

GATE – Mining Engineering

(Topic Wise Questions 2007-2017)

Topic: System Engineering

and Reliability

(Mine Planning)

Prepared by:

Vikram Seervi

IIT (BHU)

Vikramseervi007@gmail.com

GATE SYLLABUS:

Principles of planning:

Sampling methods and practices, reserve estimation techniques, basics of geostatistics and quality control, optimization of facility location, cash flow concepts and mine valuation, open pit design; GIS fundamentals.

Work-study; Concepts of reliability, reliability of series and parallel systems.

Linear programming, transportation and assignment problems, queueing, network analysis, basics of simulation.

2007

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 for the machine in years is

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

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

- Q.60 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
Job	A	19	28	31
	B	11	17	16
	C	12	15	13

The minimum total cost of assigning the jobs to the machines is

- (A) 60 (B) 54 (C) 51 (D) 49
- Q.62 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)
- Q.63 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	

- Q.64 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

2008

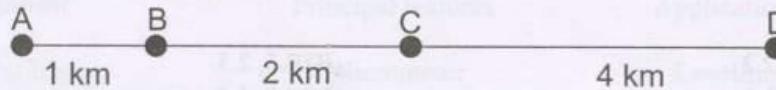
Q.18 In PERT network, the activity duration is assumed to follow

- (A) Beta distribution
- (B) Binomial distribution
- (C) Normal distribution
- (D) Weibull distribution

Q.19 For an LP problem, identify the INCORRECT statement

- (A) Optimal point 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

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 ideal distance of a coal washery along the road from the mine A in km is



- (A) 4.01
- (B) 3.91
- (C) 3.81
- (D) 3.71

- Q.40 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 the project decides to reduce the time for completion of the project to 85 days. The decision was taken after 45 days.

	A	B	C
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
- Q.41 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

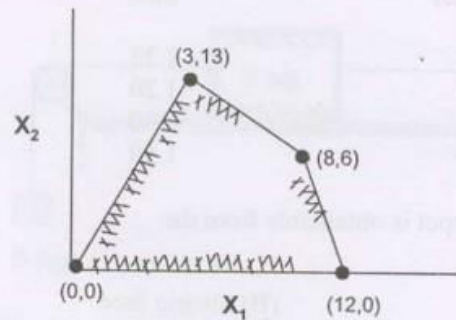
The net cash flow of mining the deposit in lakhs of rupees, is

- (A) 3.4 (B) 2.5 (C) 1.0 (D) 0.8
- Q.61 Block economic values in a 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

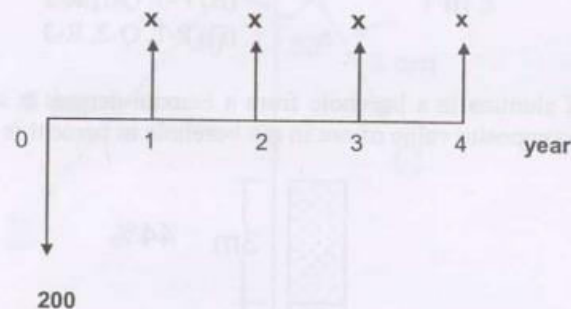
	1	2	3	4
1	-1	-1	1	-1
2	-1	1	3	-1
3	-1	-1	-1	-1

- (A) (1,1), (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)

- Q.62 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
- Q.65 A cash flow diagram is shown below. Based on NPV, at 10 % rate of interest, the minimum annuity 'x' at which the investment becomes viable is



- (A) 63
(B) 54
(C) 42
(D) 35
- Q.66 A system of two identical mine pumps connected in series has reliability 0.49. If the pumps were to be connected in parallel, the system reliability would be
- (A) 0.21
(B) 0.6
(C) 0.91
(D) 0.95

Q.67 An SDL working at different faces gives the following performance:

Operating Face	Production per blast (tonne)	Muck clearance time (hrs)
Development face	16	1.25
Splitting face	17	1.20
Slicing face	18	1.30
Heightening face	20	1.50

In 5 hrs operation maximum output is obtainable from the

- (A) Heightening face (B) Slicing face
(C) Development face (D) Splitting face

Statement for Linked Answer Questions 80 and 81: Unit cost matrix of a transportation problem is given below in certain monetary units.

		Destination			
		1	2	3	
Source	1	2	2	8	15
	2	1	5	7	40
	3	6	4	3	20
		10	25	40	
		Demand			

Q.80 The total cost of transportation based on the initial basic feasible solution obtained by the North-West corner rule is

- (A) 250 (B) 290 (C) 330 (D) 360

Q.81 The optimal solution for the transportation problem has allocation as shown below:

		Destination				
		1	2	3		
Source	1		15		15	Supply
	2	10	10	20	40	
	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

2009

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

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

Q.20 For mining property appraisals, typical reports prepared 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

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 the equipment in percentage of its original value is

- (A) 20 (B) 40 (C) 50 (D) 60

Q.37 A mine having a reserve of 320 Mt produces 4 Mt of ore at the end of 1st year. If the mine increases 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

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

Q.44 A mine workshop has 4 lathe machines and 4 tasks for completion. Each of the machines can perform each of the 4 tasks. Each task can be assigned to one and only one machine. Estimated cost in Rupees to complete each task is given in the matrix below.

		Machine			
		M1	M2	M3	M4
Task	T1	61	92	52	72
	T2	42	49	69	85
	T3	47	59	80	71
	T4	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

Q.47 The cash flow table of a manganese mine for a particular year is shown below:

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

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

2010

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 constants, the breakeven value of t is

- (A) $[c \pm \sqrt{c^2 - 4ab}]/(2a)$ (B) $[\sqrt{c^2 - 4ab}]/(2a)$
 (C) $[-c \pm \sqrt{c^2 - 4ab}]/(2a)$ (D) $[c \pm \sqrt{c^2 + 4ab}]/(2a)$

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 production
 (D) to the period during which internal rate of return is generated

Q.21 The mean and the standard deviation of the grade of iron 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

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) becomes

- (A) 10 (B) 12 (C) 14 (D) 16

- Q.34 The feasibility region of an LP problem in variables x and y is given by the following constraints, in addition to the non-negativity constraints.

$$y \leq 60; x \leq 90; x + y \leq 70.$$

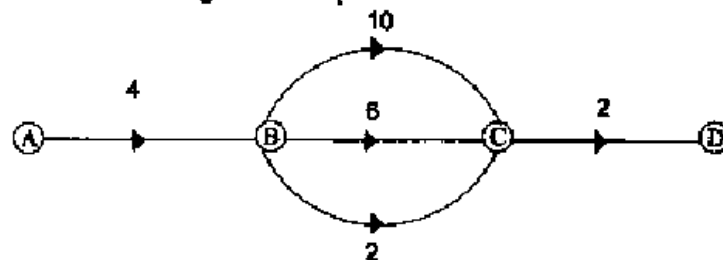
The number of corner point feasible solutions for this problem are

- (A) 3 (B) 4 (C) 5 (D) 6
- Q.35 The unit cost matrix of a balanced transportation problem is shown below

Destination		D1	D2	D3	Supply
Source	S1	7	3	6	60
	S2	5	4	9	60
	S3	8	6	7	80
Demand		50	120	30	

The transportation cost of the initial basic feasible solution obtained by the North-West corner rule is

- (A) 1025 (B) 1075 (C) 1130 (D) 1226
- Q.43 A project network comprises five activities as shown below. The activity durations, in days, are as indicated. Crashing of any activity costs Rs. 1000 per day. If the project is crashed to the shortest possible duration, the total crashing cost in Rupees is

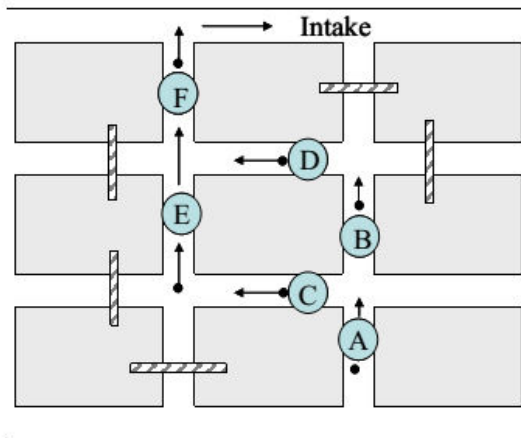


- (A) 15000 (B) 14000 (C) 13000 (D) 12000

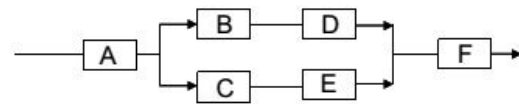
2011

- Q.36 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
- Q.37 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) 72,232 (B) 74,511 (C) 88,232 (D) 106,063
- Q.44 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

- Q.46 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

2012

- Q.23 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
- Q.34 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

- Q.36 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		
		P1	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

Linked Answer Questions

Statement for Linked Answer Questions 52 and 53:

A mining project is composed of five activities whose three time estimates in months are given below:

Activity	Estimated 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.52 The expected duration of the mining project in months is
 (A) 5 (B) 16 (C) 18 (D) 29
- Q.53 The standard deviation of the project length in months is
 (A) 2 (B) 3 (C) 6 (D) 9

2013

- 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
- Q.36 A simplex tableau shown below is generated during the maximization of a linear programming problem using simplex method

Variable	Z	X_1	X_2	X_3	X_4	RHS
Z	1	-1	0	1	0	6
X_2	0	$1/3$	1	$1/3$	0	2
X_4	0	$7/3$	0	$-2/3$	1	2

After one iteration, the value of the objective function becomes

- (A) $\frac{48}{7}$ (B) $\frac{11}{3}$ (C) $\frac{22}{7}$ (D) $\frac{2}{3}$

Statement for Linked Answer Questions 52 and 53:

Economic analysis of an iron ore deposit reveals that the net value of the ore is related to the grade mined as shown in the table.

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

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	0.79103	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

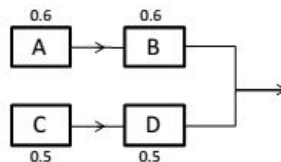
2014

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

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 _____

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



2015

Question Number : 35 Question Type : NAT

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 _____

Correct Answer:

0.75 to 0.81

Question Number : 51 Question Type : NAT

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 _____

Correct Answer :

0.5 to 0.6

Question Number : 52 Question Type : MCQ

Given the following linear programming problem,

$$\text{Maximise } z = 3x_1 + 4x_2$$

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)

Options :

1. ✖ A

2. ✖ B

3. ✖ C

4. ✔ D

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 _____

Correct Answer:

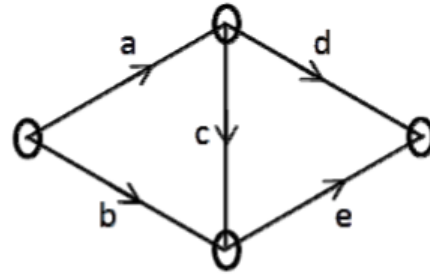
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2016

- 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



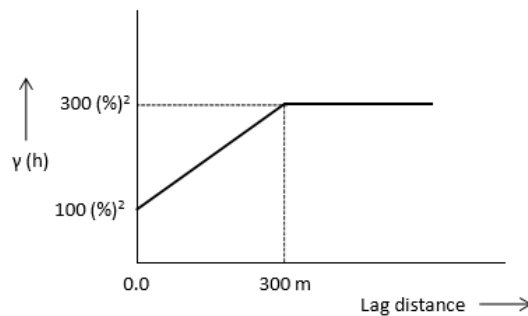
- (A) 4 (B) 6 (C) 9 (D) 13

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.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.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 _____.

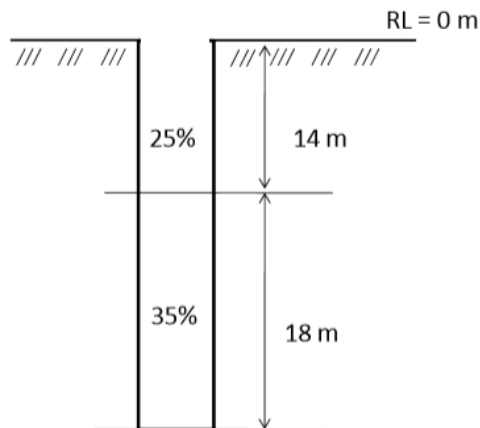


Q.54 A surface mine has 15 identical dumpers and two shovels. For shovel 1, the dumper cycle time is 30 min and the shovel loading time is 5 min. For shovel 2, the dumper cycle time is 32 min and the shovel loading time is 4.0 min. Based on match factor optimisation (equitable match factor), the ideal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

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

GATE 2016 Mining Engineering (MN)

Q.55 The composited grade value, in %, between the RLs 10 m to 20 m for the following borehole configuration is _____.



2017

Question Number : 15

Correct : 1 Wrong : -0.33

In a PERT network, the “time estimates” of an activity are the following: Optimistic time - 2 days, Most likely time - 4 days, and Pessimistic time - 12 days. The expected time and standard deviation of the activity in days are respectively

- (A) 6.0 and 2.78 (B) 5.0 and 1.66 (C) 6.0 and 1.66 (D) 5.0 and 2.78

Question Number : 32

Correct : 2 Wrong : 0

The block grade model of an ore deposit is shown in the figure below. The relationship between block value per tonne (B_v) in rupees and the block grade in percentage (x) is given below:

$$B_v = -38500 + 700 \times x, \quad \text{for } x \geq 55\% \\ = -300, \quad \text{otherwise}$$

54%	52%	53%
56%	60%	54%

Block grade model with
grade percentage (x)

If each square block contains 1000 tonne of material and the overall pit slope angle is 45° , the total value of the pit determined by the floating cone algorithm in Lakhs of rupees is _____

Question Number : 34

Correct : 2 Wrong : 0

Consider the following linear programming problem:

$$\begin{aligned} &\text{Maximize } Z = 6X + 10Y \\ &\text{Subject to } X \leq 4 \\ &\quad Y \leq 6 \\ &\quad 3X + 2Y \leq 18 \\ &\quad X \geq 0, Y \geq 0 \end{aligned}$$

The maximum value of the objective function is _____

Question Number : 35**Correct : 2 Wrong : 0**

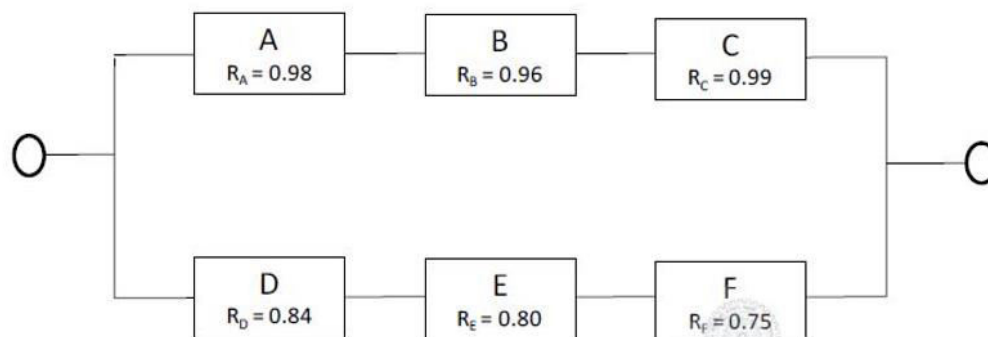
A mining company having three mines A, B and C supplies coal to three power plants P, Q and R located close to the mines. The daily production capacities of the three mines in tonnes are 700, 1200, and 1100 respectively. The daily requirements at the power plants in tonnes are 1000, 1000, and 1000 respectively. The transportation costs in rupees per tonne is given in the matrix below:

Mine \ Power plant	P	Q	R
A	15	20	60
B	5	40	20
C	30	10	50

The total cost of coal transportation in rupees from the three mines to three power plants using the least-cost method is _____

Question Number : 36**Correct : 2 Wrong : 0**

The series-parallel configuration of a system, consisting of 6 independent components A, B, C, D, E, and F with their individual reliability, is shown in the figure:



The reliability of the system is _____

Question Number : 37

Correct : 2 Wrong : 0

500 coal miners were randomly selected from an underground coal mine. It was found that 50 workers experienced an injury in the year 2014. The distribution of injury based on younger age group ($age \leq 40$ years) and older age group ($age > 40$ years) generated the following cross classification table.

Age group	Number of workers		Row total
	Injured	Non-injured	
Younger age group	20	130	150
Older age group	30	320	350
Column total	50	450	500

The odds of injury for the younger age group compared to the older age group is _____