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TEST PAPER – 03

(Chapters Covered – Productivity Management & Quality Management, Project Management & Economics of Maintenance and Spares Management)

OPERATIONS MANAGEMENT AND STRATEGIC MANAGEMENT

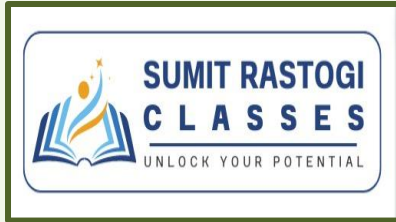
Time Allowed: 3 Hours

Full Marks: 100

**Section A contains Question Number 1. All parts of this question are compulsory.
Working notes should form part of the relevant answer.**

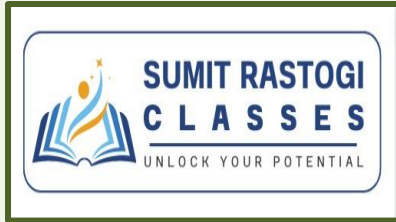
SECTION-A

- 1. Choose the correct answer from the given alternatives (you may write only the Roman number and the alphabet chosen for your answer) (2×15 = 30 Marks)**
 - (i) A cement factory of SITON (C) Ltd., in Madhya Pradesh works 7 days a week in 3 shifts per day having maintenance in the first shift of around 2 hours. It has roughly 100 workers which produces only pozzolanic properties cement better known as PPC. The output per month is around 2500 tonnes of PPC. What will be productivity per worker?**
 - (a) 20 tonnes**
 - (b) 30 tonnes**
 - (c) 25 tonnes**
 - (d) 15 tonnes**
 - (ii) For Quality Assurance in Design, Production, Installation and Servicing the Model is used.**
 - (a) ISO 9002**
 - (b) ISO 9001**
 - (c) ISO 9003**
 - (d) None of the above**
 - (iii) The Work Breakdown Structure is typically developed in which one of the following phases of the project management life cycle?**
 - (a) Project Initiation Phase**
 - (b) Project Planning Phase**
 - (c) Project Quality Management Phase**
 - (d) Execution Phase**



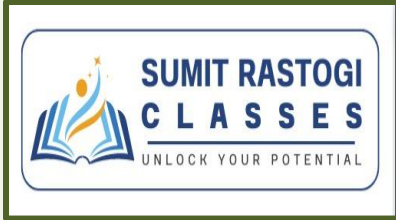
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- (iv) With reference to the operations of a manufacturing company, one of the important decisions is “Are we producing right things”? Which one of the following is related to this?
- (a) Quality Management
 - (b) Inventory Management
 - (c) Maintenance Management
 - (d) Delivery Planning
- (v) The Quality Circles and use of work teams or quality improvement teams are the examples of:
- (a) Time Reduction
 - (b) Lean Production
 - (c) Worker Involvement
 - (d) Re-Engineering
- (vi) The ISO Standard associated with the “Quality Assurance in Production and installation” is:
- (a) ISO 9001
 - (b) ISO 9002
 - (c) ISO 9003
 - (d) ISO 9004
- (vii) The Slack Time of Tail Event of Activity – D of a Project is 1 day. If the total Float and Free Float of the Activity D are 8 days and 6 days respectively, the Independent Float of D will be:
- (a) 3 Days
 - (b) 4 Days
 - (c) 5 Days
 - (d) None of the above
- (viii) In a particular plant there are 15 workers manufacturing a single product and the output per month consisting of 25 days of that particular product is 450 units. How much is the monthly productivity?
- (a) 30 units
 - (b) 18 units
 - (c) 15 units
 - (d) 25 units



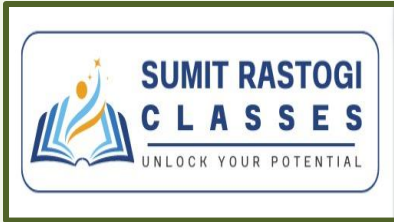
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- (ix) The ISO Standard associated with “Quality Management and Quality System Elements – Guidelines” is
- (a) ISO 9001
 - (b) ISO 9002
 - (c) ISO 9003
 - (d) ISO 9004
- (x) Which one of the following processes of Project Quality Management assures the existence and effectiveness of process and procedures tools?
- (a) Quality definition
 - (b) Quality Assurance
 - (c) Quality Control
 - (d) Quality Improvement
- (xi) Which one of the following is not the primary constraint of a project?
- (a) Time
 - (b) Cost
 - (c) Machine
 - (d) Quality
- (xii) Preventive Maintenance is useful in reducing
- (a) Inspection Cost
 - (b) Shutdown Cost
 - (c) Cost of premature replacement
 - (d) Set-up Cost of Machine
- (xiii) A workshop of Gear Tech (I) Ltd. has 20 nos. of identical machines. From the failure pattern of the machines, it is calculated that the expected time before failure is 4 months. It costs ₹500 to attend a failure machines and rectify the same. What will be the yearly cost of servicing the broken down machines?
- (a) ₹50,000
 - (b) ₹30,000
 - (c) ₹32,000
 - (d) ₹10,000
- (xiv) The spare parts which is characterized by their lower reliability as well as their lower per unit cost are classified as:
- (a) Regular spares
 - (b) Insurance spares
 - (c) Capital spares
 - (d) Rotable spares



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- (xv) Under Maintenance management, two types of costs and need to be balanced one is cost of premature replacement, other is cost of:
- (a) Purchase of Raw Materials
 - (b) Breakdown
 - (c) Purchase of finished goods
 - (d) None of the above



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SECTION-B

2. (a) STEEL MAX Ltd. invested in a precision laser cutting machine with a purchase cost of ₹5,00,000 and an installation cost of ₹50,000. The resale value remains fixed at ₹60,000 throughout its life. However, maintenance costs increase with age. The management is analyzing over a 10-year span to determine the most cost-effective replacement year.

Year	1	2	3	4	5	6	7	8	9	10
Maintenance Cost (Rs. In Thousands)	10	15	22	30	45	60	80	110	145	185

Required: (Ignore Cost of Money)

- (i) Analyze Average Annual Cost of replacement of cutting machine for each year.
(ii) Assess and Identify after how many years should Steel Max Ltd., replace the cutting machine on economic considerations. **(7 Marks)**
2. (b) SWIFT TRANS LOGISTICS Ltd. is planning a distribution centre expansion. The operation manager have split their schedule of implementation into the following 6 activities and have estimated time duration (in weeks) under 3 scenarios as under:

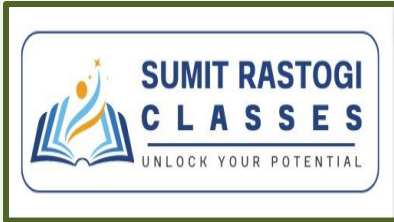
(Time in Weeks)

Activity and Identification		Optimistic Time Estimate (to)	Pessimistic Time Estimate (tp)	Most Likely Time Estimate (tm)
A	1 – 2	1	5	3
B	1 – 3	3	9	6
C	2 – 4	2	8	5
D	3 – 4	5	13	9
E	2 – 5	3	5	4
F	4 – 5	5	11	8

Required:

- (i) Assess the expected duration (in weeks) for each activity.
(ii) Design the PERT Network Diagram and indicate all paths through it.
(iii) Identify the Critical Path and its duration (in weeks).
(iv) Analyze and indicate the variance of each activity. **(7 Marks)**
3. (a) GOPA BANDHU AUDITORIUM has been decorated with 1000 coloured light bulbs. The mortality rates of this type of bulbs have been observed pursuant to a systematic study as follows:

Month	1	2	3	4
Percent Bulbs failing by month end	15	15	40	30



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It costs ₹100 to replace a fused bulb. However, if all bulbs are replaced together, it would cost ₹40 per bulb. The auditorium management is thinking to replace all bulbs at fixed interval, whether or not the bulbs are fused and also to continue replacing fused bulbs as when they get fused.

Required:

- (i) Analyze the number of light bulbs to be replaced every month.
- (ii) Assess the average monthly cost for individual replacement.
- (iii) Analyze and identify at what periodicity the Management of Gopa Bandhu Auditorium should replace all the light bulbs.
- (iv) Recommend which policy of the replacement would be economical. **(7 marks)**

3. (b) A Research and Development department of ZOBEX Ltd. is developing a power supply for console television set. The department has listed down the activities with its time in the project as under:

Activity and Identification	Preceding Activity	Normal Time (Days)
A	(1 – 2)	-
B	(1 – 3)	-
C	(2 – 3)	A
D	(2 – 4)	A
E	(3 – 4)	B, C
F	(4 – 5)	D, E

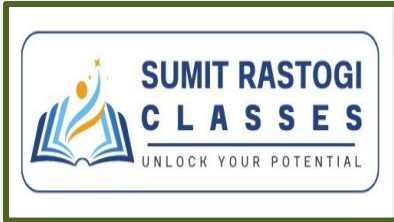
Required:

- (i) Design a PERT Network Diagram and indicate all paths through it.
- (ii) Analyze the critical path of the project.
- (iii) Assess the Minimum time (in days) for completion of the project.
- (iv) Analyze and assess the Total Float, Free Float and Independent Float available on each activity. **(7 marks)**

4. (a) Analyze the three important tools which are used for increasing productivity in industry. **(7 marks)**

4. (b) A computer of ROPAM Ltd., has 1000 Nos. of Electronic Tubes. They are subject to mortality as given below:

Period	Age of Failure (Hrs.)	Probability of Failure
1	0 – 200	0 – 10
2	201 – 400	0 – 26
3	401 – 600	0 – 35
4	601 – 800	0 – 22
5	801 – 1000	0 – 07



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If the tubes are group replaced, the cost of replacement is ₹150 per Electronic tube. Group replacement can be done at fixed intervals in the night shift when the computer is not normally used. Replacement of individual Electronic tubes which fail in Service Cost ₹600 per Electronic tube.

Assume that:

- (i) Electronic Tubes that fail during a period are replaced just before the end of the period.
- (ii) The actual percentage of failure during a period for a sub-population of the Tubes with the same age is the same as the expected percentage of failure during the period for that sub-population.

Required:

- (i) Analyze the number of Electronic Tubes to be replaced every period.
- (ii) Assess the failure costs (₹) on average of individual replacement of electronic tubes.
- (iii) Identify at what interval of time the Company should replace all the electronic Tubes.
- (iv) Advice which policy of replacement will be economical to the Company. **(7 marks)**

5. (a) BITZON Ltd., a Chemical Product Manufacturing Company have split their Schedule of Implementation into the following 6 activities and have estimated Time Duration (in weeks) under 3 Scenarios as under:

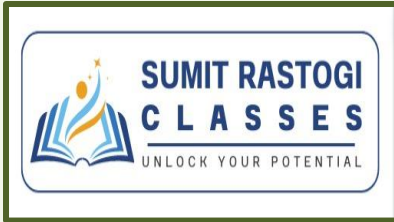
(Time in Weeks)

Activity and Identification		Optimistic time estimate	Pessimistic time estimate	Most likely time estimate
A	1 – 2	5	11	8
B	1 – 3	18	26	22
C	2 – 4	15	25	20
D	3 – 4	4	12	8
E	4 – 5	8	12	10
F	3 – 5	14	26	20

Required:

- (i) Assess the expected duration (in weeks) for each activity.
- (ii) Design the PERT Network Diagram and indicate all paths through it.
- (iii) Identify the Critical Path and its Duration (in weeks).
- (iv) Analyze and indicate the Total Float and Free Float available on each activity. **(7 marks)**

5. (b) ZOTECH Ltd., has recently won a Contract for the installation of a die casting machine at a local factory of a large national firm of electronic Engineers. The following table gives the various activities in this job and normal duration (in days) thereof.



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Activity and Identification		Optimistic time estimate	Pessimistic time estimate
A	1 – 2	-	2
B	2 – 3	A	3
C	2 – 4	A	15
D	2 – 5	A	3
E	3 – 5	B	12
F	4 – 5	C	8
G	5 – 6	D, E and F	3
H	6 – 7	G	12

Required:

- (i) Design the PERT Network diagram and indicate all path through it.
- (ii) Identify the Critical Path and its duration (in days)
- (iii) Analyze and Assess the Total Float, Free Float and Independent Float of each activities. **(7 marks)**

6. (a) RONTIX Ltd., a fleet owner finds from its past records that the cost per year of running a truck whose purchase price is ₹6,00,000 are as given below:

Year	1	2	3	4	5	6	7	8
Running Costs (₹ in Thousand)	100	120	140	180	230	280	340	400
Re-Sales Price (₹ in Thousand)	300	150	75	37.50	20	20	20	20

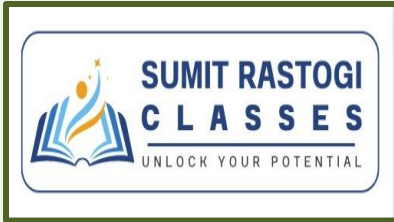
(Assume that Cost of Money is zero.)

Required:

- (i) Assess the average annual cost of truck for each year.
- (ii) Analyze and infer at what age the truck should be replaced on economic consideration. **(7 Marks)**

6. (b) TINTEX LTD., a construction company has an opportunity to submit a bid for the construction of a new apartment building. From specifications provided by the developer, a PERT Network for the project has been developed and the estimate of optimistic; most likely and pessimistic, completion duration in days (a, m and b respectively) for each activity are shown below:

Activity and Identification		Estimated time in Days		
		Optimistic (a)	Most likely (m)	Pessimistic (b)
A	1 – 2	15	20	25
B	1 – 3	20	25	30
C	2 – 3	6	10	14
D	2 – 4	8	12	16
E	3 – 4	2	6	10
F	4 – 5	6	10	14



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Required:

- (i) Assess the expected Time (in days) of the project.
- (ii) Draw the Project Network and identify all paths through it.
- (iii) Identify the Critical Path with its duration and assess the Total Float and Free Float of each activity of the Project. **(7 marks)**

7. (a) The Management of Green in Hotel is considered the periodic replacement of light bulbs fitted in its rooms. There are 500 rooms in the hotel and each room has 6 bulbs. The Management of Green in Hotel is now following the policy of replacing the bulbs as they fail at a total cost of ₹30 per bulb. The Management feels that this cost can be reduced to ₹10 by adopting the periodic replacement method.

The following mortality rate has been observed for the said light bulbs:

Month of Use	1	2	3	4	5
Prob. Of bulbs failing by the end of month	0.10	0.15	0.25	0.30	0.20

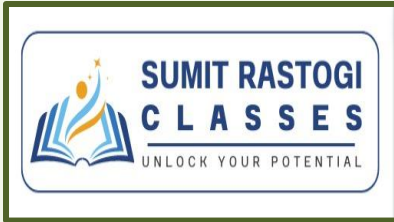
Assume that the bulbs that fail during the months are replaced just before the end of that month.

Required:

- (i) Compute the costs (in ₹) of Individual Replacement of bulbs per month.
- (ii) Present the Optimum Replacement cycle under Group Replacement.
- (iii) State best strategy for the Management of Green in Hotel to follow.
(Present calculation to the nearest integer) **(7 marks)**

7. (b) DELTA Construction Company has an opportunity to submit a bid for the construction of a new apartment building. From specifications provided by the developer, Project Manager of the company has listed down the activities with duration (in days) of the project (Construction of apartment building) as are shown below:

Activity and Identification		Proceeding Activities	Duration (in Days)
A	1 – 2	-	4
B	1 – 3		7
C	1 – 4	-	10
D	2 – 3	A	3
E	2 – 4	A	8
F	3 – 6	B and D	16
G	4 – 5	C and E	9
H	5 – 6	G	6
I	5 – 7	G	11
J	6 – 7	F & H	8



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Required:

- (i) Draw the PERT network diagram.
- (ii) What are the possible paths with duration of the said project?
- (iii) Identify the critical path with duration (in days) of the project.
- (iv) Calculate the total float and free-float for the activities, C, D, F and I of the said project. **(7 marks)**

8. (a) The Management of BB HOTEL IN is considering periodic replacement of light bulbs fitted in its rooms. There are 200 rooms in the hotel and each room has 5 bulbs. The Management is conducting a study on the life of the light bulbs. The following mortality rates have been observed for the light bulbs.

Month of USE	1	2	3	4	5
Percent of bulbs failing by that month	10	15	25	30	20

There are 1000 light bulbs in use and it costs ₹100 to replace an individual bulb which has burnt out. If all bulbs were replaced simultaneously, it would cost ₹20 per bulb. It is proposed to replace all bulbs at fixed intervals, whether or not they have burnt out and to continue replacing burnt out bulbs as they fail.

Required:

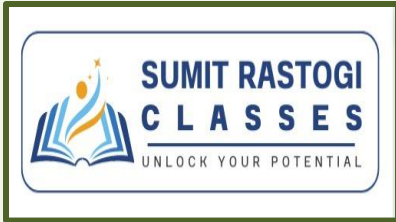
- (i) Examine the number of light bulbs to replaced every month.
- (ii) Calculate the average monthly cost (₹) of individual replacement.
- (iii) Identify at what interval of time the Management of BB HOTEL IN should replace all the light bulbs and which policy of replacement would economical. **(7 marks)**

8. (b) Jaago Engineering is analyzing the efficiency of its work and service personnel. Its service procedure is classified into the following seven activities along with its duration:

Activity	Duration (Hrs.)	Precedence Activity
A	8	-
B	4	-
C	6	A
D	9	B
E	11	A
F	3	C
G	1	D, E, F

From the above details:

- (i) Draw the network diagram.
- (ii) Find the critical path.
- (iii) Calculate the expected time.
- (iv) Slack time for each path,
- (v) Earliest Start and Finish Time,
- (vi) Latest Finish and Start Time. **(7 marks)**



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ANSWERS OF TEST PAPER – 03

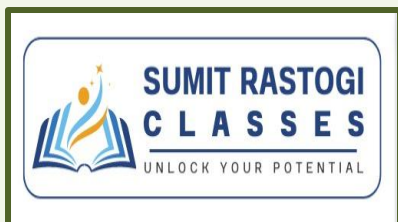
(Chapters Covered – Productivity Management & Quality Management, Project Management & Economics of Maintenance and Spares Management)

OPERATIONS MANAGEMENT AND STRATEGIC MANAGEMENT

SECTION-A

ANS.1

- (i) (c) 25 tonnes
- (ii) (b) ISO 9001
- (iii) (b) Project Planning Phase
- (iv) (a) Quality Management
- (v) (c) Worker Involvement
- (vi) (b) ISO 9002
- (vii) (c) 5 Days
- (viii) (a) 30 units
- (ix) (d) ISO 9004
- (x) (b) Quality Assurance
- (xi) (c) Machine
- (xii) (b) Shutdown Cost
- (xiii) (b) ₹30,000
- (xiv) (a) Regular spares
- (xv) (b) Breakdown



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SECTION-B

ANS. 2 (a)

C = Cost of cutting machine = ₹5,00,000 + ₹50,000 = ₹5,50,000

(i) Calculation of Annual Cost of Replacement of cutting machine each year.

Yrs.	Maintenance Cost (₹) (in 000)	Cumulative Maintenance Cost (₹) (000) (i)	Resale Value (₹) (in 000) (S)	Replacement cost (₹) (in 000) (C – S) (ii)	Total Replacement Cost (₹) (in 000) (i) + (ii)	Average Replacement cost (₹) (in 000)
1	10	10	60	490	500	500
2	15	25	60	490	515	257.5
3	22	47	60	490	537	179
4	30	77	60	490	567	141.75
5	45	122	60	490	612	122.4
6	60	182	60	490	672	112.0
7	80	262	60	490	752	107.43 ← Min ^m
8	110	372	60	490	862	107.75
9	145	517	60	490	1007	111.88
10	185	702	60	490	1192	119.20

(ii) Here Average Replacement cost is Minimum in 7th Year.

So Economic Replacement time period = 7 year.

ANS. 2 (b)

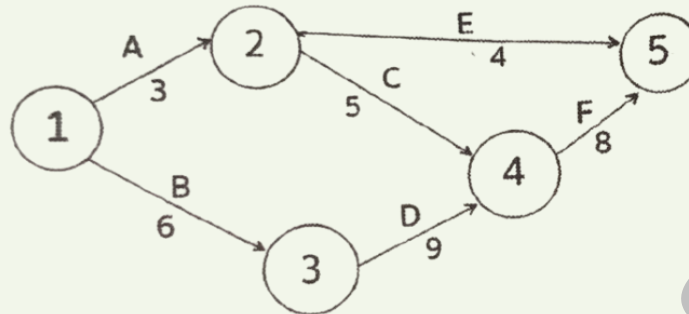
(i) Calculation of expected time and variance of each activities:

$$\text{Expected time} = t_e = \frac{t_o + t_p + 4t_m}{6}$$

$$\text{Variance} = \left(\frac{t_p - t_o}{6} \right)^2$$

Activity	t _o	t _p	t _m	t _e	Variance
A (1 – 2)	1	5	3	3	0.444
B (1 – 3)	3	9	6	6	1
C (2 – 4)	2	8	5	5	1
D (3 – 4)	5	13	9	9	1.777
E (2 – 5)	3	5	4	4	0.111
F (4 – 5)	5	11	8	8	1.

(ii)



(iii)

Path	Time Duration
(1) A → E	3 + 4 = 7 weeks
(2) A → C → F	3 + 5 + 8 = 16 weeks
(3) B → D → F	6 + 9 + 8 = 23 weeks

Critical Path: B → D → F

Project Completion time = 23 weeks

(iv) Variance of each Activities

A = 0.444 B = 1 C = 1 D = 1.777 E = 0.111 F = 1

ANS. 3 (a)

Individual Replacement Policy

Month	Probability	
x	P(x)	X P(x)
1	0.15	0.15
2	0.15	0.30
3	0.40	1.20
4	0.30	1.20
		2.85

Expected time of failure of bulb = 2.85 month

No. of Bulb failed per month = $\frac{1}{2.85} \times 100$

Individual Replacement cost per month = $\frac{1}{2.85} \times 1000 \times 100 = ₹35087.72$

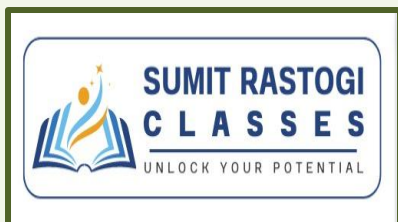
Group Replacement policy

Calculation of number of bulb replaced each month

No. of Bulb replaced in 1st month = $1000 \times 0.15 = 150$

No. of Bulb replaced in 2nd month = $1000 \times 0.15 + 150 \times 0.15 = 150 + 22.5 = 172.5$

No. of Bulb replaced in 3rd month = $1000 \times 0.40 + 172.5 \times 0.15 + 150 \times 0.15$
 $= 400 + 25.875 + 22.5 = 448.375$



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No. of Bulb replaced in 4th month = $1000 \times 0.30 + 448.375 \times 0.15 + 172.5 \times 0.15 + 150 \times 0.40 = 300 + 67.25 + 25.875 + 60 = 453.125$

Calculation of Average Replacement Cost

Month	No. of Bulb Individually Replaced	Cummulative no. of Bulb	Individual Replacement Cost (₹) (i)	Group Replacement Cost (₹) (ii)	Total Replacement Cost (₹) (i + ii)	Average Replacement Cost (Total Cost/No. of Month) (₹)
1	150	150	15000	40000	55000	55000
2	172.5	322.5	32250	40000	72250	36125
3	448.375	770.875	77087.5	40000	117087.5	39029.17
4	453.125	1224	122400	40000	162400	40600

Here Average Replacement cost is minimum in 2nd Month Group Replacement Policy will be considered on every 2 Month.

(i) No. of Bulb Replacement every Month = 351 approx.

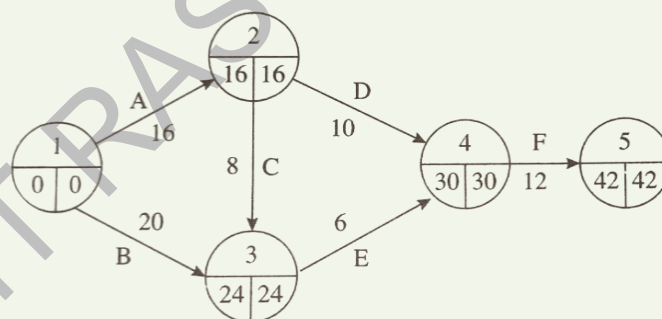
(ii) Average Individual Replacement cost per month = ₹35087.72

(iii) If all bulb be replaced then Replaced it in every two month

(iv) Individual Replacement policy is better than Group Replacement Policy.

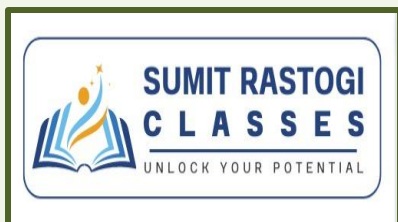
ANS. 3 (b)

(i)



(ii)

Path	Time Duration
A → D → F	16 + 10 + 12 = 38 Days
A → C → E → F	16 + 8 + 6 + 12 = 42 Days → Critical Path
B → E → F	20 + 6 + 12 = 38 Days



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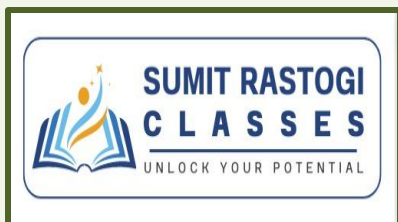
(iii) Project Completion Time = 42 Days

Activity	Time	EST	EFT	LST	LFT	Total Float	Free Float	Independent Float
A	16	0	16	0	16	0	0	0
B	20	0	20	4	24	4	4	4
C	8	16	24	16	24	0	0	0
D	10	16	26	20	30	4	4	4
E	6	24	30	24	30	0	0	0
F	12	30	42	30	42	0	0	0

ANS. 4 (a)

The productivity of an enterprise can be improved by improving the performance of various inputs and other factors affecting productivity. For this purpose, use of following tools can be recommended.

1. **Human Aspects:** Under this, cooperation of workers is sought in the following ways:
 - (i) More workers participation in management or in decision making through joint consultation.
 - (ii) Improving communication services.
 - (iii) Improving mutual trust and cooperation through improved job procedures, better training of employees, more workers incentives by implementing various incentive schemes, and labour welfare programmes.
 - (iv) Better planning of work, more effective management, more democracy in administration, improved human relations and selection and training of personnel at various levels of management are some human efforts from the side of management in order to improve the productivity.
2. **Supply of Inputs:**
 - (i) Improvement in the nature and quality of raw materials and their supplies to the work.
 - (ii) Proper provision of plant, equipment and their maintenance.
 - (iii) Introduction of more and more machines and equipment in place of physical work.
 - (iv) Full utilisation of manpower and efficiency or capacity of plant and equipment employed.
3. **Technological Aspects:** Certain methodological and technological developments are also necessary to improve the productivity of the concern.
 These are:
 - (i) Work, time and motion studies to determine better ways and means of doing a job.
 - (ii) Implementing various simplification, specialisation and standardisation programmes.
 - (iii) Applying control techniques comprising of production, planning and control, cost control and quality control techniques.
 - (iv) Improving layout of plants, shops and machine tools, and material handling and internal transportation system.
 - (v) Improving inspection techniques so as to minimise the wastage and defective work.



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ANS. 4 (b)

Period	Probability	
x	P(x)	XP(x)
1	0.10	0.10
2	0.26	0.52
3	0.35	1.05
4	0.22	0.88
5	0.07	0.35

$$\sum xp(x) = 2.9$$

Average Period of failure of a electronic tubes = 2.9

No. of failure of electronic tube per period = $1/2.9 \times 1000$

Average Replacement Cost of Electronic tubes individually = $1/2.9 \times 1000 \times 600 = ₹206896.55$

Group Replacement Policy

(i) Calculation of No. of electronic tube failed in replaced individually when Group Replacement Policy is considered.

No. of electronic tubes failed in 1st Period = $1000 \times 0.10 = 100$

No. of electronic tubes failed in 2nd Period = $1000 \times 0.26 + 100 \times 0.10$
 $= 260 + 10 = 270$

No. of electronic tubes failed in 3rd Period = $1000 \times 0.35 + 270 \times 0.10 + 100 \times 0.26$
 $= 350 + 27 + 26 = 403$

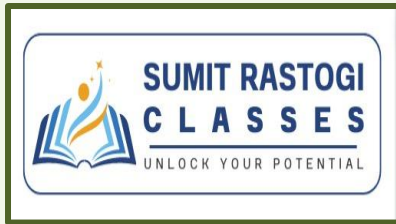
No. of electronic tubes failed in 4th Month = $1000 \times 0.22 + 403 \times 0.10 + 270 \times 0.26$
 $+ 100 \times 0.35$
 $= 220 + 40.3 + 70.2 + 35$
 $= 35.5 = 365$ (approx.)

No. of electronic tubes failed in 5th Month = $1000 \times 0.07 + 365.5 \times 0.10 + 403 \times 0.26$
 $+ 270 \times 0.35 + 100 \times 0.22$
 $= 70 + 36.55 + 105.56 + 94.5 + 22$
 $= 328.61 = 329$ (approx)

Calculation Group Replacement Cost

Period	No. of tube Failed	Cumulative no. of tube failed	Individual Replacement Cost (₹)	Group Replacement Cost (₹)	Total Replacement Cost (₹)	Average Replacement Cost (₹)
1	100	100	60,000	1,50,000	2,10,000	2,10,000
2	270	370	2,22,000	1,50,000	3,72,000	1,86,000
3	403	773	4,63,000	1,50,000	6,13,800	2,04,600
4	365	1138	6,82,800	1,50,000	8,32,800	2,08,200
5	329	1467	8,80,200	1,50,000	10,30,200	2,06,040

Here Average Replacement of Cost for 2nd Period is lower so if Group replacement policy is considered then all electronics bulb should be replaced at the end of 2nd period i.e. 201400 hrs.



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(ii) Average Individual Replacement Cost = ₹2,06,896.55

(iii) If all electronic bulbs should be replaced at the end of every 2nd period is the age of failure 201-400.

(iv) Group Replacement Policy is better than Individual Replacement Policy because Average Replacement Cost of every 2nd period is lower than Average Individual Replacement Cost.

ANS. 5 (a)

(i) Calculation of expected time of each activity

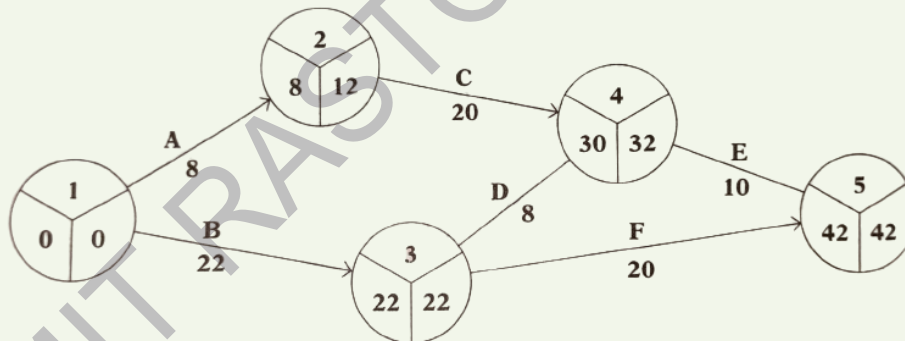
$$\text{Expected time } (t_e) = \frac{t_o + t_p + 4t_m}{6}$$

t_o = Optimistic time, t_p = Pessimistic Time

t_m = Most likely time

Activity	Expected Time (weeks)
A (1 – 2)	8
B (1 – 3)	22
C (2 – 4)	20
D (3 – 4)	8
E (4 – 5)	10
F (3 – 5)	20

(ii) Network Diagram



(iii)

Path	Time Duration
A → C → E	8 + 20 + 10 = 38 weeks
B → D → E	22 + 8 + 10 = 40 weeks
B → F	22 + 20 = 42 weeks

Critical Path = B → F

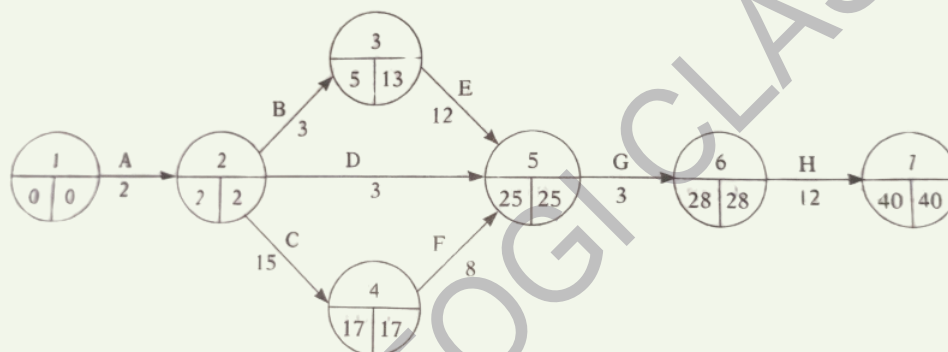
Expected time duration = 42 weeks

(iv) Calculation of Total Float and Free Float of each activities:

Activity	Time Duration	EST	EFT	LST	LFT	Total Float	Free Float
A	8	0	8	4	12	4	$4 - (12 - 8) = 0$
B	22	0	22	0	22	0	$0 - (22 - 22) = 0$
C	20	8	28	12	32	4	$4 - (32 - 30) = 2$
D	8	22	30	24	32	2	$2 - (32 - 30) = 2$
E	10	30	40	32	42	2	$2 - (42 - 42) = 2$
F	20	22	42	22	42	0	$0 - (42 - 42) = 0$

ANS. 5 (b)

(i)



(ii)

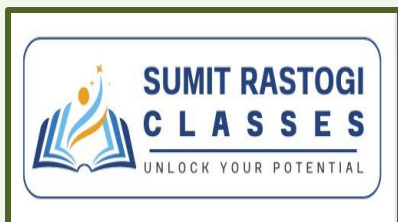
Path	Time Duration
A → B → E → G → H	$2 + 3 + 12 + 3 + 12 = 32$ Days
A → D → G → H	$2 + 3 + 3 + 12 = 20$ Days
A → C → F → G → H	$2 + 15 + 8 + 3 + 12 = 40$ days Critical path

Critical Path:- A → C → F → G → H

Project Duration = 40 Days

(iii) Calculation of total float, free float and independent float

Activity	Time	EST	EFT	LST	LFT	Total Float	Free Float	Independent Float
A	2	0	2	0	2	0	$0 - (2 - 2) = 0$	$0 - (0 - 0) = 0$
B	3	2	5	10	13	8	$8 - (13 - 5) = 0$	$0 - (2 - 2) = 0$
C	15	2	17	2	17	0	$0 - (17 - 17) = 0$	$0 - (2 - 2) = 0$
D	3	2	5	22	25	20	$20 - (25 - 25) = 20$	$20 - (2 - 2) = 20$
E	12	5	17	13	25	8	$8 - (25 - 25) = 8$	$8 - (13 - 5) = 0$
F	8	17	25	17	25	0	$0 - (25 - 25) = 0$	$0 - (17 - 17) = 0$
G	3	25	28	25	28	0	$0 - (28 - 28) = 0$	$0 - (25 - 25) = 0$
H	12	28	40	28	40	0	$0 - (40 - 40) = 0$	$0 - (28 - 28) = 0$



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ANS. 6 (a)

Calculation of average Replacement cost and Optimum Replacement period

Cost of truck = C = ₹6,00,000

Years	Running Cost (000) (₹)	Cumulative Running Cost (₹) (000)	Resale Value (S) (₹) (000)	C – S (₹) (000)	TRC (₹) (000)	ARC (₹) (000)
1	100	100	300	300	400	400
2	120	220	150	450	670	335
3	140	360	75	525	885	295
4	180	540	37.50	562.50	1102.50	275.625
5	230	770	20	580	1350	270
6	280	1050	20	580	1630	271.67
7	340	1390	20	580	1970	281.43
8	400	1790	20	580	2370	296.25

Here average replacement cost is Minimum in 5th year. So, Trucks should be replaced at 5th year.

ANS. 6 (b)

(i) Calculation of expected time of each activity

$$\text{Expected time} = t_e = \frac{t_p + t_o + 4t_m}{6} = \frac{a + b + 4m}{6}$$

Activity	t_o (a)	t_m (m)	t_p (b)	$t_e = \frac{a + b + 4m}{6}$
A	15	20	25	20
B	20	25	30	25
C	6	10	14	10
D	8	12	16	12
E	2	6	10	6
F	6	10	14	10

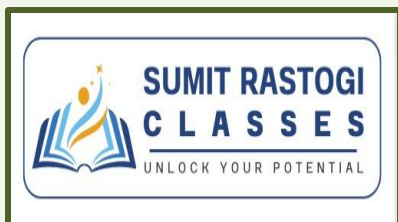
(ii)

Path	Time Duration
A → D → F	20 + 12 + 10 = 42 Days
A → C → E → F	20 + 10 + 6 + 10 = 46 Days
B → E → F	25 + 6 + 10 = 41 Days

Expected time for Completion of Project = 46 days

(iii) Critical Path = A → C → E → F

Time duration = 46 Days



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Calculation of Total Float and Free Float of each activities

Activity	Time Duration	EST	EFT	LST	LFT	Total Float	Free Float
A	20	0	20	0	20	0	0
B	25	0	25	5	30	5	5
C	10	20	30	20	30	0	0
D	12	20	32	24	36	4	4
E	6	30	36	30	36	0	0
F	10	36	46	36	46	0	0

ANS. 7 (a)

(i) Calculation of Individual replacement cost per month

Month x	Probability P(x)	x P(x)
1	0.10	0.10
2	0.15	0.30
3	0.25	0.75
4	0.30	1.20
5	0.20	1.00
		$\sum x P(x) = 3.35$

Expected time of failure of a bulb = 3.35 Month

Average No. of Bulb failed per Month = $1/3.35 \times 3000$

(No. of Bulb = $500 \times 6 = 3000$)

Individual replacement cost per month = $1/3.35 \times 3000 \times 30 = ₹26865.27$

(ii) Calculation of group replacement cost per month

Calculation of No. of bulb failed each month

No. of bulb failed in 1st Month = $3000 \times 0.10 = 300$

No. of bulb failed in 2nd Month = $3000 \times 0.15 + 300 \times 0.10$
 $= 450 + 30 = 480$

No. of bulb failed in 3rd Month
 $= 3000 \times 0.25 + 300 \times 0.15 + 480 \times 0.10$
 $= 750 + 45 + 48 = 843$ bulb

No. of bulb failed in 4th Month
 $= 3000 \times 0.30 + 843 \times 0.10 + 480 \times 0.15 + 300 \times 0.25$
 $= 900 + 84.3 + 72 + 75 = 1131.3$
 $= 1131$ bulb

No. of bulb failed in 5th Month
 $= 3000 \times 0.20 + 1131 \times 0.10 + 843 \times 0.15 + 480 \times 0.20 + 300 \times 0.30$
 $= 600 + 113.1 + 126.45 + 96 + 90$
 $= 1025.55 = 1026$ bulb

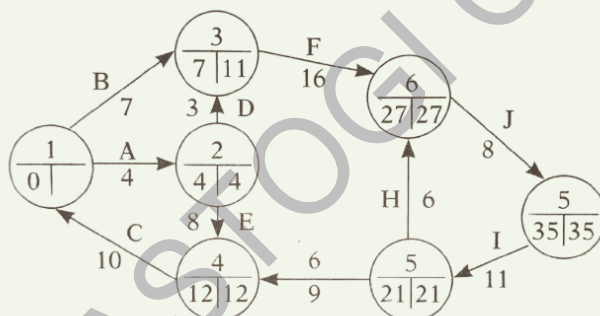
Month	No. of bulb failed	Cumulative No. of bulb failed	Individual Replacement Cost (₹)	Group Replacement Cost (₹)	Total Replacement Cost (₹)	Average Replacement Cost (₹)
1	300	300	9000	30000	39000	39000
2	480	780	23400	30000	53400	26700
3	843	1623	48690	30000	78690	26230
4	1131	2754	82620	30000	112620	28155
5	1026	3780	113400	30000	143400	28680

(iii) Group replacement cycle is considered every 3 month, because average replacement cost of every 3 month is lower.

(iv) Group replacement cost of every 3 month interval is lower than individual replacement cost so group replacement policy is better than individual replacement policy.

ANS. 7 (b)

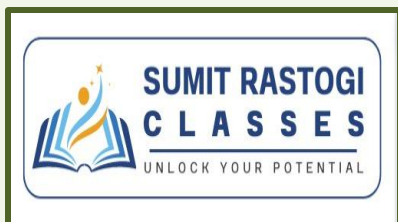
(i) PERT Network Diagram.



(ii)

Path	Time Duration
(i) B → F → J	31 Days
(ii) A → D → F → J	31 Days
(iii) A → E → G → H → J	35 Days
(iv) A → E → G → I	32 Days
(v) C → G → H → J	33 Days
(vi) C → G → I	30 Days

(iii) Critical Path = A → E → G → H → J
Time duration of Project



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(iv) Calculation of Total Float & Free Float

Activity	Time Duration	EST	EFT	LST	LFT	Total Float	Free Float
A	4	0	4	0	4	0	0
B	7	0	7	4	11	4	0
C	10	0	10	2	12	(2)	(2)
D	3	4	7	8	11	(4)	(0)
E	8	4	12	4	12	0	0
F	16	7	23	11	27	4	4
G	9	12	21	12	21	0	0
H	6	21	27	21	27	0	0
I	11	21	32	24	35	(3)	(3)
J	8	27	35	27	35	0	0

Total Float = LST – EST

Free Float = Total Float – Head Stock

Activity	Total Float	Free Float
C	2	2
D	4	0
F	4	4
G	3	3

ANS. 8 (a)

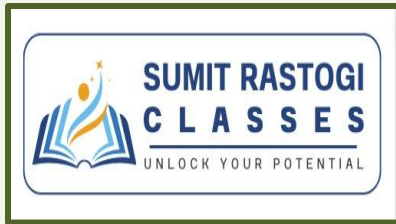
Individual Replacement Policy

Month x	Probability P(x)	XP (x)
1	0.10	0.10
2	0.15	0.30
3	0.25	0.75
4	0.30	1.20
5	0.20	1.00
		$\Sigma \times P(x) = 3.35$

Expected time of failure of a bulb = 3.35 Month

Average number of Bulb failed per month = $1/3.35 \times 1000$

Individual Replacement Cost per month = $1000/3.35 \times 100$
 = ₹29850.75



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Group Replacement Policy

(i) Calculation of No. of bulb replaced every month

$$\text{No. of bulb replaced in 1}^{\text{st}} \text{ Month} = 1000 \times 0.10 = 100$$

$$\text{No. of bulb failed in 2}^{\text{nd}} \text{ Month} = 1000 \times 0.15 + 100 \times 0.10 = 150 + 10 = 160$$

$$\text{No. of bulb failed in 3}^{\text{rd}} \text{ Month} = 1000 \times 0.25 + 160 \times 0.10 + 100 \times 0.15 = 250 + 160 + 15 = 281$$

$$\begin{aligned} \text{No. of bulb failed in 4}^{\text{th}} \text{ Month} &= 1000 \times 0.30 + 281 \times 0.10 + 160 \times 0.15 + 100 \times 0.25 \\ &= 300 + 28.1 + 24 + 25 = 377.1 = 377 \text{ (approx)} \end{aligned}$$

$$\begin{aligned} \text{No. of Bulb failed in 5}^{\text{th}} \text{ Month} &= 1000 \times 0.20 + 377 \times 0.10 + 281 \times 0.15 + 160 \times 0.25 + 100 \\ &\quad \times 0.30 = 200 + 37.7 + 42.15 + 40 + 30 = 349.85 = 350 \end{aligned}$$

Calculation of Average Replacement Cost

Month	No. of Bulb failed	Cumulative No. of Bulb failed	Individual Rep. Cost	Group Rep. Cost	TRC	ARC
1	100	100	10000	20000	30000	30000
2	160	260	26000	20000	46000	23000
3	281	541	54100	20000	74100	24700
4	377	918	91800	20000	111800	27950
5	350	1268	126800	20000	146800	29360

Here Average Replacement Cost is Minimum in 2nd Year.

Group Replacement policy can be considered in every 2 month interval.

(ii) Average individual Rep. Cost = ₹29850.75.

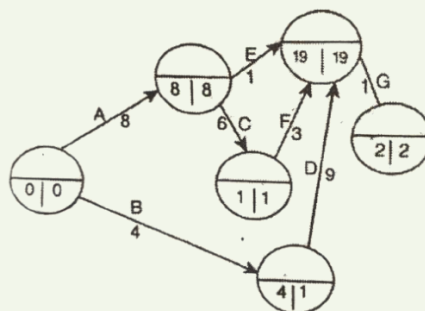
(iii) If Group Replacement Policy is Considered then all bulb can be replaced in every two month interval. Comparison between Group Replacement Policy and Individual replacement policy.

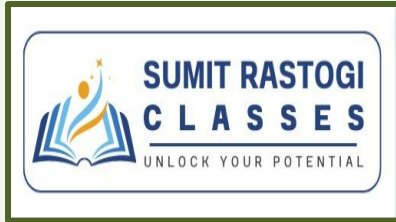
Average Group Rep. Cost in every 2 month interval = ₹23000

Average Individual Rep. Cost = ₹29850.750

Average Group Rep. Cost is Lower than Average Individual Rep. Cost. So Group Replacement Policy is better than individual replacement policy.

ANS. 8 (b)





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- (i) The network diagram is drawn above
(ii) Critical Path: A-E-G
(iii) Expected Time: 20 Hrs.
(iv) Slack Time for each path ACFG: 2 Hrs.
A-E-G: 10 Hrs.
B-D-G: 6 Hrs.
(v) & (vi) Calculated in the following table:

Activity	Duration	EST	EFT	LFT	LST
A	8	0	8	8	0
B	4	0	4	10	6
C	6	8	14	16	10
D	9	4	13	19	10
E	11	8	19	19	8
F	3	14	17	19	16
G	1	19	20	20	19