine contains 4.5% free silica. As per the CMR 2017, the maximum allowable respirable dust concentration, in mg/m^3, in the mine air is

(A) 1.5   (B) 2.0   (C) 2.5   (D) 3.0

Q.12 The purpose of rotating a whirling hygrometer in hygrometric survey is to

(A) wet the cotton wick with water thoroughly
(B) maintain constant temperature of water in the container
(C) create steady state evaporation of moisture from the wet bulb surface
(D) prevent the heat produced by the cap lamp of the observer from affecting the readings

Q.13 Stone dust barriers in underground coal mines are used to arrest

(A) black damp explosions
(B) air blast
(C) firedamp explosions
(D) coal dust explosions

Q.14 The correct sequence of attachments between the winding rope and the cage in a drum winding system is

(A) Triangular plate → Rope capel → Bull chain → Detaching hook → Cage chain
(B) Rope capel → Bull chain → Triangular plate → Detaching hook → Cage chain
(C) Detaching hook → Rope capel → Bull chain → Cage chain → Triangular plate
(D) Rope capel → Detaching hook → Bull chain → Triangular plate → Cage chain

Q.15 The functions of automatic contrivances in a winding system are to prevent

(A) over-speeding and over-winding
(B) slow banking and load balancing
(C) over loading and load balancing
(D) over-speeding and load balancing

Q.16 A low-grade deep-seated ore body dipping at 70° has a strike length of 2 km, and width of 100 m. The ore body and wall rocks are weak and fractured. The preferred method of mining is

(A) shrinkage stoping
(B) cut-and-fill stoping
(C) block caving
(D) room and pillar stoping

Q.17 If the figures A and B represent contour plots in a terrain, then the correct statement is
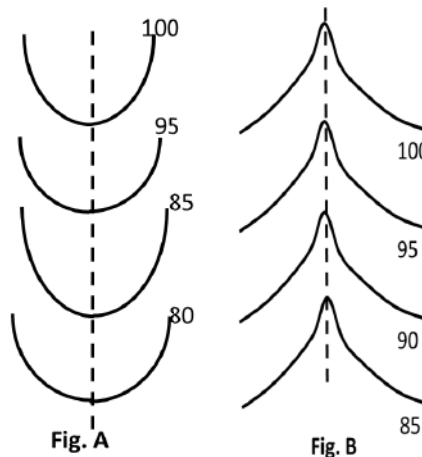
Fig. A   Fig. B

(A) Fig. A shows ridge and Fig. B shows valley
(B) Fig. A shows anticline and Fig. B shows syncline
(C) Fig. A shows syncline and Fig. B shows anticline
(D) Fig. A shows valley and Fig. B shows ridge.

Q.18 The availability of water in the root zone for plant use is maximum in the case of

(A) sand
(B) loam
(C) clay
(D) gravel

Q.19   If the time to failure of a machine component is exponentially distributed, the reliability of the same at Mean Time To Failure (MTTF), (*rounded off to three decimal places*), is _____.

Q.20   The major and minor principal stresses at a point are 25 MPa and -5 MPa respectively. The maximum shear stress, in MPa at that point is _____.

Q.21   For a function $f(x)$, $f(1) = 5$ and $f'(1) = -5$. Ignoring all higher order terms in Taylor series, the value of the function at $x = 1.01$ (*rounded off to two decimal places*) is _____.

Q.22   Proximate analysis of a coal sample gives 2.46% moisture, 25.73% volatile matter, and 42.89% ash. The volatile matter of the coal sample, in percentage, on dry ash free (daf) basis (*rounded off to two decimal places*) is _____.

Q.23   A coarse sand aquifer has porosity 20% and hydraulic conductivity 3.5×10^{-3} m/s. If the hydraulic gradient is 0.00423 (m/m), then the average linear velocity of the groundwater in mm/s, (*rounded off to three decimal places*) is _____.

Q.24   In a slake durability test, mass of the drum with samples before the test and mass of the drum with oven-dried samples after the test are 1.52 kg and 1.48 kg respectively. If the mass of the drum is 1.05 kg, slake durability index in percentage (*rounded off to two decimal places*) is _____.

Q.25   The ionic concentration of a mine water sample with pH close to 7.0 is given below. The alkalinity of the water expressed as equivalent $CaCO_3$, in mg/l, (*rounded off to two decimal places*) is _____.

Cations	mg/l	Anions	mg/l
Ca^{2+}	95.0	HCO_3^-	160.0

Q. 26 – Q. 55 carry two marks each.

Q.26 From an elevated point A, when a stone is thrown vertically, it attains an upward velocity of v at a height of h from the point A. While falling, its downward velocity becomes $2v$ at a distance h below the point A. The maximum height attained by the stone from point A is

(A) $5h/3$ (B) $4h/3$ (C) $6h/7$ (D) $2h$

Q.27 Water is pumped through a steel pipe of diameter 200 mm at a flow rate of 30 l/s. If the dynamic viscosity of water is 10^{-3} Pa.s, the Reynolds number of the flow is

(A) 2.83×10^3 (B) 2.83×10^4 (C) 1.91×10^5 (D) 1.91×10^6

Q.28 Matrix $\mathbf{A} = \begin{pmatrix} 0 & 2\beta & \gamma \\ \alpha & \beta & -\gamma \\ \alpha & -\beta & \gamma \end{pmatrix}$ is orthogonal. The values of α, β and γ respectively are

(A) $\pm \dfrac{1}{\sqrt{3}},\ \pm \dfrac{1}{\sqrt{2}},\ \pm \dfrac{1}{\sqrt{6}}$

(B) $\pm \dfrac{1}{\sqrt{3}},\ \pm \dfrac{1}{\sqrt{6}},\ \pm \dfrac{1}{\sqrt{2}}$

(C) $\pm \dfrac{1}{\sqrt{6}},\ \pm \dfrac{1}{\sqrt{3}},\ \pm \dfrac{1}{\sqrt{2}}$

(D) $\pm \dfrac{1}{\sqrt{2}},\ \pm \dfrac{1}{\sqrt{6}},\ \pm \dfrac{1}{\sqrt{3}}$

Q.29 Match the following based on the equipment usage in a comminution circuit:

Equipment	Usage
P. Gyratory crusher	1. Secondary crushing
Q. Cone crusher	2. Grinding
R. Ball mill	3. Sizing
S. Grizzly	4. Primary crushing

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

Q.30 Match the following for coal mining operation:

Mining Method	Mode of Extraction	Loading/Conveying Equipment
P. Longwall	A. Cutting by continuous miner	1. AFC
Q. Mechanized bord and pillar	B. Drilling and blasting	2. LHD
R. Semi-mechanized bord and pillar	C. Cutting by shearer	3. Apron loader and gathering arm
S. Blasting gallery	D. Long hole drilling and blasting	4. SDL

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

Q.31 In the context of mine planning, match the following:

Technique/ Algorithm	Preferred Application
P. Lerchs-Grossman algorithm	1. Ultimate pit limit
Q. Kriging	2. Cut-off grade optimization
R. Lane's theory	3. Mine life
S. Taylor's rule	4. Reserve estimation

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

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

Q.32 The figures shown represent the analysis of gas samples collected from a sealed off area in a coal mine over a period of time. The best representation of the progressive change of gaseous environment inside the sealed-off area is
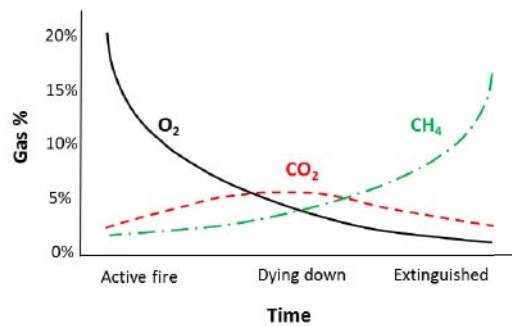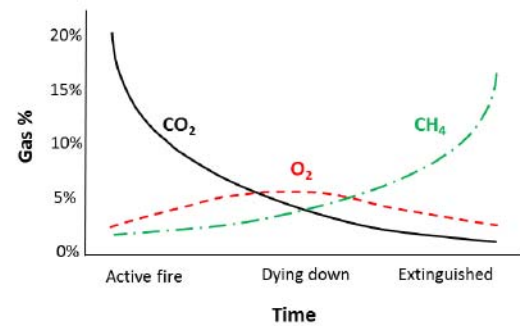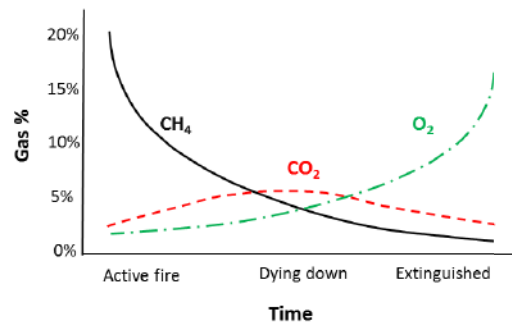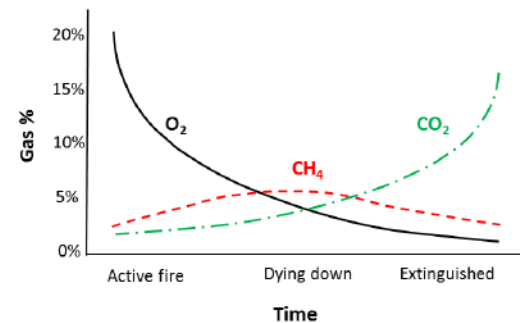
Figure P

Figure Q

Figure R

Figure S

(A) Figure P   (B) Figure Q   (C) Figure R   (D) Figure S

Q.33   The net annual cash flows for two small scale mining projects A and B are given below. The correct decision assuming 10% discount rate as per NPV criterion is

Annual Cash flow (in Rs. Crore)

Period in years	Project A	Project B
0	-200	-300
1	0	0
2	200	100
3	140	150
4	0	200

(A) Project A is accepted but project B is rejected
(B) Projects A and B both are rejected
(C) Project A is rejected but project B is accepted
(D) Projects A and B are both accepted but project A is better than project B

Q.34   Match the following features with the mining methods:

	Features		Mining method
P	Ring Drilling	1	Vertical crater retreat method
Q	Grizzly sublevel	2	Sublevel stoping
R	Spherical charge blasting	3	Underhand cut-and-fill stoping
S	Cemented hydraulic fill	4	Block caving method

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

Q.35   If area S, in the x-y plane, is bounded by a triangle with vertices $(0, 0)$, $(10, 1)$ and $(1, 1)$, the value of $\iint\limits_{S} \sqrt{xy - y^2}\, dxdy$ is _____.

Q.36   A double ended ranging drum shearer operates in a longwall retreating panel. The following data are provided:

Face length	: 200 m	Average cutting speed	: 1.5 m/min
Web depth	: 0.6 m	Average flitting speed	: 4.0 m/min
Cutting height	: 2.5 m	Number of shifts/day	: 3
Density of coal	: 1.4 tonne/m³		

Method of cutting is unidirectional and each shift requires a non-operational time of 2.0 hours. The production per day in tonne (*rounded off to one decimal place*) is _____.

Q.37   In the linear programming problem,
        Maximize $Z = 48X_1 + 36X_2$
        Subject to:

$$X_1 \leq 5$$
$$X_2 \leq 8$$
$$2X_1 + \frac{4}{3}X_2 \leq 16$$
$$X_1 + X_2 = 10$$
$$X_1 \geq 4, \text{ and}$$
$$X_1 \geq 0, X_2 \geq 0$$

The value of Z is _____ .

Q.38   A shovel operates 300 days in a year, 2 shifts in a day, and 4 hours in a shift to achieve the target production of 30 Million tonne per annum. The following parameters relate to the loading operations:

Bucket capacity of shovel   : 15 m^3
Shovel cycle time   : 44 s
Bucket fill factor   : 0.85
Bulk density of the muck   : 3.00 tonne/m^3

The minimum number of shovels required to achieve the production is _____ .

Q.39   A set of tubs is pulled by a 15 tonne diesel locomotive at a gradient of 1 in 100 with an acceleration of 0.05 m/s^2. The coefficient of adhesion between the wheel and the track is 0.2 and the frictional resistance coefficient is 0.01. The maximum mass, in tonne, the locomotive can pull (*rounded off to one decimal place*) is _____ .

Q.40   The characteristic curves of two mine fans installed in series in a fan drift are $P = 2000 - 6Q - 0.2Q^2$ and $P = 3000 - 8Q - 0.2Q^2$ where P is pressure in Pa and Q is quantity in m^3/s. If the mine quantity is 70 m^3/s, the mine resistance, in Ns^{2}m^{-8}, (*rounded off to two decimal places*) is _____ .

Q.41   Three equipment A, B, and C located side by side and operating simultaneously produce a sound power level of 77.5 dB. The sound power levels of A and B are 68 dB and 70 dB respectively. The sound power level of C (*rounded off to one decimal place*) in dB, is _____ .

Q.42   The main surface fan of a mine as shown in the figure, has characteristic curve approximated by $P = 1700 - 10Q$, where P is pressure in Pa and Q is quantity in m^3/s. A booster fan is installed in section A such that there is no air flow in section B. The operating pressure of the main surface fan, in Pa, (*rounded off to two decimal places*) is _____.
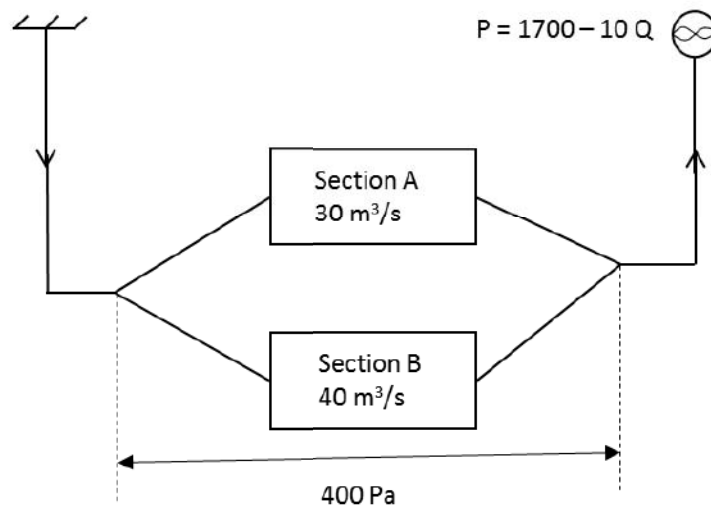
Q.43   Two points A and B are located 150 m apart in the East-West orientation on the bank of a river as shown in the figure. Considering a station C on the north bank the bearings of AC and BC are observed to be 42^0 and 335^0 respectively. The width of the river, in m, (*rounded off to two decimal places*) is _____.
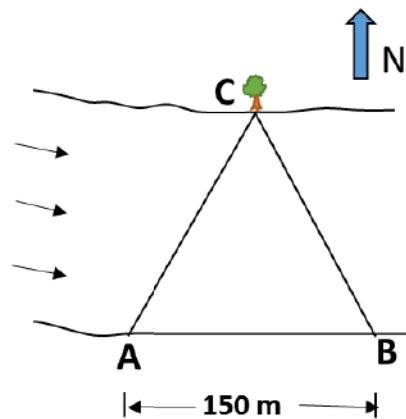

Figure not to scale

Q.44   If $x = 3^{1/3} + 3^{-1/3}$, the value of $3x^3 - 9x - 10$ is _____.

Q.45   A pump delivers 3000 liter of water in 2.0 minutes through a pipe of length 1000 m laid on a gradient of 1 in 10. The combined efficiency of pump and motor is 70%. If friction and shock losses are negligible, the input power to the motor in kW (*rounded off to one decimal place*) is _____.

Q.46   A sand water slurry of specific gravity 1.45 contains sand of grain density 2.6 g/cc. The weight percent of sand in the slurry (*rounded off to two decimal places*) is _____.

Q.47   For a mining company the unit transportation cost from a mine to a washery, and supply and demand are shown below:

		Washery				Supply
		A	B	C	D	
Mine	M1	30	0	40	20	500
	M2	24	16	22	40	700
	M3	0	32	28	36	800
Demand		300	400	600	700	

The total cost of transportation using the Vogel's approximation method is _____.

Q.48   In a bord and pillar panel, 6 square pillars are developed as shown in the figure below. The depth of the seam is 300 m and the average unit weight of overburden rock is 25 kN/m^3. If the pillar strength is 15 MPa, the safety factor of the shaded pillar zone (*round off to two decimal places*) is _____.
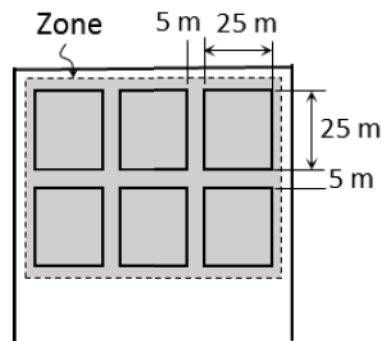

Q.49   Water enters a sump having the shape of an inverted frustum at a rate of 500 m^3/h. The sump is initially filled up to 2.0 m height. The time taken in days to fill the remaining part of the sump (*rounded off to one decimal places*) is _____.
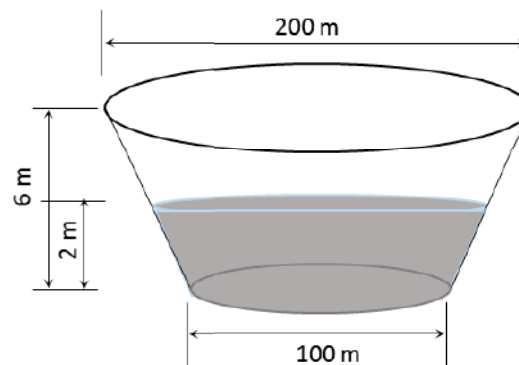
Q.50   The uniaxial stress-strain behavior of a rock sample is shown in the figure. The elastic modulus E is 20,000 MPa. If ε_p is the plastic strain, the value of the damage parameter D (*rounded off to two decimal place*) is _____.
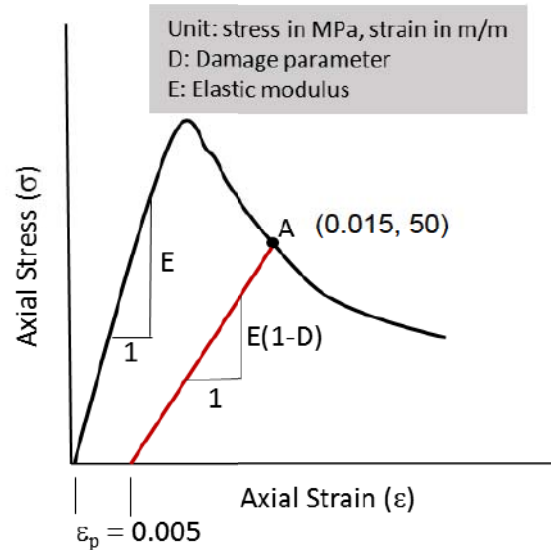
Q.51   The insitu stress field around a circular tunnel is shown in the figure. Points A and B are located at the boundary of the tunnel. If the tangential stress at Point A is 3 times of that at Point B, the value of insitu stress ratio, k is _____.
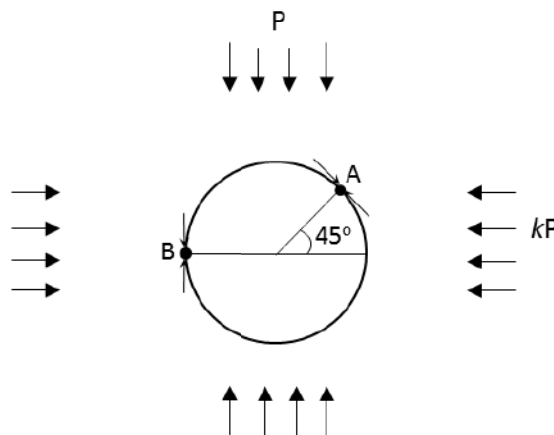
Q.52   Data related to explosive and blasthole are given below. Assuming 1 kcal to be 4.2 kJ, the power of explosive in GW in the blasthole (*round off to one decimal place*) is _____.

Diameter of the borehole	: 200 mm
Charge length	: 8 m
Density of ANFO	: 0.8 g/cc
Heat of explosion	: 912 cal/g
VOD	: 4500 m/s
Initiation	: Bottom

Q.53 A rock block of mass 100 kg is to be lifted by a horizontal force P as shown in the figure below. Smooth rollers are placed between the wedges. The coefficient of static friction between wedge A and surface C and between wedge B and surface D is 0.3. Ignoring the weight of the wedges and the friction between the roller and the wedges, the minimum force P in kg required to lift the block (*round off to one decimal place*) is _____ .
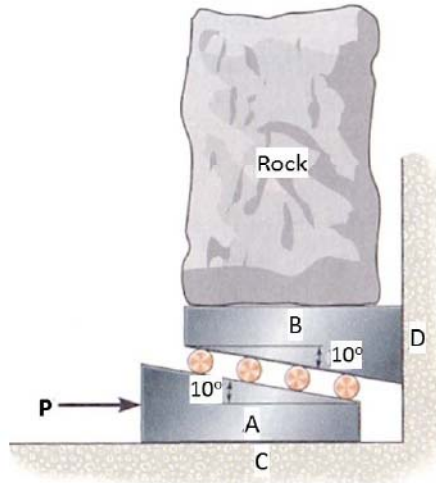
Q.54 A joint plane dipping at 30° intersects the slope edge and the crest as shown in the figure below. The unit weight of rock is 25 kN/m³, and cohesion and friction angle of the joint surface are 40 kPa and 25° respectively. The safety factor of the shaded block (*round off to two decimal places*) is _____ .
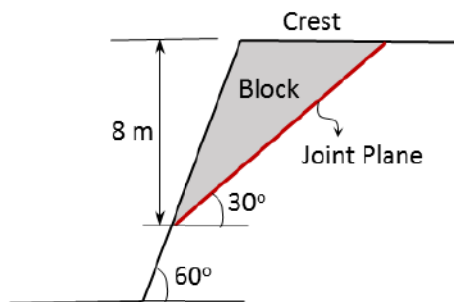
Q.55 The random variable X has probability density function as given by

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

The value $E(X^2)$ (*rounded off to one decimal place*) is _____ .

END OF THE QUESTION PAPER

Q.No.	Type	Section	Key	Marks
1	MCQ	GA	C	1
2	MCQ	GA	C	1
3	MCQ	GA	D	1
4	MCQ	GA	C	1
5	MCQ	GA	B	1
6	MCQ	GA	C	2
7	MCQ	GA	D	2
8	MCQ	GA	A	2
9	MCQ	GA	C	2
10	MCQ	GA	D	2
1	MCQ	MN	B	1
2	MCQ	MN	C	1
3	MCQ	MN	D	1
4	MCQ	MN	A	1
5	MCQ	MN	B	1
6	MCQ	MN	A	1
7	MCQ	MN	C	1
8	MCQ	MN	B	1
9	MCQ	MN	D	1
10	MCQ	MN	A	1
11	MCQ	MN	B	1
12	MCQ	MN	C	1
13	MCQ	MN	D	1

Q.No.	Type	Section	Key	Marks
14	MCQ	MN	D	1
15	MCQ	MN	A	1
16	MCQ	MN	C	1
17	MCQ	MN	A	1
18	MCQ	MN	B	1
19	NAT	MN	0.350 to 0.375	1
20	NAT	MN	15 to 15	1
21	NAT	MN	4.94 to 4.96	1
22	NAT	MN	46.00 to 48.00	1
23	NAT	MN	0.070 to 0.080	1
24	NAT	MN	91.00 to 92.00	1
25	NAT	MN	131.10 to 131.20	1
26	MCQ	MN	A	2
27	MCQ	MN	C	2
28	MCQ	MN	D	2
29	MCQ	MN	C	2
30	MCQ	MN	B	2
31	MCQ	MN	C	2
32	MCQ	MN	A	2
33	MCQ	MN	D	2
34	MCQ	MN	C	2
35	NAT	MN	6 to 6	2
36	NAT	MN	2450.1 to 2550.5	2

Q.No.	Type	Section	Key	Marks
37	NAT	MN	408 to 408	2
38	NAT	MN	4 to 4	2
39	NAT	MN	102.5 to 107.5	2
40	NAT	MN	0.40 to 0.45	2
41	NAT	MN	75.5 to 76.5	2
42	NAT	MN	858.25 to 865.25	2
43	NAT	MN	108.00 to 111.00	2
44	NAT	MN	0 to 0	2
45	NAT	MN	33.0 to 37.0	2
46	NAT	MN	50.00 to 52.00	2
47	NAT	MN	37200 to 37200	2
48	NAT	MN	1.38 to 1.40	2
49	NAT	MN	7.1 to 7.5	2
50	NAT	MN	0.72 to 0.77	2
51	NAT	MN	2 to 2	2
52	NAT	MN	430.0 to 437.0	2
53	NAT	MN	50.0 to 51.0	2
54	NAT	MN	2.12 to 2.22	2
55	NAT	MN	0.5 to 0.7	2