

# Revisionary Test Paper \_ June 2018

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**Intermediate  
Group II  
Paper 9: Operations Management & Strategic Management  
(SYLLABUS – 2016)**

**SECTION - A  
OPERATIONS MANAGEMENT**

**PART-I – Objective Questions**

1. (A) Choose the most correct alternative:

i. Example of production by disintegration is :

- (a) Automobile
- (b) Locomotive
- (c) Crude oil
- (d) Mineral water.

ii. Fixing Flow lines in production is known as :

- (a) Scheduling
- (b) Loading
- (c) Planning
- (d) Routing

iii. The material handling cost per unit of product in continuous production is:

- (a) Highest compared to other systems
- (b) Lower than other systems
- (c) Negligible
- (d) Cannot say.

iv. Important factor in forecasting production is:

- (a) Environmental changes
- (b) Available capacity of machines
- (c) Disposable income of the consumer
- (d) Changes in preference of the consumer.

v.  $(\text{Total station time}/\text{Cycle time} \times \text{Number of work stations}) \times 100$  is known as:

- (a) Line Efficiency
- (b) Line smoothness
- (c) Balance delay of line
- (d) Station efficiency

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- vi. **Tempering is a process of:**
- (a) Joining
  - (b) Heat Treatment
  - (c) Surface Treatment
  - (d) Forming
- vii. **For production planning:**
- (a) Short term forecasting is useful
  - (b) Medium term forecasting is useful
  - (c) Long term forecasting is useful
  - (d) Forecasting is not useful.
- viii. **To decide work load for men and machines:**
- (a) Medium range forecasting is used
  - (b) Short term forecasting is used
  - (c) Long range forecasting is used
  - (d) A combination of long range and medium range forecasting is used
- ix. **Addition of value to raw materials through application of technology is**
- (a) Product
  - (b) Production
  - (c) Transformation
  - (d) None of these
- x. **Scheduling shows:**
- (a) Total cost of production
  - (b) Total material cost
  - (c) Which resource should do which job and when
  - (d) The flow line of materials
- xi. **JIT stands for:**
- (a) Just time purchase
  - (b) Just in time production
  - (c) Just in time use of materials
  - (d) Just in time order the material
- xii. **The following establishes time sequence of operations:**
- (a) Routing
  - (b) Sequencing
  - (c) Scheduling
  - (d) Dispatching

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xiii. **Linear Programming is a technique used for determining:**

- (a) Production Programme
- (b) Plant Layout
- (c) Product Mix
- (d) Manufacturing Sequence.

xiv. **One of the important charts used in Programme control is:**

- (a) Material Chart
- (b) Gantt Chart
- (c) Route Chart
- (d) Inspection Chart

xv. **One of the product examples for Line Layout is:**

- (a) Repair Workshop
- (b) Welding Shop
- (c) Engineering College
- (d) Cement.

**Answer:**

- i. (c) Crude Oil – By separating the contents of crude oil the desired fuel oils are produced.
- ii. (d) Routing – Routing decision involves deciding the division of work into operations, the sequence in which each operation is to be done, division of each operation into elements.
- iii. (b) Lower than other systems – Since machines are so located as to minimize distance between consecutive operations.
- iv. (b) Available capacity of machines – Capacity of machines is one of the limiting factor for deciding production volume, other factors given help in forecasting the demand.
- v. (a) Line efficiency –  $\text{Line efficiency} = \frac{\text{Total minutes produced by the line}}{\text{total minutes attended by all operators}}$ .
- vi. (b) Heat Treatment – Tempering is the process of reheating which will reduce the brittleness and soften the steel.
- vii. (a) Short term forecasting is useful
- viii. (b) Short term forecasting is used
- ix. (b) Production
- x. (c) Which resource should do which job and when
- xi. (b) Just in time production
- xii. (c) Scheduling
- xiii. (c) Product Mix
- xiv. (b) Gantt chart
- xv. (d) Cement – Line layout is suitable in plants manufacturing standardized products on mass scale like cement, paper, chemical etc.

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1. (b) Match each item in column A with appropriate item in column B:

Column A	Column B
(I) KANBAN	(a) Transportation Application
(II) VAM	(b) Metal Cutting
(III) Broaching	(c) Scheduling
(IV) Tools	(d) Job Evaluation
(V) Ranking Method	(e) Machine Shop

1. (c) Match the following cases:

Column A	Column B
(I) Linear Programming	(a) Quality Control
(II) Average Outgoing Quality	(b) Cost control
(III) Value Analysis	(c) Crashing
(IV) Programme Evaluation and Review Technique	(d) Product Mix Determination
(V) Network Analysis	(e) Project Planning

1. (d) Indicate whether the following statements are true/ false:

- I. Material handling is an integral part of sales process.
- II. The time horizon selected for forecasting depends on time required for production cycle.
- III. Rucker plan is a group incentive plan
- IV. Assignment problem is solved by Johnson and Bellman method.
- V. Preventive maintenance is useful in reducing inspection cost.

Answer: 1. (b)

1.(c)            2.(a)            3.(b)            4.(e)            5.(d)

Answer: 1. (c)

1.(d)            2.(a)            3.(b)            4.(e)            5.(c)

Answer: 1. (d)

I.(F)            II.(F)            III.(T)            IV.(T)            V.(F)

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## Part II: Subjective Questions

### 2. Describe the areas of production planning & control.

Answer:

(a) Production Planning and Control encompasses the following areas:

- (i) **Materials:** Planning for procurement of raw materials, components and spare parts in the right quantities and specifications at the right time from the right source at the right price. Purchasing, storage, inventory control, standardisation, variety reduction, value analysis and inspection are the other activities associated with materials.
- (ii) **Methods:** Choosing the best method of processing from several alternatives. It also includes determining the best sequence of operations (process plans) and planning for tooling, jigs and fixtures etc.
- (iii) **Machines and Equipments:** Manufacturing methods are related to production facilities available in the production system. It involves facilities planning, capacity planning, allocation and utilization of plant and equipments, machines etc.  
It also involves equipments replacement policy, maintenance policy and maintenance schedules, tools manufacture and maintenance of tools etc.
- (iv) **Manpower:** Planning for man power (labour, supervisory and managerial levels) having appropriate skills and expertise.
- (v) **Routing:** Determining the flow of work, material handling in the plant, and sequence of operations or processing steps. This is related to considerations of appropriate shop layout and plant layout, temporary storage locations for raw materials, components and semi finished goods, and of materials handling system.
- (vi) **Estimating:** Establishing operation times leading to fixation of performance standards both for workers and machines.
- (vii) **Loading and Scheduling:** Machine loading is allocation of jobs to machines in conjunction with routing and with due consideration for capacity of machines and priority for jobs in order to utilize the machines to the maximum possible extent. Scheduling ensures that parts, sub assemblies and finished products are completed as per required delivery dates. It provides a time table of manufacturing activities. It ensures balanced load on all work centres and ensures even flow of work through the manufacturing facilities.
- (viii) **Dispatching:** This is concerned with the execution of the planning functions. It gives necessary authority to start a particular work which has already been planned under routing and scheduling functions. Dispatching is release of orders and instructions for the starting of production in accordance with the route sheets and schedule charts.
- (ix) **Expediting:** Means chasing, follow up or progressing which is done after dispatching function. It keeps a close liaison with scheduling in order to

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provide an efficient feedback and prompt review of targets and schedules.

- (x) **Inspection:** This function is related to maintenance of quality in production and of evaluating the efficiency of the processes, methods and labour so that improvements can be made to achieve the quality standards set by product design.
- (xi) **Evaluating:** The objective of evaluation is to improve performance. Performance of machines, processes and labour is evaluated to improve the same.
- (xii) **Cost Control:** Manufacturing cost is controlled by wastage reduction, value analysis, inventory control and efficient utilization of all resources.

3. List the major areas and types of maintenance an organization may use in those areas.

Answer:

Areas of maintenance

The major areas of maintenance are:

- (1) Civil maintenance
- (2) Mechanical maintenance
- (3) Electrical maintenance

Types of maintenance: In all the above stated areas, organization may use any or all the five types of maintenance:

- (a) Break down maintenance or corrective maintenance,
- (b) Preventive maintenance,
- (c) Predictive maintenance,
- (d) Routine maintenance,
- (e) Planned maintenance.

4. (a) The following is the demand for Product A in 5 towns :

Population (in lacs) : X	9	5	8	5	3
Demand : Y	12	20	15	10	5

Estimate the demand for Product A for a town with a population of 10 lacs.

(b) The annual sales of TV sets by a dealer in Delhi are as under:

Year	2013	2014	2015	2016	2017
Sales (thousand units)	3	14	36	4	33

Fit a linear trend equation to the sales figure and estimate the sales for the year 2018.

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4 (a) Answer:

Population (in lacs) : X	Demand : Y	Squares of population : X <sup>2</sup>	Product of population and sales : XY
9	12	81	108
5	20	25	100
8	15	64	120
5	10	25	50
3	5	9	15
$\Sigma X = 30$ N = 5	$\Sigma Y = 62$	$\Sigma X^2 = 204$	$\Sigma XY = 393$

Regression equation of Y on X:  $Y = a + b X$

To find the value of "a" and "b" the following equations are to be solved:

$$\Sigma Y = na + b\Sigma X \quad \dots\dots\dots (i)$$

$$\Sigma XY = a\Sigma X + b \Sigma X^2 \quad \dots\dots\dots (ii)$$

By putting the values, we get

$$62 = 5a + 30b \quad \dots\dots\dots (iii)$$

$$393 = 30.a + 204b \quad \dots\dots\dots (iv)$$

Multiplying equation no. (iii) by 6 and putting it as no. (v) we get

$$372 = 30.a + 180b \quad \dots\dots\dots (v)$$

By deducting equation (v) from (iv), we get

$$393 - 372 = (30a - 30a) + (204b - 180b)$$

$$21 = 24b$$

$$b = 21/24 = 0.875$$

By Substituting the value of b in equation no (iii), we get

$$62 = 5a + (30 \times 0.875)$$

$$= 5a + 26.25$$

$$5a = 62 - 26.25 = 35.75$$

$$a = 35.75 / 5 = 7.15$$

Now, by putting the values of a, b and X (i.e. 10) in the regression equation of Y on X,

We get  $Y = a + b X$

$$= 7.15 + (0.875 \times 10)$$

$$= 7.15 + 8.75$$

$$= 15.9$$

Hence, the expected demand for Product A for a town with a population of 10 lacs will be approximately 16.

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4 (b) Answer:

Year	Time deviation from 2015 X	Sales ('000 units) Y	Square of Time deviation X <sup>2</sup>	Product of Time deviation & sales XY
2013	-2	3	4	-6
2014	-1	14	1	-14
2015	0	36	0	0
2016	+1	4	1	4
2017	+2	33	4	66
n = 5	ΣX = 0	ΣY = 90	ΣX <sup>2</sup> = 10	ΣXY = +50

Regression equation of Y on X.

$$Y = a + bX$$

$$a = \frac{\Sigma Y}{n} = \frac{90}{5} = 18$$

$$b = \frac{\Sigma XY}{\Sigma X^2} = \frac{50}{10} = 5$$

$$Y = 18 + 5X$$

$$Y_{2018} = 18 + 5(3) = 18 + 15 = 33 \text{ i.e. } 33000 \text{ units of TVs.}$$

5. (a) Calculate the economic run length, if

Annual demand (A)	=12,000 units
Set-up cost (S)	= Rs.60 per run
Production rate (P)	=18,750 units per year
Unit cost (C)	= Rs.5 per unit
Inventory carrying rate (I)	=20% per annum

5. (b) Precision Assembly Ltd. requires 8000 pieces of a bought out component in a year. Price of the item is Rs.6 and it has been found that it takes Rs.60 to place an order. If the carrying cost is 25% of the value of inventory held in stock, what would be the optimum size of each order? How many orders will be required to be placed in a year by the company for this component?



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Answer: 5. (a)

$$\text{Economic run length} = \sqrt{\frac{2 \times S \times A}{P \left[ 1 - \frac{D}{P} \right]}}$$

$$\text{Where D is Daily demand rate} = \frac{12,000}{360} = \frac{100}{3}$$

$$= \sqrt{\frac{2 \times 60 \times 12,000}{20\% \text{ of } 5 \left[ 1 - \frac{100/3}{18,750/360} \right]}}$$

$$= \sqrt{\frac{14,40,000}{1 \left[ 1 - \frac{16}{25} \right]}} = \sqrt{\frac{14,40,000}{9/25}} = 2,000 \text{ units}$$

Answer: 5. (b)

Optimum size of order

$$= \sqrt{\frac{2 \times \text{Annual requirement} \times \text{order costs}}{\text{Price per component} \times \text{carrying cost}}}$$

$$= \sqrt{\frac{2 \times 8,000 \times 60}{6 \times 0.25}} = \sqrt{6,40,000} = 800 \text{ pieces}$$

$$\text{No of orders to be placed} = \frac{8,000}{800} = 10$$

6. (a) Explain the meaning of plant layout?

(b) Explain -Plant layout – Principles.

Answer: 6. (a)

Plant layout implies physical arrangement of machines, equipments and other facilities on the factory floor in such a manner that they may be handled efficiently. Plant layout, also known as layout of facility refers to the configuration of department, work-centres and equipment and machinery with focus on the flow of materials or work through the production system. Plant layout or facility layout means planning for location of all machines, equipments, utilities, work stations, customer service areas, material storage areas, tool servicing areas, tool cribs, aisles, rest rooms, lunch rooms, coffee / tea bays, offices, and computer rooms and also planning for the patterns of flow of materials and people around, into and within the buildings. Layout planning involves decisions about the physical arrangement of economic activity centres within a facility. An economic activity centre can be anything that consumes space, a person or group of people, a machine, a work station, a equipments to operate more effectively.

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Answer: 6. (b)

The layout selected in conformity with layout principles should be an ideal one. These principles are:

- Principle of Minimum Travel: Men and materials should travel the shortest distance between operations so as to avoid waste of labour and time and minimize the cost of materials handling.
- Principle of Sequence: Machinery and operations should be arranged in a sequential order. This principle is best achieved in product layout.
- Principle of Usage: Every unit of available space should be effectively utilized. This principle should receive top consideration in towns and cities where, land is costly.
- Principle of Compactness: There should be a harmonious fusion of all the relevant factors so that the final layout looks well integrated and compact.
- Principle of Safety and Satisfaction: The layout should contain build in provisions for safety for the workmen. It should also be planned on the basis of the comfort and convenience of the workmen so that they feel satisfied.
- Principle of Flexibility: The layout should permit revisions with the least difficulty and at minimum cost.
- Principle of Minimum Investment: The layout should result in savings in fixed capital investment, not by avoiding installation of the necessary facilities but by an intensive, use of available facilities.

7. (a) There are two industries A and B manufacturing hose couplings. The standard time per piece is 15 minutes. The output of two small scale industries is 30 and 20 respectively per shift of 8 hours. Find the productivity of each per shift of 8 hours. What is the expected production of each per week consisting of 6 days?

(b) The following data is available for a machine in a manufacturing unit:

Hours worked per day	8
Working days per month	25
Number of operators	1
Standard minutes per unit of production	
Machine time	22
Operator time	<u>8</u>
Total time per unit	30

- (i) if plant is operated at 75% efficiency, and the operator is working at 100% efficiency, what is the output per month?
- (ii) If machine productivity is increased by 10% over the existing level, what will be the output per month?
- (iii) If operator efficiency is reduced by 20% over the existing level, what will be the output per month?

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Answer 7 (a):

$$\text{Productivity} = \frac{\text{Actual Production}}{\text{Standard Production}}$$

$$\text{Standard production of hose complings per shift} = \frac{8 \times 60}{15} = 32 \text{ pcs.}$$

$$\text{Productivity of industry A} = \frac{30}{32} = \frac{15}{16} \text{ and productivity of industry B} = \frac{20}{32} = \frac{5}{8}$$

If the productivity is expressed in percentage, the same for A is  $\frac{15}{16} \times 100 = 93.75\%$

$$\text{And productivity of industry B is } \frac{5}{8} \times 100 = 62.5\%$$

$$\text{Production per week of industry A} = 30 \times 16 = 480 \text{ nos.}$$

$$\text{Production per week of industry B} = 20 \times 6 = 120 \text{ nos.}$$

Answer 7 (b):

- (i) Hours worked per day = 8  
Working days per month = 25  
Hours worked per month = 25 x 8 = 200 hrs.  
Machine time = 8 minutes  
Operator time = 30 minutes = ½ hr.

$$\text{No. of units produced / month / operator} = \frac{200}{1/2} = 400$$

As the no. of operator is 1, monthly production = 400 units. As the plant operates at 75% efficiency.

$$\text{Monthly production} = 400 \times \frac{75}{100} = 300 \text{ units.}$$

- (ii) If machine productivity is increased by 10% i.e. Machine time =  $22 \times \frac{100}{(100+10)} = 20$  minutes.

$$\text{Then, total time} = 20 + 8 = 28 \text{ minutes}$$

$$\text{Monthly production} = \frac{400 \times 30}{28} \times \frac{75}{100} = 321 \text{ units.}$$

- (iii) If operator efficiency reduced by 20% i.e.

$$\text{Operator time} = 8 \times \frac{(100+20)6}{100} = 8 \times 7.2 = 57.6 \text{ minutes.}$$

$$\text{Total time} = 22 + 57.6 = 79.6 \text{ minutes.}$$

$$\text{Monthly production} = \frac{400 \times 30}{79.6} \times \frac{75}{100} = 113.06 \text{ units} = 113 \text{ units.}$$

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8. A soap factory adopts the piece rate system for its packing section, the rate being 10 paise. There is a guaranteed wage of Rs.20 per day. The following data is available in regard to the number of soap cakes packed per day.

Worker	No. of soap cakes packed
A	800
B	600
C	100
D	700

- (a) (i) What is the wage payable to each worker?  
 (ii) What is the average cost of packing per soap cake for the day?
- (b) The standard time for packing is 4 minutes in the above example.  
 (i) What is the labour productivity of each worker for a shift duration of 480 minutes?  
 (ii) What is the productivity of the group?  
 (iii) Give your comments on the productivity figures obtained.

Answer: (a)

- i. Wages payable are – (A)  $800 \times 0.10 = \text{Rs.}80$ ; (B)  $600 \times 0.10 = \text{Rs.}60$ ; (C)  $100 \times 0.10 = \text{Rs.}100 = \text{Rs.}20$  (guaranteed wage); (D)  $700 \times 0.10 = \text{Rs.}70$
- ii. Average cost of packing per soap for the day  

$$= \frac{80+60+20+70}{800+600+100+700} \times 100 = 23000 / 2200 = 10.45 \text{ paise approx.}$$

(b)

- i. Labour productivity or each worker (A) :  $[800 \div (480/4)] \times 100 = 666.7\%$ ; (B) :  $[600 \div (480/4)] \times 100 = 500\%$ ; (C) :  $[100 \div (480/4)] \times 100 = 83.3\%$ ; (D) :  $[700 \div (480/4)] \times 100 = 583.3\%$
- ii. Productivity of the group =  $[(800 + 600 + 100 + 700)] \div \frac{480 \times 4}{4} \times 100 = 458.3\%$
- iii. Productivity figures of all the workers except C are excellent. Group productivity is also quite good.

9. A company's fixed and variable costs for manufacturing a component on three alternative machines are given below, formulate the decision rules for selecting the machines.

	Fixed Cost (Rs.)	Variable Cost (Rs. / unit)
Engine lathe	5	0.20
Capstan lathe	30	0.10
Automat	70	0.05

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**Answer:**

The total cost = fixed cost + [variable cost / unit x no. of units]

Let,  $T_{c1}$ ,  $T_{c2}$  and  $T_{c3}$  be the total costs for engine lathe, capstan lathe and automat respectively

Let, 'x' be the number of units to be manufactured then,

$$\text{Total cost on Engine lathe } (T_{c1}) = 5 + 0.2x$$

$$\text{Total cost on Capstan lathe } (T_{c2}) = 30 + 0.1x$$

$$\text{Total cost on Automat } (T_{c3}) = 70 + 0.05x$$

Now, comparing the  $T_{c1}$  and  $T_{c2}$ .

$$\therefore 5 + 0.2x = 30 + 0.1x$$

$$\therefore 0.1x = 25$$

$$\therefore x = 250$$

Comparing the  $T_{c2}$  and  $T_{c3}$

$$\text{At B.E.P. } T_{c2} = T_{c3}$$

$$\therefore 30 + 0.1x = 70 + 0.05x$$

$$\therefore 0.05x = 40$$

$$\therefore x = 800$$

Decision Rules

- (i) If the quantity is below 300, select engine lathe
- (ii) Between 300 to 800, select capstan lathe
- (iii) Above 800, Automat is to be selected.

10. The owner of a Shop is interested to determine, how many advertisements to release in the selected three magazines K, L and M. His main purpose is to advertise in such a way that total exposure to principal buyers of his goods is maximized. Percentages of readers for each magazine are known. Exposure in any particular magazine is the number of advertisements released multiplied by the number of principal buyers. The following data are available:

Particulars	Magazines		
	K	L	M
Readers	1.0 lakh	0.6 lakh	0.4 lakh
Principal Buyers	20%	15%	8%
Cost per Advertisement	8,000	6,000	5,000

The budgeted amount is at the most Rs.1.0 lakh for the advertisements. The owner has already decided that magazine K should have not more than 15 advertisements and that L and M should get at least 8 advertisements. Formulate a Linear Programming Model for this problem.

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**Answer:**

Let us first calculate, effective exposure.

Magazine (A)	No. of Principal Buyers (B)	No. of Readers (C)	Effective Exposure (D = B x C)
K	20%	1,00,000	20,000
L	15%	60,000	9,000
M	8%	40,000	3,200

Let  $X_1$ ,  $X_2$  and  $X_3$  represent the number of advertisement inserted in the three magazines K, L and M respectively.

Since the objective is to maximize the effective exposures, the objective function is given by – Maximize  $Z = 20,000x_1 + 9,000x_2 + 3,200x_3$

Subject to:

$8,000x_1 + 6,000x_2 + 5,000x_3 \leq \text{Rs.}1,00,000$  (Budgeted Amount constraint)

$X_1 \leq 15$  (Maximum No. of advertisements constraint)

$X_2 \geq 8$  (Minimum No. of Advertisements constraint)

$X_3 \geq 8$  (Minimum No. of advertisements constraint)

$X_1 \geq 0$  (Non – Negativity constraint)

**11. Four Operators  $O_1$ ,  $O_2$ ,  $O_3$  and  $O_4$  are available to a manager who has to get four jobs  $J_1$ ,  $J_2$ ,  $J_3$  and  $J_4$  done by assigning one job to each operator. Given the time needed by different operators for different jobs in the matrix below:**

	$J_1$	$J_2$	$J_3$	$J_4$
$O_1$	12	10	10	8
$O_2$	14	12	15	11
$O_3$	6	10	16	4
$O_4$	8	10	9	7

(i) How should manager assign the jobs so that the total time needed for all four jobs is minimum?

(ii) If job  $J_2$  is not to be assigned to operator  $O_2$ , what should be the assignment over how much additional total time will be required?

**Answer 11:**

Step 1 → Row subtraction: Subtracting the minimum element of each row from all elements of that row.

operators	Job			
	$J_1$	$J_2$	$J_3$	$J_4$
$O_1$	4	2	2	0
$O_2$	3	1	4	0
$O_3$	2	6	12	0
$O_4$	1	3	2	0

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Step 2 → Column Subtraction: Subtracting the minimum element of each column from all element of that column and drawing minimum number of lines to cover all zeros.

operators	Job			
	J <sub>1</sub>	J <sub>2</sub>	J <sub>3</sub>	J <sub>4</sub>
O <sub>1</sub>	<del>3</del>	<del>1</del>	<del>0</del>	<del>0</del>
O <sub>2</sub>	<del>2</del>	<del>0</del>	<del>2</del>	<del>0</del>
O <sub>3</sub>	1	5	10	0
O <sub>4</sub>	<del>0</del>	<del>2</del>	<del>0</del>	<del>0</del>

Step 3 → Assignment: Selecting a row containing exactly one unmarked zero and surrounding it by '□' and draw a vertical line through the column containing this zero. Repeating this process till no such row is left; they selecting a column containing exactly one unmarked zero and surrounding it by '□' and draw a horizontal line through the row containing this zero and repeating the process till no such column is left.

operators	Job			
	J <sub>1</sub>	J <sub>2</sub>	J <sub>3</sub>	J <sub>4</sub>
O <sub>1</sub>	<del>3</del>	<del>1</del>	□ 0 □	<del>0</del>
O <sub>2</sub>	<del>2</del>	□ 0 □	<del>2</del>	<del>0</del>
O <sub>3</sub>	1	5	10	□ 0 □
O <sub>4</sub>	□ 0 □	<del>2</del>	<del>0</del>	<del>0</del>

Step 4 → Computing the Minimum Time:

	Time
Operator O <sub>1</sub> is assigned to Job J <sub>3</sub>	10
Operator O <sub>2</sub> is assigned to Job J <sub>2</sub>	12
Operator O <sub>3</sub> is assigned to Job J <sub>4</sub>	4
Operator O <sub>4</sub> is assigned to Job J <sub>1</sub>	8
<b>Total</b>	<b>34</b>

(ii) Step 1 → If Job J<sub>2</sub> is not be assigned to operator O<sub>2</sub> then put a '-' in the cell to obtain the following matrix.

Operators	Job			
	J <sub>1</sub>	J <sub>2</sub>	J <sub>3</sub>	J <sub>4</sub>
O <sub>1</sub>	12	10	10	8
O <sub>2</sub>	14	-	15	11
O <sub>3</sub>	6	10	16	4
O <sub>4</sub>	8	10	9	7

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Step 2 → **Row Subtraction:** Subtracting the minimum element of each row from all elements of that row.

operators	Job			
	J <sub>1</sub>	J <sub>2</sub>	J <sub>3</sub>	J <sub>4</sub>
O <sub>1</sub>	4	2	2	0
O <sub>2</sub>	3	-	4	0
O <sub>3</sub>	2	6	12	0
O <sub>4</sub>	1	3	2	0

Step 3 → **Column Subtraction:** Subtracting the minimum element of each column from all elements of that column and drawing minimum number of lines to cover all zeros.

operators	Job			
	J <sub>1</sub>	J <sub>2</sub>	J <sub>3</sub>	J <sub>4</sub>
O <sub>1</sub>	<del>3</del>	<del>0</del>	<del>0</del>	<del>0</del>
O <sub>2</sub>	2	-	2	0
O <sub>3</sub>	1	4	10	0
O <sub>4</sub>	<del>0</del>	1	0	<del>0</del>

Since the number of lines = 3 and order of matrix = 4, we will have to take step to increase the number of zeros.

**Step 4** → Subtracting the minimum uncovered element (1 in this case) from all uncovered elements and adding it to all elements at the intersection point of the above lines and then drawing minimum number of lines to cover all zeros.

operators	Job			
	J <sub>1</sub>	J <sub>2</sub>	J <sub>3</sub>	J <sub>4</sub>
O <sub>1</sub>	3	0	0	1
O <sub>2</sub>	1	-	1	0
O <sub>3</sub>	0	3	9	0
O <sub>4</sub>	0	1	0	1

Since the number of lines drawn (4) = order of matrix (4), the above matrix will provide the optimal solution.

**Step 5** → **Assignment:** Selecting a row containing exactly one unmarked zero and surrounding it by '□' and draw a vertical line through the column containing this zero. Repeating this process till no such row is left; then selecting a column containing exactly one unmarked zero and surrounding it by '□' and draw a horizontal line through the row containing this zero and repeating the process till no such column is left.

operators	Job			
	J <sub>1</sub>	J <sub>2</sub>	J <sub>3</sub>	J <sub>4</sub>
O <sub>1</sub>	3	□ 0	0	1
O <sub>2</sub>	1	-	1	□ 0
O <sub>3</sub>	□ 0	3	9	0
O <sub>4</sub>	0	1	□ 0	1



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**Step 6** → Computing minimum Time:

	Time
Operator O <sub>1</sub> is assigned to Job J <sub>2</sub>	10
Operator O <sub>2</sub> is assigned to Job J <sub>4</sub>	11
Operator O <sub>3</sub> is assigned to Job J <sub>1</sub>	6
Operator O <sub>4</sub> is assigned to Job J <sub>3</sub>	9
<b>Total</b>	<b>36</b>

Additional Total Time required = 36 – 34 = 2 units of time.

**12. A project consists for four (4) major jobs, for which four (4) contractors have submitted tenders. The tender amounts, in thousands of rupees, are given below:**

Contractors	Jobs			
	A	B	C	D
1	120	100	80	90
2	80	90	110	70
3	110	140	120	100
4	90	90	80	90

Find the assignment, which minimizes the total cost of the project. Each contracts has to be assigned one job.

**Answer 12:**

The given problem is a standard minimization problem. Subtracting the minimum element of each row from all its elements in turn, the given problem reduces to

Contractors	Jobs			
	A	B	C	D
1	40	20	0	10
2	10	20	40	0
3	10	40	20	0
4	10	10	0	10

Now subtract the minimum element of each column from all its elements in turn. Draw the minimum number of lines horizontal or vertical so as to cover all zeros.

Contractor	Jobs			
	A	B	C	D
1	<del>30</del>	<del>10</del>	0	<del>10</del>
2	0	10	40	0
3	0	30	20	0
4	<del>0</del>	<del>0</del>	0	<del>10</del>

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Since the minimum number of lines to cover all zeros is equal to 4 (= order of the matrix), this matrix will give optimal solution. The optimal assignment is made in the matrix below:

Contractor	Jobs			
	A	B	C	D
1	30	10	0	10
2	0	10	40	<del>0</del>
3	<del>0</del>	30	20	0
4	<del>0</del>	0	<del>0</del>	10

The optimal assignment is

Contractors	Job	Cost (in thousands of rupees)
1	C	80
2	A	80
3	D	100
4	B	90

Hence, total minimum cost of project will be Rs.3,50,000.

13. Find the initial feasible solution by North - West Corner Method.

	W <sub>1</sub>	W <sub>2</sub>	W <sub>3</sub>	W <sub>4</sub>	Supplies
F <sub>1</sub>	48	60	56	58	140
F <sub>2</sub>	45	55	53	60	260
F <sub>3</sub>	50	65	60	62	360
F <sub>4</sub>	52	64	55	61	220
Demand	200	320	250	210	

W<sub>j</sub> → Warehouse, F<sub>i</sub> → Factory & Cell entries are unit costs.

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Answer:

**Initial Feasible Solution by North West Corner method (Nwcm)**

	W <sub>1</sub>	W <sub>2</sub>	W <sub>3</sub>	W <sub>4</sub>	Supplies
F <sub>1</sub>	140 48	60	56	58	140
F <sub>2</sub>	60 45	200 55	53	60	260
F <sub>3</sub>	50	120 65	240 60	62	360
F <sub>4</sub>	52	64	10 55	210 61	220
Demand	200	320	250	210	

14. (a) Explain the different activities included in JIT manufacturing.  
 (b) Identify the information that should be collected before scheduling maintenance activities.

Answer:

(a) JIT manufacturing includes many activities:

- (i) Inventory reduction: JIT is a system for reducing inventory levels at all stages of production viz. raw materials, work-in-progress and finished goods.
- (ii) Quality improvement: JIT provides a procedure for improving quality both within the firm and outside the firm.
- (iii) Lead time reduction: With JIT, lead time components such as set-up and move times are significantly reduced.
- (iv) Vendor control / performance improvement: JIT gives the buying organization greater power in buyer-supplier relationship. The firm moves from a situation where multiple suppliers are used to a situation where only one or two suppliers are used for supplying most parts. With fewer suppliers; the buying organization has more power because it is making larger purchases from each vendor. Also, the buying organization can now impose higher requirements on each supplier in terms of delivery and quality.
- (v) Continuous Improvement: In the JIT system, existing problems are corrected and new problems identified in a never-ending: approach to operations management.
- (vi) Total Preventive Maintenance: JIT emphasizes preventive maintenance to reduce the risk of equipment break-downs which may cause production hold ups and increase in manufacturing cycle time due to delays.

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(viii) Strategic Gain: JIT provides the firm's management with a means of developing, implementing and maintaining a sustainable competitive advantage in the market place.

- (b) The following information should be collected before scheduling maintenance activities:
- (i) Manpower (maintenance crew) available.
  - (ii) Pending maintenance work (in terms of man hours backlog).
  - (iii) Availability of machine or equipment for preventive maintenance service.
  - (iv) Availability of proper tools, handling equipments, consumables, spare parts etc.
  - (v) Availability of special maintenance equipments if any, special fixtures and tools, cranes, etc.
  - (vi) Whether additional manpower is available at outside sources to be hired when needed.
  - (vii) When to start the maintenance work and when it should be completed.
  - (viii) Previous maintenance history records or charts.

15. (a) The management of ABC Company is considering the question of marketing a new product. The fixed cost required in the project is Rs. 4,000. Three factors are uncertain viz. the selling price, variable cost and the annual sales volume. The product has a life of only one year. The management has the data on these three factors as under:

Selling Price Rs.	Probability	Variable Cost	Probability Rs.	Sales Volume	Probability (Units)
3	0.2	1	0.3	2,000	0.3
4	0.5	2	0.6	3,000	0.3
5	0.3	3	0.1	5,000	0.4

Consider the following sequence of thirty random numbers:

81, 32, 60, 04, 46, 31, 67, 25, 24, 10, 40, 02, 39, 68, 08, 59, 66, 90, 12, 64, 79, 31, 86, 68, 82, 89, 25, 11, 98, 16.

Required: Using the sequence (First 3 random numbers for the first trial, etc.) simulate the average profit for the above project on the basis of 10 trials.

(b) The director of finance, for a farm cooperative is concerned about the yields per acre she can expect from this year's corn crop. The probability distribution of the yields for the current weather conditions is given below:

Yield in kg. per acre	Probability
120	0.18
140	0.26
160	0.44
180	0.12

She would like to see a simulation of the yields she might expect over the next 10 years for weather conditions similar to those she is now experiencing.

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- (i) Simulate the average yield she might expect per acre using the following random numbers: 20, 72, 34, 54, 30, 22, 48, 74, 76, 02.

She is also interested in the effect of market-price fluctuations on the cooperative's farm revenue. She makes this estimate of per-kg prices for corn.

Price per kg (Rs.)	Probability
2.00	0.05
2.10	0.15
2.20	0.30
2.30	0.25
2.40	0.15
2.50	0.10

- (ii) Simulate the price she might expect to observe over the next 10 years using the following random numbers: 82, 95, 18, 96, 20, 84, 56, 11, 52, 03

Answer: (a)

**Table I – Random Number Coding**

	Probabilities	Cumulative Probabilities	Random numbers assigned
Selling Price (Rs.)			
3	0.2	0.2	00 – 19
4	0.5	0.7	20 – 69
5	0.3	1.0	70 – 99
Variable cost (Rs.)			
1	0.3	0.3	00 – 29
2	0.6	0.9	30 – 89
3	0.1	1.0	90 – 99
Sales Volumes (Units)			
2,000	0.3	0.3	00 – 29
3,000	0.3	0.6	30 – 59
5,000	0.4	1.0	60 - 99

**Table II – Simulation Activity**

S. No.	Random No.	Selling Price (Rs.)	Random No.	Variable cost (Rs.)	Random No.	Sales Volume ('000 units')
1	81	5	32	2	60	5
2	04	3	46	2	31	3
3	67	4	25	1	24	2
4	10	3	40	2	02	2
5	39	4	68	2	08	2
6	59	4	66	2	90	5
7	12	3	64	2	79	5
8	31	4	86	2	68	5
9	82	5	89	2	25	2
10	11	3	98	3	16	2

Profit = (Selling Price – Variable cost) × Sales Volume – Fixed cost.

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Simulated Profit in ten trials would be as follows:

S. No.	Profit
1	(Rs. 5 – Rs. 2) x 5,000 units – Rs.4,000 = Rs. 11,000
2	(Rs. 3 – Rs. 2) x 3,000 units – Rs.4,000 = Rs.– 1,000
3	(Rs. 4 – Rs. 1) x 2,000 units – Rs.4,000 = Rs. 2,000
4	(Rs. 3 – Rs. 2) x 2,000 units – Rs.4,000 = Rs.– 2,000
5	(Rs. 4 – Rs. 2) x 2,000 units – Rs.4,000 = Rs. 0
6	(Rs. 4 – Rs. 2) x 5,000 units – Rs.4,000 = Rs. 6,000
7	(Rs. 3 – Rs. 2) x 5,000 units – Rs.4,000 = Rs. 1,000
8	(Rs. 4 – Rs. 2) x 5,000 units – Rs.4,000 = Rs. 6,000
9	(Rs. 5 – Rs. 2) x 2,000 units – Rs.4,000 = Rs. 2,000
10	(Rs. 3 – Rs. 3) x 2,000 units – Rs.4,000 = Rs.– 4,000
<u>Total Rs.21,000</u>	

Therefore, average profit per trial =  $\frac{\text{Rs.21,000}}{10} = \text{Rs.2,100}$

**Answer (b):**

**Table I - Random Number Coding (Yield)**

Yield in kg. per acre	Probability	Cumulative Probability	Random numbers assigned
120	0.18	0.18	00-17
140	0.26	0.44	18-43
160	0.44	0.88	44-87
180	0.12	1.00	88-99

**Table II - Random Number Coding (Price)**

Price per kg.	Probability	Cumulative Probability	Random numbers assigned
2.00	0.05	0.05	00-04
2.10	0.15	0.20	05-19
2.20	0.30	0.50	20-49
2.30	0.25	0.75	50-74
2.40	0.15	0.90	75-89
2.50	0.10	1.00	90-99

**Table III - Simulation Work Sheet**

A Year	B Random No.	C (Simulation yield)	D Random number	E Price	F = C x E Revenue/acre
1	20	140	82	2.40	336
2	72	160	95	2.50	400
3	34	140	18	2.10	294
4	54	160	96	2.50	400
5	30	140	20	2.20	308
6	22	140	84	2.40	336
7	48	160	56	2.30	368
8	74	160	11	2.10	336
9	76	160	52	2.30	368
10	02	120	03	2.00	240
Total =					3,386

Average revenue per acre is  $\frac{3,386}{10} = \text{Rs.338.60}$

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16. (a) In a bank with a single server, there are two chairs for waiting customers. On an average one customer arrives every 10 minutes and each customer takes 5 minutes for getting served. Make suitable assumptions, find
- the Probability that an arrival will get a chair to sit on,
  - the probability that an arrival will have to stand, and
  - expected waiting time of a customer.
- (b) P Ltd. quality control deptt. is managed by a single person who takes an average 10 minutes in checking point of each of the machine coming for inspection. The machines arrive once in every 12 minutes on an average. One hour of the machine is valued at Rs.20 per hour and that of person is valued at Rs.10 per hour. What are the average hourly queuing system costs associated with the quality control deptt.?

Answer: 16 (a)

Following assumptions are made for solving the given queuing problem:

- The arrival rate is randomly distributed according to Poisson distribution.
- The mean value of the arrival rate is  $\lambda$ .
- The service time distribution is approximated by an exponential distribution and the rate of service is  $\mu$
- The rate of service is greater than the rate of arrivals (i.e.  $\mu > \lambda$ ).
- The queue discipline is first-come-first-served (FIFO).

From the data of the problem:

Arrival rate,  $\lambda = 10$  minutes of 6 customer per hour.

Service rate,  $\mu = 5$  minutes or 12 customer per hour.

There are two chairs excluding the service one.

(i) The probability that an arrival will get a chair to sit on is given by:

$$\begin{aligned} P_0 + P_1 + P_2 &= \left(1 - \frac{\lambda}{\mu}\right) + \frac{\lambda}{\mu} \left(1 - \frac{\lambda}{\mu}\right) + \left(\frac{\lambda}{\mu}\right)^2 \left(1 - \frac{\lambda}{\mu}\right) \\ &= \left(1 - \frac{6}{12}\right) + \frac{6}{12} \left(1 - \frac{6}{12}\right) + \left(\frac{6}{12}\right)^2 \left(1 - \frac{6}{12}\right) \\ &= \frac{1}{2} + \frac{1}{2} \cdot \frac{1}{2} + \left(\frac{1}{2}\right)^2 \cdot \frac{1}{2} = \frac{1}{2} + \frac{1}{4} + \frac{1}{8} = \frac{7}{8} = 0.875 \end{aligned}$$

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Alternatively,

Probability of having less than 3 customers in system

$$\begin{aligned} &= 1 - \left(\frac{\lambda}{\mu}\right)^n \\ &= 1 - \left(\frac{6}{12}\right)^3 \\ &= 1 - \frac{1}{8} = \frac{7}{8} = 0.875 \end{aligned}$$

(ii) The probability that an arrival will have to stand is given by:

$$1 - (P_0 + P_1 + P_2) = 1 - \frac{7}{8} = \frac{1}{8} = 0.125$$

Alternatively, a person will have to stand if the queue has 3 or more customers in it, the probability in such a case is given by:

$$\begin{aligned} P(n \geq 3) &= \left(\frac{\lambda}{\mu}\right)^3 \\ &= \left(\frac{6}{12}\right)^3 = \frac{1}{8} = 0.125 \end{aligned}$$

(iii) Expected waiting time of a customer in the queue is given by:

$$W_a = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{6}{12(12 - 6)} = \frac{1}{2 \times 6} \text{ hour or 5 minutes}$$

**Answer: 16 (b)**

$$\text{Arrival Rate} = \lambda = \frac{60}{12} = 5 \text{ per hour}$$

$$\text{Service Rate} = \mu = \frac{60}{10} = 6 \text{ per hour}$$

$$\text{Average no. of machines in system} = \frac{\lambda}{\mu - \lambda} = \frac{5}{6 - 5} = 5$$

Cost per machine hour is Rs. 20

Average hourly queuing system cost = 5 × Rs. 20 = Rs. 100

Average hourly cost for the employee = Rs. 10 per hour

Total costs associated with deptt. purpose = Rs. 100 + Rs. 10 = Rs. 110



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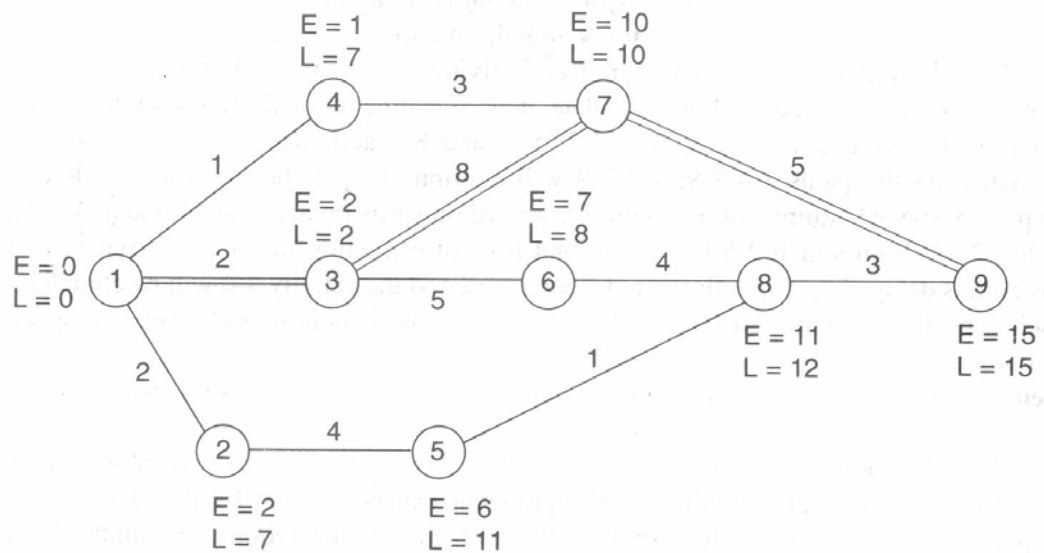
17. The following table lists the activities of a maintenance project:

Activity	Duration (in months)
1-2	2
1-3	2
1-4	1
2-5	4
3-6	5
3-7	8
4-7	3
5-8	1
6-8	4
7-9	5
8-9	3

- (I) Draw the project network.  
 (II) Find the critical path and duration of the project

Answer: 17

- (i) The network for the given project is drawn below:



Various paths	Duration of paths
1 – 3 – 7 – 9	2 + 8 + 5 = 15
1 – 3 – 6 – 8 – 9	2 + 5 + 4 + 3 = 14
1 – 2 – 5 – 8 – 9	2 + 4 + 1 + 3 = 10
1 – 4 – 7 – 9	1 + 3 + 5 = 9

Hence the critical path is 1 – 3 – 7 – 9 with project duration of 15 days

- (ii) The critical path is 1-3-7-9 and the project duration is 15 months

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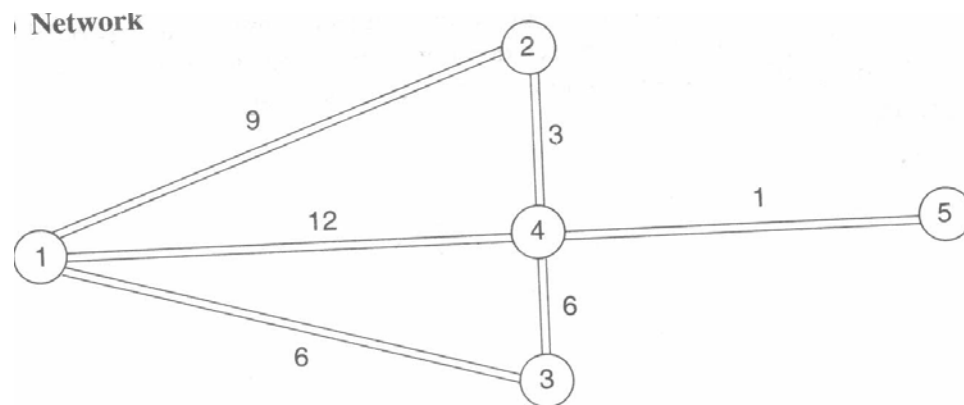
18. A small project consist of six activities with the following information:

Activity	Normal Duration	Minimum Time to Complete Activity	Reduction Cost per day
1-2	9	6	20
1-3	6	5	25
1-4	12	10	30
2-4	3	3	-
3-4	6	6	-
4-5	1	1	-

- (a) Draw the network and find Critical Path and normal Project duration  
 (b) Find out the various alternatives to reduce the normal duration to 12 days with the help of minimum time given for completing each activity and associated cost and suggest best alternative.

Answer:

(a)



Various paths

1 - 2 - 4 - 5

1 - 3 - 4 - 5

1 - 4 - 5

Duration of paths

$9 + 3 + 1 = 13$

$6 + 6 + 1 = 13$

$12 + 1 = 13$

(b) Statement showing various alternatives to reduce Normal project Duration and Associated Cost.

Activity	Days reduced	Reduction Cost per days	Total cost (2) × (3)
(1)	(2)	(3)	(4)
1- 2	1	20	20
1- 4	1	25	25
1- 3	1	30	30
			75

Since only one alternative exist, Hence the minimum cost to reduce project duration to 12 days is Rs. 75.

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19. (a) A workshop has 20 nos. of identical machine. The failure pattern of the machine is given below:-

Elapsed time after Maintenance attention (in month)	Probability of failure
1	0.20
2	0.15
3	0.15
4	0.15
5	0.15
6	0.20

It costs Rs.150 to attend a failed machine and rectify the same. Compute the yearly cost of servicing the broken down machines.

- (b) A Public transport system is experiencing the following number of breakdowns for months over the past 2 years in their new fleet of vehicles:

Number of breakdowns	0	1	2	3	4
Number of months this occurred	2	8	10	3	1

Each break down costs the firm an average of Rs. 2,800. For a cost of Rs. 1,500 per month, preventive maintenance can be carried out to limit the breakdowns to an average of one per month. Which policy is suitable for the firm?

**Answer (a)**

Expected time before failure.

$$= 0.20 \times 1 + 0.15 \times 2 + 0.15 \times 3 + 0.15 \times 4 + 0.15 \times 5 + 0.15 \times 6 = 3.5 \text{ months}$$

Therefore number or repair / machine / annum =  $12 / 3.5$

Considering 20 machines and Rs.150 to attend a failed machine the yearly cost of servicing

$$= 12 / 3.5 \times 20 \times 150 = \text{Rs.}10286$$

**Answer (b)**

Converting the frequencies to a probability distribution and determining the expected cost / month of breakdowns we get:

No. of breakdowns	Frequency in months	Frequency in per cent	Expected Value
0	2	0.083	0.000
1	8	0.333	0.333
2	10	0.417	0.834
3	3	0.125	0.375
4	1	0.042	<u>0.168</u>
			Total 1.710

Breakdown cost per month; expected cost =  $1.710 \times \text{Rs.}2800 = \text{Rs.}4788$ .

Preventive maintenance cost per month: -

Average cost one breakdown /month = Rs.2,800

Maintenance contract cost /month = Rs.1,500

Total Rs.4,300.

Thus, preventive maintenance policy is suitable for the firm.

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20. (a) A Firm is considering the replacement of a machine. The purchase price of the machine is Rs.16,600 while its scrap value is Rs.1,600. The data on maintenance cost in various years are as follows:

Year									
Maintenance:	1	2	3	4	5	6	7	8	9
Cost (in Rs.)	: 300	700	1000	1500	2100	2800	3600	4800	6200

What is the optimum replacement interval?

- (b) The following mortality rates have been observed for a certain type of light bulbs:

Week	1	2	3	4	5
Per cent failing by end of week	10	25	50	80	100

There are 1,000 bulbs in sue, and it costs Rs.2 to replace an individual bulb which has burnt out. If all bulbs were replaced simultaneously it would cost 50 paise 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. At what intervals should all the bulbs be replaced?

**Answer (a)**

Here we are given the maintenance cost  $M(t)$ , the scrap value  $S(t)$  and the cost of machine as  $C = \text{Rs.}16,600$ . We now compute the average cost per year during the life of the machine as shown in the following table:

Year (t)	Maintenance cost $\Sigma M(t)$	Cumulative maintenance cost $M(t)$	Loss in Purchase Price $C - S$	Total cost $C - S + \Sigma M(t)$	Average annual cost $T_A$
1	300	300	15,000	15,300	15,300
2	700	1,000	15,000	16,000	8,000
3	1,000	2,000	15,000	17,000	5,667
4	1,500	3,500	15,000	18,500	4,625
5	2,100	5,600	15,000	20,600	4,120
6	2,800	8,400	15,000	23,400	3,900
7	3,600	12,000	15,000	27,000	3,857
8	4,800	16,800	15,000	31,800	3,975
9	5,200	23,000	15,000	38,000	4,222

According to the above table, the lowest average cost per year is achieved by replacing the machine at the end of seventh year.

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Answer (b)

**Chart Showing Optimal Replacement Period**

	1	2	3	4	5
% failing during the week	10	15	25	30	20

Initial cost =  $1000 \times .5 = 500$

Week	Bulbs to be replaced cost	Weekly cost	Cumulative cost	Total Cost	Avg. weekly cost
1	$1,000 \times 0.1 = 100$	200	200	700	700
2	$1,000 \times 0.15 + 100 \times 0.1 = 160$	320	520	1020	510
3	$1,000 \times 0.25 + 100 \times 0.15 + 100 \times 0.10 = 281$	562	1,082	1,582	527

It should be replaced by the end of Second Week.

21. A faculty in a college is planned to rise to strength of 50 staff members and then to remain at that level. The wastage of recruits depends upon their length of service and is as follows:

Year:	1	2	3	4	5	6	7	8	9	10
Total % who left up to:	5	35	36	65	70	76	80	86	95	100

the end of year

- (i) Find the number of staff members to be recruited every year.
- (ii) If there are seven posts of Head of Deptt. for which length of service is the only criterion of promotion, what will be average length of service after which a new entrant should expect promotion?

**Answer:**

Let us assume that the recruitment per year is 100. From above it is clear that the 100 who join in the first year will become zero in 10th year, the 100 who join in the 2nd year will (serve for 9 years and) become 5 at the end of the 10th year and the 100 who join in the 3rd year will (serve for 8 years and) become 14 at the end of the 10th year and so on. Thus, when the equilibrium is attained, the distribution length of service of staff members will be as under:

Year	No. of staff members
0	100
1	95
2	65
3	44
4	35
5	30
6	24
7	20
8	14
9	5
10	0
Total	432

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(i) Thus if 100 staff members are recruited every year, the total number of staff members after 10 years of service = 432

100 to maintain a strength of 50, the number to be recruited every year =  $\frac{100}{432} \times 50 = 11.6$

It is assumed that those staff members who completed x years' service but left before x + 1 years' service, actually left immediately before completing x + 1 years.

If it is assumed that they left immediately after completing x years' service, the total number will become 432 - 100 = 332 and 100 the required intake will be  $50 \times \frac{100}{332} = 15$

In actual practice they may leave at any time in the year so that reasonable number of recruitments per year =  $\frac{11.6+15}{2} = 13$  (approx)

(ii) If we recruit 13 persons every year then we want 7 seniors. Hence if we recruit 100 every year, we shall require  $\frac{7}{13} \times 100 = 54$  (approx.) seniors.

It can be seen that 54 seniors will be available if we promote them during 6th year of their service ( $\because 0 + 5 + 14 + 20 + 24 = 63 < 54$ ).

$\therefore$  The promotion of a newly recruited staff member will be due after completing 5 years and before putting in 6 years of service.

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## SECTION – B STRATEGIC MANAGEMENT

### PART-I – Objective Questions

1. (a) M.C.Q.

(i) The BCG growth matrix is based on two dimensions:

- (A) market size and competitive intensity
- (B) relative market share and market/industry growth rate
- (C) profit margins and market size
- (D) market size and market share

(ii) The essential ingredients of Business Process Re-engineering are:

- (A) Continuous improvements of products, processes and technologies.
- (B) Advanced planning in the areas of technologies, processes and strategic partnerships etc.
- (C) Fundamental rethinking and radical redesign of business process to achieve dramatic results.
- (D) Generation, comparison and evolution of many ideas to find out one worthy of development.

(iii) Marketing Research studies are undertaken:

- (A) to measure brand loyalty of a class of consumers
- (B) to predict market potential of a product on a future date
- (C) to understand product-price relationships
- (D) all of the above.

(iv) The Product Market matrix comprising of Strategies of Penetration, Market Development, Product Development and Diversification was first formulated by

- (A) Ansoff
- (B) Drucker
- (C) Porter
- (D) Andrews

(v) The strategy of the Reliance Group in India would be a good example of

- (A) Conglomerate diversification
- (B) Market development
- (C) Price Transfers
- (D) Concentric Diversification

(vi) For an actor in Bollywood, his outstanding performance would be a/an

- (A) Asset
- (B) Strategic asset.
- (C) Core competency
- (D) Capability

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(vii) In product life cycle, 'cash cows' indicates

- (A) High share
- (B) Low growth and negative cash flow
- (C) High share, low growth and large positive cash flow
- (D) Low share, high growth and large positive cash flow

(viii) If an organisation acquires its supplier, it is an example of:

- (A) Horizontal integration
- (B) Forwards vertical integration
- (C) Backwards vertical integration
- (D) Downstream vertical integration.

(ix) Typically Profits are highest in which stage of the industry life-cycle?

- (A) Introduction
- (B) Growth
- (C) Maturity
- (D) Decline

(x) Delphi Technique:

- (A) is an attempt to describe a sequence of events that demonstrates how a particular goal might be reached
- (B) is a method of obtaining a systematic refined consensus from a group of experts
- (C) is assessing the desirability of future goals and thereafter selecting those areas of development that are necessary to achieve the desired goals
- (D) is concentrating on the impact which various forecasted technological developments might have on particular industries

**Answer:**

- (i)-(B)      (ii)-(C)      (iii)-(D)      (iv)-(A)      (v)-(A)      (vi)-(C)  
(vii)-(C)      (viii)-(C)      (ix)-(B)      (x)-(B)

## Part II: Subjective Questions

(2) (a) What does Corporate Mission mean? (b) What is a Mission Statement?

**Answer: 2(a)**

A mission can be defined as a general objective. It is the fundamental unique purpose that sets it apart from other firms of its type. It indicates the nature and scope of business operations in terms of product, market and technology.

Corporate mission establishes the principal concentration of company effort in terms of customers.

It provides a systematic yet somewhat visionary overview of a company's position in the competitive world. A mission provides the basis of awareness of a sense of purpose, the competitive environment, the degree to which the firm's mission fits its capabilities and the opportunities which the environment offers.



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**A PSU supplying energy describes its mission as follows:** To achieve and maintain a leading position as suppliers of quality equipment, systems and services to serve the national and international markets in the field of energy. The areas of interest would be the conversion, transmission, utilisation and conservation of energy for applications in the power, industrial and transportation fields. To strive for technological excellence and market leadership in these areas'.

Through its mission, a company indicates what it is trying to achieve and in what field. Mission represents company's objectives in qualitative terms. Ackoff refers to such objectives as stylistic objectives. It may be noteworthy that corporate missions are more ethical and philosophical in character and reflect the top management's values. They do not have a fixed time period. While stating its mission the company's management should go further and spell out in precise terms what the company has to accomplish and the extent of managerial action required to fill the gap. This is why an enterprise develops a set of long-range objectives.

**(b)** A Mission Statement is a document, embodying some of the matters as outlined above. A Mission Statement provides a statement to insiders and outsiders on what the organisation stands for. It conveys the grand design of the firm and conveys what it wants to be. A Mission statement might be a short sentence, or a whole page. It is intentionally unquantified and vague and is sometimes seen as a statement of an organisation's values, rather than its distinctly commercial objectives. It should be a statement of the guiding priorities that govern a firm's behaviour. Mission statement should be simple to understand and as such jargons and buzzwords should be avoided. It should be appropriate to the organisation in terms of its culture, history and shared values. It should be consistent with the present situation. It should be written in a positive tone. Mission statement should be unique to the organisation. Further, it should be enduring and should guide and inspire the organisation for many years to come. Mission Statements are rarely changed as otherwise they have less force, and become mere slogans. However, there is no standardised content or format of Mission Statement.

### **3) Examine the BCG Matrix for the evaluation of Business Portfolio. List the weaknesses of the method.**

**Answer:**

The Boston Consulting Group (BCG) model, popularly known as the BCG Matrix and Growth-Share Matrix, is based on two variables, viz., the rate of growth of the product-market and the market share in that market held by the firm relative to its competitors.

The market growth rate is an indicator of the attractiveness of the industry and the relative market share is an indicator of the strength of the firm in that industry relative to its competitors.

In the following figure, the vertical axis measures the annual growth rate of the market and the horizontal axis shows the relative market share of the firm. Each of these dimensions is divided into two categories of high and low, making up a matrix of four cells. These four cells are described below.

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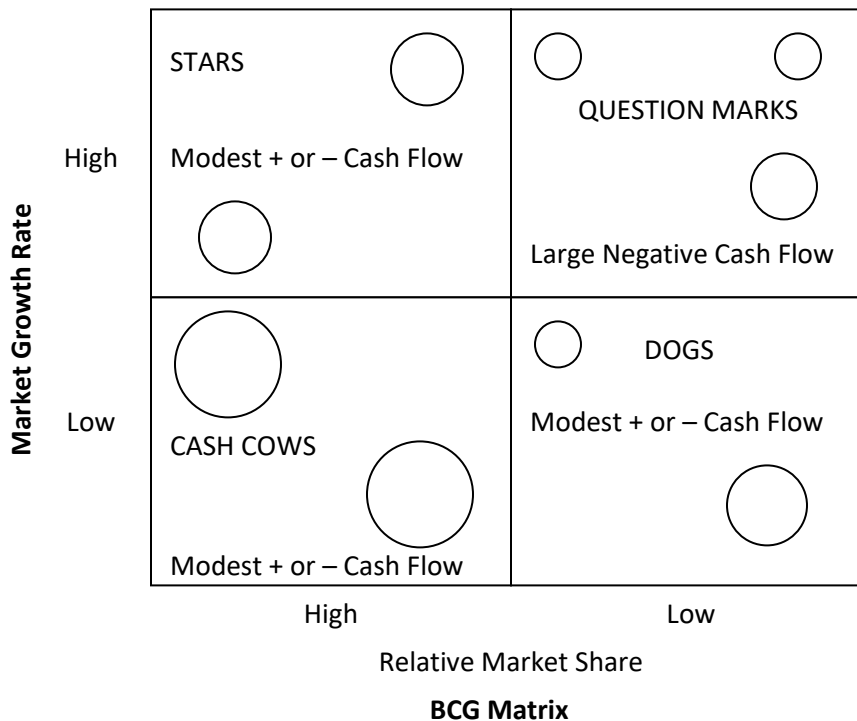
**High Growth-Low Market Share:** Products in this cell are in fast growing markets but their relative market shares are low. They are, therefore, aptly described as question marks - the company confronts the critical question of whether to make further investments in these businesses to build up market share or to divest and get out.

A question mark may call for heavy investment and other capabilities to increase its market share and become a star. If the company has the strength to increase its market share, the right strategy would be to build, i.e., to build up the market shares so that the question mark becomes a star.

**High Growth- High Market Share:** Products in this cell are called stars. They are promising products because they have a relatively high market share and the market is growing fast. Stars are usually profitable and would be the future cash cows. Many stars call for substantial investment to maintain their market share in the fast growing market. This may necessitate reinvestment of internal accruals and sourcing external funds. Several stars, therefore, may not produce cash flow for the company until the market matures and the stars become cash cows.

In the figure, there are two stars. The appropriate strategy for stars often is to hold, i.e., to maintain the market share which usually requires, as indicated above, large investments to increase supply and to fight competition.

**Low Growth - High Market Share:** As the market matures or when the market growth rate becomes low the stars would become cash cows. Cash cows are, thus, high market share business in slow growth industries. Being in slow growth industries, they do not normally require significant reinvestment. Cash cows generate lot of cash which may be used to finance the development of other businesses of the company like stars and question marks. A company which does not have cash cows would find it difficult to develop its business.



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## **Low Growth - Low Market Share:**

Businesses with low market share in low growth industries are described as dogs.

Dogs may produce low profits or loss. If a dog does not generate satisfactory return and if there is no chance of improving it, one may be tempted to advocate divestment. A dog may be harvested before liquidation.

**The Weaknesses of B.C.G. Matrix:** The criticism of the GSM approach tends to focus on its oversimplified and some what misleading representation of possible strategy position.

(i) This approach to strategy development encourages the use of general rather than specific criteria,

(ii) It implies assumptions about mechanism of corporate financing and market behaviour that are either unnecessary or false.

(iii) The BCG also ends to overlook other important strategic factors that are a function of the external competitive environments. For example, technological change, barriers to entry, social, legal, political and environmental pressure, unions and related human factors, elasticity of demand and the cynical nature of sales.

(iv) The application of the BCG to strategic decision-making is in the manner of the diagnostic rather than a prescriptive aid in the instances where observed cash flow pattern do not confirm with those on which the four product market categories are based. This commonly occurs where changes in product market strategies have short term transient effects on cash flow.

## **4) Discuss on the Product Life Cycle Matrix.**

### **Answer:**

In this matrix, the market situation is described in four stages (from embryonic to ageing and the competitive situation is shown in five categories (from weak to dominant). The purpose of the matrix is to establish the appropriateness of a particular strategy in relation to these two dimensions.

The position within the life cycle and of the company is determined in relation to eight external factors (or disciplines) of the evolutionary stage of the industry. These are:

- (i) market growth rate
- (ii) growth potential
- (iii) breadth of product line
- (iv) number of competitors
- (v) spread of market share among the competitors
- (vi) customer loyalty
- (vi) entry barriers and
- (viii) technology.

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It is the balance of these factors which determines the life cycle.

	Embryonic	Growth	Mature	Ageing
Dominant	Fast growth, Start up.	Fast growth. Attain cost leadership, renew, defend position	Defend position. Attain cost leadership, Renew. Fast growth	Defend position, Focus, Renew, Growth with industry
Strong competitive position	Start up. differentiate fast growth.	Fast growth, Renew, Focus, differentiate	Attain cost leadership, Renew, Focus, Differentiate growth with Industry.	Find niche hold niche-hang on. Growth with industry. Harvest.
Favourable	Start up. Differentiate Focus, fast growth.	Differentiate Focus, Catch up, Growth with Industry,	Harvest, Hang on Find Niche, Hold Niche, Renew turn around, Differentiate Focus, grow with Industry.	Retrench, Turn around.
Tenable	Start up. Grow with Industry. Focus.	Harvest, Catch up. Hold niche, Hang on, Find niche, Turnaround, Focus, Grow with industry.	Harvest. Turn around, Find niche, Retrench,	Divest Retrench
Weak	Find niche, catch up. Grow with industry.	Turnaround, Retrench	Withdraw, Divest	Withdraw

**Stages of Industry Maturity**  
**Fig. The life cycle Portfolio Matrix**

**Note:** The lines across the table indicate the growth history of different products of the company during life cycle.

The competitiveness of the organisation can be established by looking at the characteristics of each category. Thus, a dominant position usually results from quasi-monopoly.

Strong organisations are those that can follow strategies of their own choice without too much concern for competitors.

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5) Distinguish between:

(a) Plan and Policies; (b) Corporate Planning and Long-Range Planning;

**Answer: 5(a)**

Planning is an intellectual process of determining the objectives of an organisation. It is based on an analysis of the organisations

(i) strengths and weakness &

(ii) competitive and environmental factors.

It identifies and evaluates alternative courses of achieving such objectives with a view to choosing one or more of the alternatives and finally developing programmes and operational plans for achieving these objectives.

➤ Planning is futuristic. It involves formal rational process.

➤ Policy is a guideline for action for subordinates.

It could be a major policy or a minor policy, the corporate policy or a divisional policy. The purpose of policy, as a guide to decision making is to spell out and clarify strategy. It sharpens the meaning of the strategy and guides specific decisions in a direction that supports the strategy. It is key administrative tool for effective implementation and execution of strategies.

**Answer: 5 (b)**

**Corporate Planning and Long-Range Planning:** Corporate planning is concerned with determination of objectives treating the company as a whole and developing means to achieve the overall Company's objectives. It may encompass both short periods as well as long periods. It is an integrated system approaching plans of different components of the organisation. Corporate Planning is done at the corporate level.

Long Range Planning is a systematic and formalised process concerned with directing and controlling future options of an enterprise towards desired objectives for periods spreading generally over 5 or more years. It provides an opportunity to management to anticipate future problems and to have greater freedom of action to resolve them in an orderly manner.

6 (a) Discuss the approaches to Strategic Planning.

(b) Define a SBU structure. What are its characteristics?

**Answer: 6(a)**

It is important to operate a planning process which will not only produce realistic and potentially rewarding plans but will also secure the support of all those involved in implementing them. There are three approaches that can be adopted to strategic planning:

(i) A top-down process, in which managers are given targets to achieve which they pass on down the line.

(ii) A bottom-up process, in which functional and line managers in conjunction with their staff submit plans, targets and budgets for approval by higher authority.

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(iii) An iterative process, which involves both the top-down and bottom-up setting of targets.

There is a toand-from movement between different levels until agreement is reached. However, this agreement will have to be consistent with the overall mission, objectives and priorities and will have to be made within the context of the financial resources available to the organization. The iterative approach, which involves the maximum number of people, is the one most likely to deliver worthwhile and acceptable strategic plans.

**Answer: (b)**

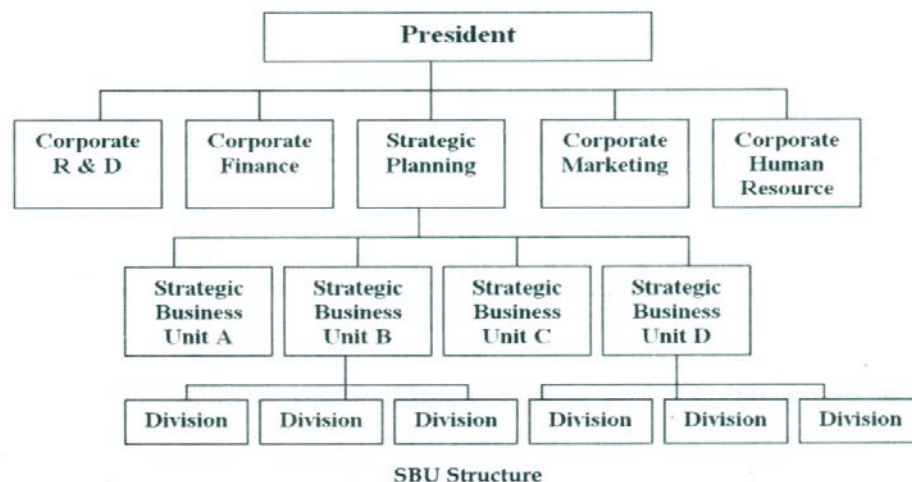
Strategic Business Unit (SBU) implies an **independently managed division of a large company**, having its own vision, mission and objectives, whose planning is done separately from other businesses of the company. The vision, mission and objectives of the division are both distinct from the parent enterprise and elemental to the long-term performance of the enterprise.

There are **three levels** in a strategic business unit, wherein the **corporate headquarters** remain at the top, **SBU's** in the middle and divisions clustered by similarity, within each SBU, remain at the bottom. Hence, the **divisions** within the SBU are associated with each other, and the SBU groups are independent of each other. From the strategic viewpoint, each SBU is an independent business.

Big organisation like Unilever, etc have many SBUs for their different categories of products like Cosmetics, Food products and Beverages, etc, and each is managed through separate unit head.

The three most important Characteristics of SBU are:

- It is a single business or a collection of related businesses which offer scope for independent planning and which might feasibly stand alone from the rest of the organisation.
- Has it's own set of competitors.
- Has a manager who has responsibility for strategic planning and profit performance, and who has control of profit-influencing factors.



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## 7) Explain how strategies are formulated?

### Answer:

The following are the steps involved in the strategy formulation.

#### **I. Defining the Company Mission:**

- Mission, Basic product/service, primary market, principal technology, company goals, survival, growth, profitability, company philosophy, public image etc.

#### **II. Assessing the External Environment:**

- Remote and operating environment.

#### **III. Industry Analysis:**

- How competitive forces shape strategy?
- Threat of Entry; Powerful suppliers and Buyers.
- Substitute products etc.

#### **IV. Evaluating the Multinational environment:**

- Why companies internationalise?
- Complexity of the Multinational environment.
  - i. Control problems of the multinational firm
  - ii. Multinational strategic planning
  - iii. Multi domestic industries and Global industries

#### **V. Environmental Forecasting:**

- Selection of critical environmental variables
- Selection of sources of significant environmental information
- Evaluate forecasting techniques
- Integrate forecast results into the strategies management process
- Monitor the critical aspects of managing forecasts.

#### **VI. Company profile: International Analysis of the firm:**

- Development of the company profile.
- Identification of strategic internal factors
- Evaluation of strategic internal factors

#### **VII. Formulating long-term objectives and grand strategies:**

##### **Long term objectives:**

- Profitability
- Productivity
- Competitive position
- Employee development
- Employee relations
- Technological leadership
- Public responsibility

##### **Qualities of long term objectives:**

- Acceptable
- Flexible
- Measurable
- Motivating
- Understandable Suitable

**Grand Strategies:** Master/business strategies, intended to provide basic direction for strategic activities

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## Various types of grand strategies:

- (a) Concentration (on current business) (increasing of present products in present markets).
- (b) Market development (selling present products in new markets)
- (c) Product Development (developing new product for present markets)

Specific options under the grand strategies of concentration market development and product development.

### (i) Concentration:

#### (a) Increasing present customers rate of usage:

- Increasing the size of purchase
- Advertising other uses
- Giving price incentives for increased usage.

#### (b) Attracting competitors' customers:

- Establishing sharper brand differentiation
- Increasing promotional effort
- Initiating price cuts

#### (c) Attracting nonusers to buy the product

- Inducing trial use through sampling, price, incentives and so on.
- Pricing up or down Advertising new uses

### (ii) Market Development:

#### (a) Opening additional geographical markets

- Regional expansion
- National expansion
- International expansion

#### (b) Attracting other market segments:

- Developing product versions to appeal to other segments
- Entering other channels of distribution
- Advertising in other media.

### (iii) Product Development:

#### (a) Developing new product features:

- Adopt (to other ideas, developments) Modify (change colour, shape, form, sound)
- Magnify (stronger, longer, thicker, extra value) Minify (smaller, shorter, and lighter)
- Substitute (other ingredients, process, power)
- Rearrange (other patterns, layout, sequence, components)
- Reverse (inside out)
- Combine (blend, combine units, purposes, appeals, ideas)

#### (b) Developing quality variations

#### (c) Developing additional models and sizes

## VIII. Strategic Analysis and Choice:

- SWOT Analysis
- Grand strategy selection
- Behavioural considerations affecting strategic choice
- Role of past strategy
- Degree of firm's external dependence
- Attitudes towards risk
- Internal political considerations
- Timing considerations
- Competitive reaction



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## 8. Explain the significance of Strategy Evaluation?

### Answer:

Evaluation of strategy of an enterprise is as important as strategy formulation because it provides an insight into the efficacy and effectiveness of the overall plan as well as sub-plans in attaining the desired results. It also enables the management to judge the suitability of the on-going strategy in changing socio-economic, political and technological developments and corporate conditions and points out to the need for modification in strategy in order to seize emerging opportunities and minimise new threats.

On the basis of periodic strategy evaluation, the central management can determine precisely whether programmes are being carried out in such a way that corporate objectives will be attained satisfactorily.

Strategy evaluation also influences the behaviour of events and ensures that they conform to plans. It serves the 'steering function' - to steer the organisation and the various sub-systems within it on the right track and to negotiate their way through a turbulent environment. It aims at promoting integration between short-range and long-range plans and between the enterprise and the environment.

Strategy evaluation serves as a valuable instrument for the purpose of achieving stability and continuity on the one hand and adaptation and adjustment on the other. Organisational stability is sought through appraisal of operational policies and procedures. This ensures the steady state of the organisation to establish itself, to derive and consolidate the gains from resources already committed, to preserve the system's vitality and viability. Periodic appraisal of strategy provides an opportunity to the management to make requisite adjustments in objectives, strategies and policies in tune with the dynamics of the external environment.

Finally, strategy evaluation can help the management in making effective use of scarce and valuable resources of the enterprise. It strives for minimising the variability in the deployment of resources so that the intended goals are achieved with the least cost and few untoward consequences.

## 9. Write short note on:

- (a) The McKinsey 7S Framework
- (b) Strategic cost analysis in marketing
- (c) Benefits of Strategic management
- (d) Contingency Plan
- (e) Elements of the marketing mix
- (f) Strategic Management Process

### Answer: (a)

The McKinsay 7S framework is shown in the given figure.

The model considers the criteria for success of a business or organisation and forms an interconnected framework of seven elements:

- Structure
- Strategy
- Skills

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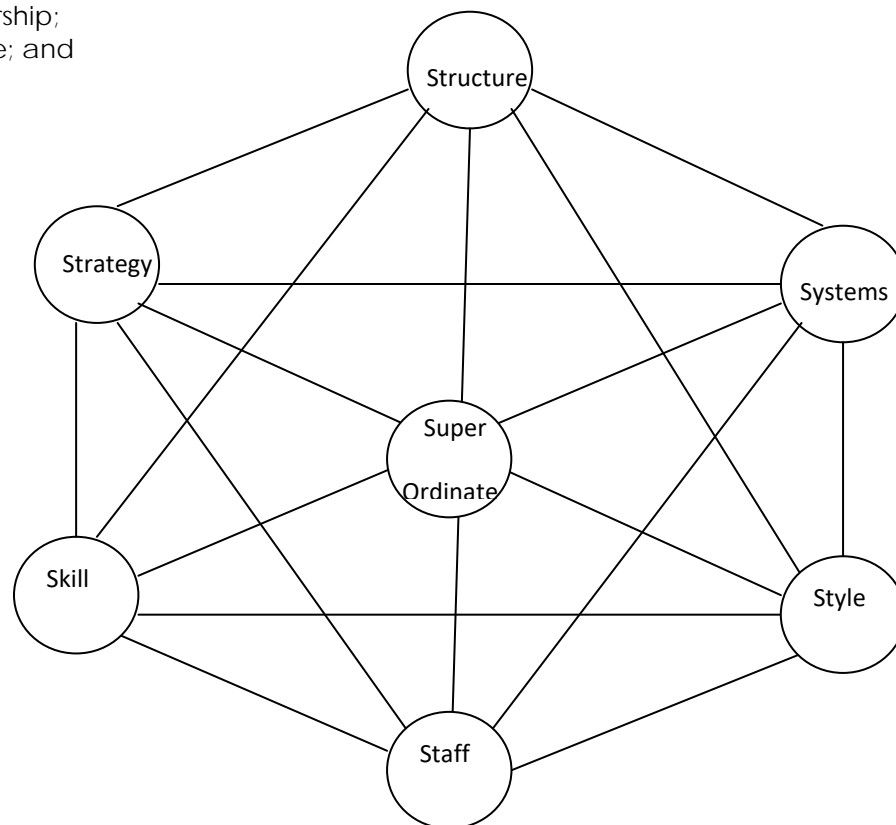
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- Staffs
- Systems
- Style and
- Shared value.

Of these, the first two, strategy and structure form the hardware of the organisation. The remaining components constitute the software. The hard components are easily recognised as important, the soft ones, often barely recognised, are equally critical and important for the success of a firm. Of these, shared values, systems, style all relate to behavioural patterns involving a staff (people) and their skill. This behavioural pattern act as the binding fabric that successfully holds the company's cohesive activities and strategies together. Four major aspects of this behavioural fabric are of crucial importance.

These are:

- power
- leadership;
- culture; and
- risk



**The Seven-S Model**

**(b)** Cost analysis with reference to marketing relate mostly to the traditional approaches and some modern approaches too. The discipline called strategic cost management has the important tenets of total cost management, activity based costing; value chain analysis etc.

According to Porter (Competitive Strategy), industry's profitability is a function of the collective strength of five competitive forces, bargaining power of suppliers,

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bargaining power of buyers, the threat of substitutes, the entry of new competitors, and the rivalry among the existing competitors. These five forces determine the industry's profitability because they influence the prices, cost and required investments of firms in an industry, Cost analysis oriented towards strategic advantages should therefore address all these five areas

- (c) Strategic management is defined as a set of decisions and actions resulting in formulation and implementation of strategies designed to achieve the objectives of an organisation.

The following are some of the benefits that would accrue to any company if it practices sound strategic management.

- (i) Financial benefits: Improved financial performance in terms of both profit and growth
- (ii) Enhanced capability of problem Prevention:
- (iii) Improved quality of strategic decisions through group interaction,
- (iv) Greater Employee Motivation.
- (v) Reduction of gaps and overlaps in activities
- (vi) Minimum resistance to change,
- (vii) Positive impact on the long-term prosperity of the firm
- (viii) Leads to better analysis and diagnosis of the current and likely future environment, identifying opportunities and threats.

- (d) A company should be well prepared to deal with contingencies, i.e., unforeseen or other critical developments that affect the company, like major changes in competitive environment, government policy or budget allocation, strikes, war, internal disturbances, natural calamities, etc. A contingency plan, thus, is a plan to cope with critical developments which mark major deviations from the strategic planning process. Some examples of such critical problems are given below.

- (i) If an important player is taken over by another firm, what strategy should the company employ to deal with the new situation?
- (ii) If the government lowers the import barrier, how will the company face the competitive forces unleashed by it?
- (iii) If the market is affected by a short supply, should and will the company be able to increase supply to take advantage of the situation?

The advantage of contingency planning is that when external opportunities occur contingency plans could allow an organisation to capitalise on them quickly. Contingency planning gives user's three major benefits - it permits quick response to change, it prevents panic in crisis situations, and it makes managers more adaptable by encouraging them to appreciate just how variable the future can be.

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## (e) Elements of the marketing mix:

Marketing mix is the set of marketing tools that the firm uses to pursue its marketing objectives in its target market. There are literally dozens of marketing mix tools. McCarthy popularised a four-factor classification of these tools called the four P's: Product, price, place and promotion. The most basic marketing-mix tool is product, which stands for the firm's tangible offer to the market, including the product quality, design, features, branding and packaging. A critical marketing-mix tool is price, namely the amount of money that the customers have to pay for the product. Place, another key marketing-mix tool, and stands for the various activities the company undertakes to make the product accessible and available to target customers. Promotion, the fourth marketing mix tool, stands for the various activities the company undertakes to communicate and promote its products to the target market.

## (f) Strategic Management Process:

Strategic management can be defined as the art and science of formulating, implementing and evaluating cross-functional decisions that enable an organisation to achieve its objectives.

Strategic Management is the means by which the management establishes purpose and pursues the purpose through co-alignment of organisational resources with environment, opportunities and constraints.

The Strategic Management process is most often described as a rational and an analytical process consisting of the following activities in 2 Phases viz., Phase-I & Phase-II.

### Phase-I: Strategy Formulation

- Environmental scanning basically for analysing each threat facing the company and opportunities;
- Developing Corporate Vision, Mission, Goals/Strategic Objectives;
- Organisational Analysis analysing the Mission, Strengths and Weaknesses, Opportunities and Threats;
- Strategic Goals Setting, which would-be-e4earr-easy to understand, easily measurable and achievable.
- Strategic Actions Formulations/An Action Plan to achieve the goals set;
- Developing the Functional Level Strategy, Business Level Strategy, Global Strategy and Corporate Level Strategy;
- Initiating Planning Process-Corporate Planning, Long Range Planning& Business Policy Planning;

### Phase-II: Strategy Implementation:

- Laying down Principles for Corporate Performance, Governance and Ethics;
- Operationalising Strategy;
- Executing the strategy, using various tools;
- Introduce Controls;
- Detect Variance, Measure Variance, Match against Control & Initiate Feedback for Revision, if necessary;
- Strategy Evaluation and Control;