

OPERATIONS MANAGEMENT

&

STRATEGIC MANAGEMENT



Group - II

Paper - IX



THE INSTITUTE OF COST ACCOUNTANTS OF INDIA
(Statutory body under an Act of Parliament)
www.icmai.in

SYLLABUS - 2016

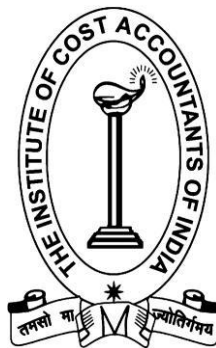
WORK BOOK

OPERATIONS MANAGEMENT & STRATEGIC MANAGEMENT

INTERMEDIATE

GROUP – II

PAPER – 9



The Institute of Cost Accountants of India

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Preface

Professional education systems around the world are experiencing great change brought about by the global demand. Towards this end, we feel, it is our duty to make our students fully aware about their curriculum and to make them more efficient.

Although it might be easy to think of the habits as a set of behaviours that we want students to have so that we can get on with the curriculum that we need to cover. It becomes apparent that we need to provide specific opportunities for students to practice the habits. Habits are formed only through continuous practice. And to practice the habits, our curriculum, instruction, and assessments must provide generative, rich, and provocative opportunities for using them.

The main purpose of this volume is to disseminate knowledge and motivate our students to perform better, as we are overwhelmed by their response after publication of the first edition. Thus, we are delighted to inform our students about the **e-distribution of the second edition of our 'Work book'**.

This book has been written to meet the needs of students as it offers the practising format that will appeal to the students to read smoothly. Each chapter includes unique features to aid in developing a deeper understanding of the chapter contents for the readers. The unique features provide a consistent reading path throughout the book, making readers more efficient to reach their goal.

Discussing each chapter with illustrations integrate the key components of the subjects. In the second edition, we expanded the coverage in some areas and condensed others.

It is our hope and expectation that this second edition of work book will provide further an effective learning experience to the students like the first edition.

The Directorate of Studies,

The Institute of Cost Accountants of India

SUGGESTED MARKS DISTRIBUTION FROM EXAMINATION POINT OF VIEW

Only for Practice Purpose

		Paper-5/6/7/8/11	Paper-9/10/12
Total 100 Marks	[3 Hours]	Objective = 25 Marks	= 28 Marks
		Others = 75 Marks	= 72 Marks

Objective Question

25 Marks/28 Marks (1 Mark each questions)	MCQ	1 mark
	Match	1 mark
	True/False	1 mark
	Fill in the Blanks	1 mark

Short Notes / Case Study

Minimum Marks for each Questions	4 Marks
Maximum Marks for each Questions	10 Marks

Practical Problem

Minimum Marks for each Questions	4 Marks
Maximum Marks for each Questions	15 Marks

Study Note – 1

OPERATIONS MANAGEMENT - INTRODUCTION

Learning Objective: The goal of operations management is to maximize efficiency while producing goods and services that effectively fulfil customer needs. Operations are one of the three strategic functions of any organization. Operations decisions include decisions that are strategic in nature, meaning that they have long-term consequences and often involve a great deal of expense and resource commitments.

1. Define Operations management.

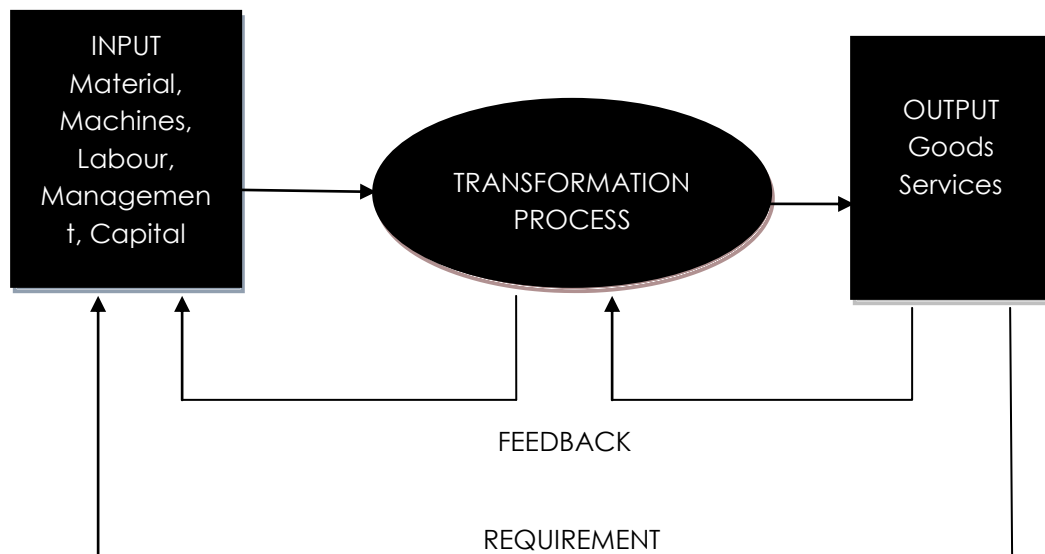
Answer:

Operations management designs and deals with operations of productive system—system which produces goods and services and operations manager is responsible for smooth running of this system. Every book one reads, every video one watches, every e-mail one sends, and every medical treatment one receives involves the operations function of one or more organizations.

2. What is called operations/Operating System?

Answer:

Operations is defined as a transformation—a transformation of input in the form of material, machines, Labour, Management, capital to output in the form of goods and services. Operations as a transformation process looks like following:



Therefore an Operating System is defined as a configuration of resources combined for the provision of goods or services. Further to ensure that the desired output are obtained, an organization takes measurements at various points in the transformation process (feedback) and then compares with them with previously established standards to determine whether corrective action is needed (control).

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3. What is the Objective of Operations Management?

Answer:

In operations management we try to ensure that the transformation process is performed efficiently and that the output is of greater value than the sum of the inputs. Input-transformation-output process itself can be viewed as a series of activities along a value chain extending from supplier to customer and operations management thrives for customer satisfaction with effective utilization of resources.

4. Match the items in first column with that in second column:

Transformation process	Sector where found
i) Physical	a) Communication
ii) Psychological	b) Health care
iii) Locational	c) Manufacturing
iv) Physiological	d) Entertainment
v) Informational	e) Retail Operations
vi) Exchange	f) Transport

Answer:

i)/(c); ii)/(d); iii)/(f); iv)/(b); v)/(a); vi)/(e)

5. Match the item in Column I with that in Column II

Column I (Input)	Column II (output)
a) Physical	i) BSNL telecommunication service
b) Exchange	ii) Health Service in Medical College
c) Locational	iii) Railway Service
d) Psychological	iv) Shopping in Big bazar
e) Physiological	v) Movie in Inox
f) Informational	vi) Production of Ignis in Maruti Ltd

Answer:

(a)/(vi); (b)/(iv); (c)/(iii); (d)/(v); (e)/(ii); (f)/(i)

6. Relate the following characteristics to either Product (P) or Service (S):

- High contact with clients or customers;
- Location dependent on location of local customers, clients and users;
- Large units that can take advantage of economies of scale;
- Availability achieved by keeping the productive system open for operation;
- Achievable Inventory;
- Markets served by the productive system are regional, national and international;
- Demand on system variable on weekly, monthly and seasonal basis;
- Complex and interrelated processing;

Answer:

a) S; b) S; c) P; d) S; e) P; f) P; g) P; h) S;

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7. Choose the correct answer:

Modern views classifies Production management decisions pertaining to

- a) People;
b) People, supply, space;
c) People, supply, space and time;
d) People, supply, space, time and feelings;

Answer:

(C)

8. Choose the correct answer:

Under people centric production and operations management function to maintain desired quality and productivity which of the following people centric decision is required most?

- a) HR decision; b) Supply decision; c) Spatial decision; d) Timing decision;

Answer:

(a)

9. For Outpatient ward of a general hospital name individual components in Input-Transformation process-Output system.

Answer:

- ▶ Input: Unhealthy patient (Physical)
- ▶ Transformation Process: Uses physical resources like Doctors, Nurses, and other Staff & Equipment etc.
- ▶ Output: Healthier/Cured Person (Physical)

10. In an operating system's output goods-service combination is a continuum. Explain

Answer:

An operating system can provide physical goods as well as services together and clear demarcation of the output activity may not be always possible. A mobile manufacturer in addition to mobile sets (good) also provides after sales service. Therefore the concepts of "physical goods production" and "service provision" are not mutually exclusive. In fact in most cases these are mixed, one being more predominant than the other.

It can range from primarily goods, with little service, to primarily service, with few goods. Because there are relatively few pure goods or pure services, companies usually sell product packages, which are a combination of goods and services. There are elements of both goods production and service delivery in these product packages. This makes managing operations more interesting, and also more challenging.

11. The four primary functional areas of a business unit are marketing, finance, operations and human resources. Write down the mutual interactions of operations with Marketing, HR and Finance functions.

Answer:

Marketing to Operation	Operations to Marketing
Provides sales forecasts, customer Orders, customer feedback, Product Development.	Provides information on Product/Service availability, lead time estimates, Order status, delivery schedule etc.

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HR to Operations	Operations to HR
Provides information on personnel need Skill sets, performance evaluation, Job Designs, work measurement.	Provides information on Hiring/firing Training, legal requirements Union contract negotiations.
Finance to Operation	Operations to Finance
Provides budgets, cost analysis Capital investments, Stockholders Requirements etc.	Provides information on Product & Inventory data, capital budgeting Requests, Capacity expansion plans etc

12. Choose the correct answer:

Configuration of resources combined for the provision of goods or services is known as:

- a) Productive System; b) Operating System;
c) Service System; d) Operations Management;

Answer:

b)

13. Match Column A with Column B

Column A	Column B
a) Product Packages	i) Part of operations functions itself providing operations with parts and materials, performing work on products and/or performing services;
b) Operations functions	ii) An organization takes measurements at various points in the transformation process and then compares them with previously established standards to determine whether corrective action is needed;
c) Internal part of a supply chain	iii) There are elements of both goods production and service delivery;
d) Process	iv) Include process design, process execution and process monitoring;
e) BPM	v) Consists of one or more actions that transform inputs into outputs;
f) Feedback & Control	vi) Add value during the transformation process;

Answer:

a)/(iii), b)/(vi), c)/(i), d)/(v), e)/(iv), f)/(ii),

14. What is called Business Process?

Answer:

Business process, large or small, is composed of a series of supplier-customer relationships where every business organization every department and every individual operation is both a customer of the previous step in the process and a supplier to the next step in the process. The following figure illustrates the same:





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15. Write down the general categories of a business process.

Answer:

Generally speaking, there are three categories of a business process:

1. Upper-Management Process—these govern the operation of the entire organization. e.g. corporate governance, corporate strategy;
2. Operational Process – these are the core process that make up the value stream. e.g. purchasing, producing, marketing, sales etc;
3. Supporting Process – these support the core processes. e.g. accounting, human resources, information technology etc.



Study Note – 2 OPERATIONS PLANNING

Learning Objective: Operational planning is the process of planning strategic goals and objectives to tactical goals and objectives. An operational plan draws directly from agency and program strategic plans to describe agency and program missions and goals, program objectives, and program activities.

1. Define Forecasting. Why Productions and Operations departments need forecasts?

Answer:

Forecasting means peeping into the future. As future is unknown and is anybody's guess but the business leaders in the past have evolved certain systematic and scientific methods to know the future by scientific analysis based on facts and possible consequences. Thus, this systematic method of probing the future is called forecasting.

Production and Operation departments will produce goods as per the sales program given by the sales department, but it has to prepare forecast regarding machine capacity required, materials required and time required for production and so on. Knowledge on Forecasting helps in this regard.

2. Why Sales Forecasting is the most important activity in the business?

Answer:

All business and industrial activities revolve around the sale and its future planning. To know what a business will do we must know its future sales. All other activities depend upon the sales of the concern. Sales forecasting as a guiding factor for a firm because it enables the firm to concentrate its efforts to produce the required quantities, at the right time at reasonable price and of the right quality. Sales forecasting is the basis of planning the various activities i.e.; production activities, pricing policies, programme policies and strategies, personnel policies as to recruitment, transfer, promotion, training, wages etc.

3. What are the time ranges for Short-term, Medium-term and Long-term Forecasting?

Answer:

Short term forecasting period may be one week, two weeks or a couple of months. Medium term forecasting period may vary from 3 to 6 months. Long term forecasting period may vary from one year to any period. The objective of above said forecast is naturally different.

4. Write down the objectives of Long-range Forecasting.

Answer:

- (i) To work out expected capital expenditure for future developments or to acquire new facilities;
- (ii) To determine expected cash flow from sales;
- (iii) To plan for future manpower requirements;
- (iv) To plan for material requirement;
- (v) To plan for Research and Development. Here much importance is given to long range growth factor;

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5. Write down the objectives of Medium-range Forecasting;

Answer:

- (i) To determine budgetary control over expenses;
- (ii) To determine dividend policy;
- (iii) To find and control maintenance expenses;
- (iv) To determine schedule of operations;
- (v) To plan for capacity adjustments;

6. Write down the objectives of Short-range Forecasting;

Answer:

- (i) To estimate the inventory requirement;
- (ii) To provide transport facilities for finished goods;
- (iii) To decide workloads for men and machines;
- (iv) To find the working capital needed;
- (v) To set-up of production run for the products;
- (vi) To fix sales quota;
- (vii) To find the required overtime to meet the delivery promises;

7. What are the factors influencing business forecasting?

Answer:

- (i) Environmental changes;
- (ii) Changes in the preference of the user;
- (iii) Number of competitive products;
- (iv) Disposable income of the consumer;

8. What are the important factors for production forecasting?

Answer:

- (i) Demand from the marketing department;
- (ii) Rate of labours absenteeism;
- (iii) Availability of materials;
- (iv) Available capacity of machines;
- (v) Maintenance schedules;
- (vi) Delivery date schedules;

9. Name the factors on which methods of forecasting depends.

Answer:

- (i) Period selected for the forecast;
- (ii) The information or data available on hand;
- (iii) What are the expectation from you expect from the information from the forecast;

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10. Match the items in column (1) with those in column (2).

(1)	(2)
a) A process of combining, averaging or evaluating, in some other way, the opinions and views of top executives;	i) Sales Forecasting under Expert's Opinions;
b) Quite appropriate when the product is quite new in the market or good estimators are not available or where buyers do not prepare their purchase plan;	ii) Market test method of sales forecasting;
c) More appropriate where users of the product are numbered and a new product is to be introduced for which no previous records can be made available;	iii) Composite method of sales forecasting;
d) Views of salesmen, branch manager, area manager and sales manager are secured for the different segments of the market;	iv) Executive judgment method of sales forecasting;
e) Opinions of experts given in the newspapers and journals for the trade, wholesalers and distributors for company's products, agencies or professional experts are taken.	v) User's Expectation method of sales forecasting;

Answer:

a)/(iv); b)/(ii); c)/(v); d)/(iii); e)/(i);

11. Demand in (000 MT) for sugar of Sour India is given below:

Year	2010	2011	2012	2013	2014	2015	2016
Demand	77	88	94	85	91	98	90

(i) Fit a straight line trend by method of least square;

(ii) Calculate trend values and plot observed and trend values on a graph;

(iii) Obtain the forecast of demand for the year 2017;

Answer:

(i) The trend line is represented as $Y_t = a + bX$

Where Y_t = the trend value (which is to be predicted);

a = the Y axis intercept;

b = slope of the trend line;

X = the independent variable, the time;

a and b are computed as

$$b = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum X^2 - n\bar{X}^2}, \quad a = \bar{Y} - b\bar{X}$$

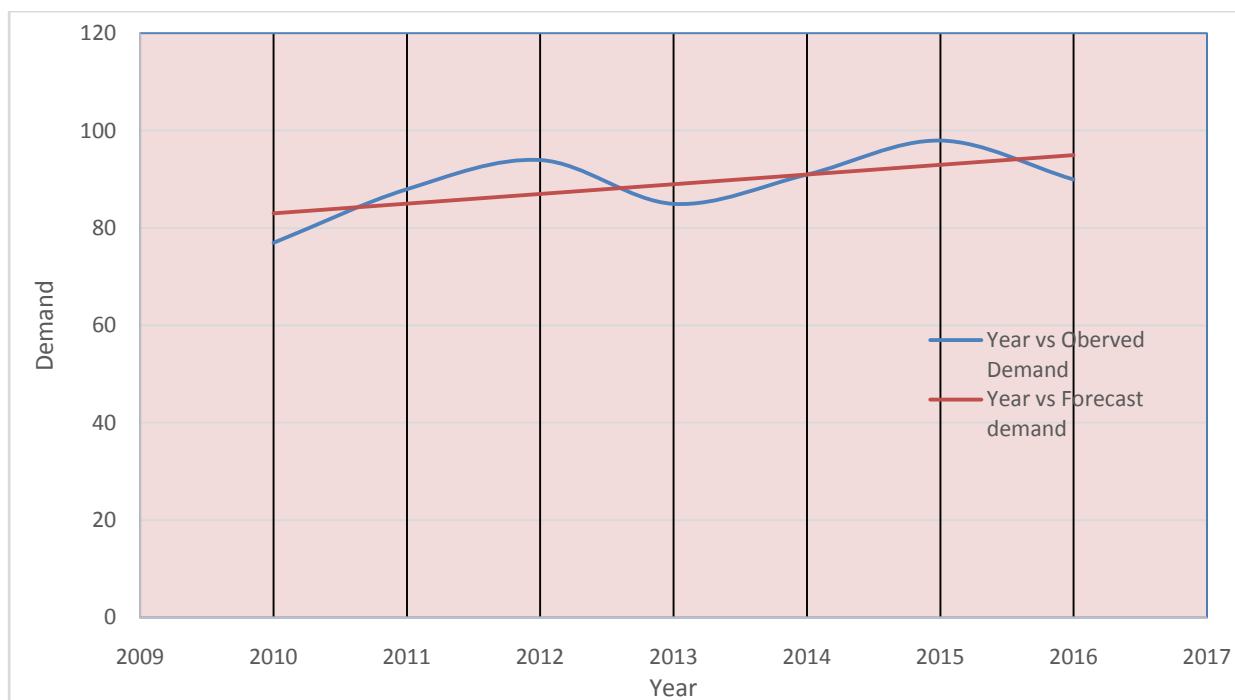
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The computations are in the following table

Year	X	Demand, Y	XY	X ²	Trend Values Y _t
2010	0	77	0	0	83
2011	1	88	88	1	85
2012	2	94	188	4	87
2013	3	85	255	9	89
2014	4	91	364	16	91
2015	5	98	490	25	93
2016	6	90	540	36	95
Total	21	623	1925	91	125

$$\bar{X} = \frac{21}{7} = 3 \text{ \& } \bar{Y} = \frac{623}{7} = 89 \text{ So } b = \frac{(1925 - 7 \times 3 \times 89)}{(91 - 7 \times 3 \times 3)} = 2 \text{ and } a = 89 - 2 \times 3 = 83$$

- (ii) Trend values are calculated from equation $Y_t = a + bX$ and given in last column of the above table; Plot is shown below



- (iii) Forecast value for 2017 = $83 + 2 \times 7 = 97$

12. The following table shows the profits, ₹ Y (in'000) of a shop in Xth year as given below:

X	2010	2011	2012	2013	2014
Y	1250	1400	1650	1900	2300

- Fit a straight line trend by method of least square;
- Calculate trend values and plot observed and trend values on a graph;
- Obtain the forecast of demand for the year 2017;

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Answer:

- i) The problem is similar to problem given in Q (11) above. But we will do this problem in a bit different way. Here $n = 5$ (in Q11 it was 7) an odd and therefore we could shift the origin to the middle time period, viz. 2012. Let $X = t - 2012$;

The trend line is represented as $Y_t = a + bX$

Where Y_t = the trend value (which is to be predicted);

a = the Y axis intercept;

b = slope of the trend line;

X = the independent variable, the time;

a and b are computed as

$$b = \frac{\sum XY}{\sum X^2}, \quad a = \bar{Y} \text{ as } \sum X = 0$$

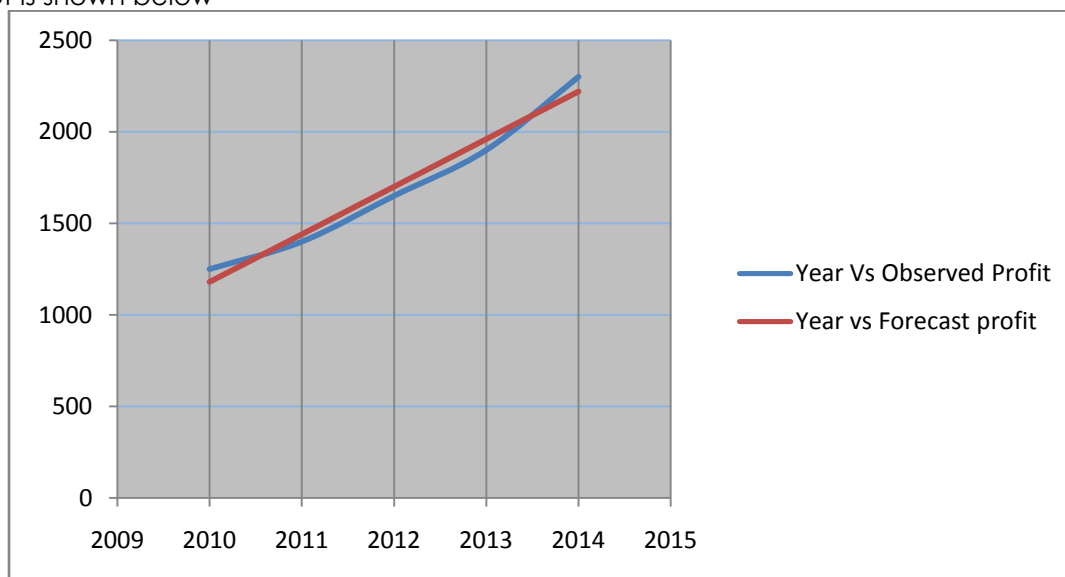
The computations are in the following table

Year(t)	X	Profits(Y)	X ²	XY	Trend values (Yt)
2010	-2	1250	4	-2500	1180
2011	-1	1400	1	-1400	1440
2012	0	1650	0	0	1700
2013	1	1900	1	1900	1960
2014	2	2300	4	4600	2220
Total	0	8500	10	2600	1700

$$\bar{X} = \frac{0}{5} = 0 \text{ \& } \bar{Y} = \frac{8500}{5} = 1700$$

$$\text{So } b = \frac{(2600)}{(10)} = 260 \text{ and } a = 1700$$

- (ii) Trend values are calculated from equation $Y_t = a + bX$ and given in last column of the above table; Plot is shown below



- (iii) Forecast value for 2017 = $1700 + 260 \times 5 = 3000$

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13. The following table shows the profits, ₹ Y (in'000) of a shop in Xth year as given below:

X	2010	2011	2012	2013	2014	2015	2016	2017
Y	80	90	92	83	94	99	92	104

- (i) Fit a straight line trend by method of least square;
(ii) Calculate trend values and plot observed and trend values on a graph;
(iii) Obtain the forecast of demand for the year 2018;

Answer:

- (i) The problem is similar to problem given in Q (12) above except here n = 8 an even and therefore we could shift the origin to the time which is the arithmetic mean of the two middle terms, viz.2013 & 2014 and we take

$$X = \frac{t - \frac{2013+2014}{2}}{1/2(\text{interval})} = 2(t-2013.5)$$

The trend line is represented as $Y_t = a + bX$

Where Y_t = the trend value (which is to be predicted);

a = the Y axis intercept;

b = slope of the trend line;

X = the independent variable, the time;

a and b are computed as

$$b = \frac{\sum XY}{\sum X^2}, \quad a = \bar{Y} \text{ as } \sum X = 0$$

The computations are in the following table

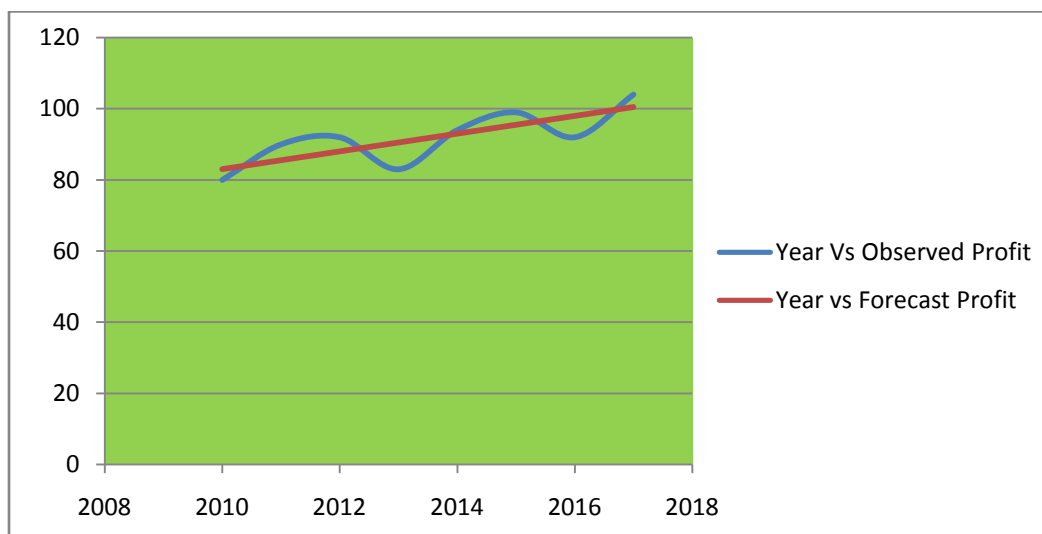
Year(t)	X	Profits(Y)	X ²	XY	Trend Values(Y _t)
2010	-7	80	49	-560	83
2011	-5	90	25	-450	85.5
2012	-3	92	9	-276	88
2013	-1	83	1	-83	90.5
2014	1	94	1	94	93
2015	3	99	9	297	95.5
2016	5	92	25	460	98
2017	7	104	49	728	100.5
Total	0	734	168	210	734

$$\bar{X} = \frac{0}{8} = 0 \text{ \& } \bar{Y} = \frac{734}{8} = 91.75$$

$$\text{So } b = \frac{(210)}{(168)} = 1.25 \text{ and } a = 91.75$$

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- (ii) Trend values are calculated from equation $Y_t = a + bX$ and given in last column of the above table;
Plot is shown below



- (iii) Forecast value for 2018 = $91.75 + 1.25 \times 9 = 103$

14. Why Capacity planning is required?

Answer:

Capacity planning is required for the following:

- Sufficient capacity is required to meet the customers demand in time;
- Capacity affects the cost efficiency of operations;
- Capacity affects the scheduling system;
- Capacity creation requires an investment;
- Capacity planning is the first step when an organisation decides to produce more or new products;

15. How Capacity of a plant is measured?

Answer:

Capacity of a plant is usually expressed as the rate of output, i.e., in terms of units produced per period of time (i.e., hour, shift, day, week, month etc.). But when firms are producing different types of products, it is difficult to use volume of output of each product to express the capacity of the firm. In such cases, capacity of the firm is expressed in terms of money value (production value) of the various products produced put together.

16. What are the activities involved in Capacity Planning Decisions?

Answer:

Capacity planning involves activities such as:

- Assessing the capacity of existing facilities;
- Forecasting the long-range future capacity needs;
- Identifying and analysing sources of capacity for future needs;
- Evaluating the alternative sources of capacity based on financial, technological and economical
- Considerations;
- Selecting a capacity alternative most suited to achieve strategic mission of the firm;

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17. Name the factors that affect determination of Plant Capacity.

Answer:

- Capital investment required;
- Changes in product design, process design, market conditions and product life cycles;
- Flexibility for capacity additions;
- Level of automation desired;
- Market demand for the product;
- Product obsolescence and technology obsolescence;
- Type of technology selected;

18. Which one of the following is not the factor influencing effective capacity?

- (i) Level of automations desired;
- (ii) Forecasts of Demand;
- (iii) Plant and labour efficiency;
- (iv) Multiple Shift operation;

Answer: (i)

19. Plant and labour efficiency are very much essential to arrive at realistic capacity planning. Explain

Answer:

It is difficult to attain 100 per cent efficiency of plant and equipment. The efficiency is less than 100 percent because of the enforced idle time due to machine breakdown, delays due to scheduling and other reasons. The plant efficiency varies from equipment to equipment and from organisation to organisation. Labour efficiency contributes to the overall capacity utilisation. The standard time set by industrial engineer is for a representative or normal worker. But the actual workers differ in their speed and efficiency. The actual efficiency of the labour should be considered for calculating efficiency. Thus plant and labour efficiency are very much essential to arrive at realistic capacity planning.

20. Name five reasons because of which Over Capacity are preferred.

Answer:

- Fixed cost of the capacity is not very high;
- Subcontracting is not possible because of secrecy of design and/or quality requirement;
- The time required to add capacity is long;
- The company cannot afford to miss the delivery, and cannot afford to loose the customer;
- There is an economic capacity size below which it is not economical to operate the plant;

21. Name reasons because of which Over Capacity are preferred.

Answer:

- Shortage of products does not affect the company (i.e., lost sales can be compensated);
- The technology changes fast, i.e., the rate of obsolescence of plant and equipment are high;
- The cost of creating the capacity is prohibitively high;

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22. What are the general factors considered for selecting Manufacturing facilities?

Answer:

- Land Costs;
- Construction Costs;
- Transportation costs pre & post operation stage;
- Proximity to suppliers;
- Labour availability;
- Electricity/Utilities availability;
- Environmental & other Govt. Regulations;

23. What are the general factors considered for selecting Retail & Service facilities?

Answer:

- Land /Leasing Costs;
- Proximity to customers;
- No of customers;
- Environmental & other Govt. Regulations;

24. Match the item in Column (1) with that in Column (2).

(1)	(2)
a) It produces distinguished products in different locations;	i) Ordnance factories of India;
b) It produces multiple products in same location;	ii) ACC Cement;
c) It produces same products in different locations;	iii) Indian Railways;
d) It feeds one plant with products of another plant;	iv) Maruti Udyog;

Answer:

a)/(iii); b)/(iv); c)/(ii); d)/(i);

25. What are the costs associated with decision on plant layout?

Answer:

- Cost of movement of materials from one work area to another;
- Cost of space;
- Cost of production delay, if any, which are the indirect costs;
- Cost of spoilage of materials;
- Cost of labour dissatisfaction and health risks;
- Cost of changes required, if the operational conditions change in the future. This is long term cost;
- Cost of customer dissatisfaction due to poor service (quality, delivery, flexibility, responsiveness) which may be due to poor lay out;

26. What are the most common reasons for design of new layout?

Answer:

- (i) Layout is one of the key decisions that determine the long-run efficiency in operations;
- (ii) Layout has many strategic implications because it establishes an organisation's competitive priorities in regard to capacity, processes, flexibility and cost as well as quality of work life, customer contact and image (in case of service organisations);
- (iii) A n effective layout can help an organisation to achieve a strategic advantage that supports differentiation low cost, fast response or flexibility;
- (iv) A well designed layout provides an economic layout that will meet the firm's competitive requirements;

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27. Match the item in Column (1) with that in Column (2).

(1)	(2)
a) It is to avoid waste of labour and time and to minimize cost of material handling;	i) Layout principle of Compactness;
b) It is to use effectively every unit of available space;	ii) Layout Principle of Sequence
c) It is for harmonious fusion of all the relevant factors so that the final layout looks well integrated and compact;	iii) Layout Principle of Minimum Investment;
d) It permits revisions with the least difficulty and at minimum cost;	iv) Layout Principle of Safety and Satisfaction;
e) It is followed for comfort and convenience of the workmen so that they feel satisfied.	v) Layout Principle of Minimum Travel;
f) It is for savings in fixed capital investment, not by avoiding installation of the necessary facilities but by an intensive use of available facilities;	vi) Layout Principle of Usage
g) It arranges Machinery and operations in a sequential order.	vii) Principle of Flexibility

Answer:

a)/(v); b)/(vi); c)/(i); d)/(vii); e)/(iv), f)/(iii), g)/(ii)

28. A company produces 2000 TV sets in a year for which it needs an equal number of tubes of a certain type. Each tube costs D10 and the cost to hold a tube in stock for a year is D2.4. The cost of placing an order is D150 which is not related to size. Consider no of working days as 250 days. Lead time is 15 working days. Compute EOQ and reorder level.

Answer:

$$EOQ = \sqrt{\frac{2AD}{h}} \text{ where } A = \text{cost of placing an order, } D = \text{annual demand, } h = \text{holding cost;}$$

$$= \sqrt{\frac{2 \times 150 \times 2000}{2.40}} = \sqrt{\frac{600000}{2.4}} = \sqrt{250000} = 500$$

With no of working days in the year = 250 days and lead time = 15 working days, the daily demand = 2000/250 = 8 tubes.

Demand during lead time = 15 x 8 = 120 tubes.

So re-order level = 120 tubes.

29. Using the following data obtain the EOQ and the total variable cost associated with the policy of ordering quantities of that size:

Annual Demand (in D) = D20000

Ordering Cost = D150/order

Inventory carrying cost = 24% of average inventory value

Answer:

$$EOQ = \sqrt{\frac{2AcD}{i}} \text{ where } A = \text{cost of placing an order, } cD = \text{the annual demand in rupee terms, } i = \text{the holding rate.}$$

$$= \sqrt{\frac{2 \times 150 \times 20000}{0.24}} = \text{D}5000$$

$$\text{Total cost} = \sqrt{2 \times A \times cD \times i} = \sqrt{2 \times 150 \times 20000 \times 0.24} = \text{D } 1200$$

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30. Bearing Hub Company is going to build a new plant to manufacture bearings. The site selection team is evaluating three sites and they have scored the important factors for each as follows. Compute total score of each locations under location factor rating scheme.

Location factor	Scores(0 to 100)			
	Weight	Site 1	Site 2	Site 3
Labour pool and climate	0.30	80	65	90
Proximity to suppliers	0.20	95	88	78
Wage rates	0.15	75	95	85
Community environment	0.15	60	80	90
Proximity to customers	0.10	65	90	95
Shipping modes	0.05	85	90	60
Air service	0.05	50	65	90

Answer:

				Wtd Scores	Wtd Scores	Wtd Scores
Weight	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
0.3	80	65	90	24	19.5	27
0.2	95	88	78	19	17.6	15.6
0.15	75	95	85	11.25	14.25	12.75
0.15	60	80	90	9	12	13.5
0.1	65	90	95	6.5	9	9.5
0.05	85	90	60	4.25	4.5	3
0.05	50	65	90	2.5	3.25	4.5
			Total	76.5	80.1	85.85

Site 3 has the highest factor rating compared with the other locations, however, this evaluation would have to be used with other information, particularly a cost analysis before making a decision in favour of site 3 or others.

31. M/s. ABC Ltd. are the manufacturers of a product called "Super Z" The following are the details of their operation during 2017:

Average monthly market demand 5,000 units

Ordering cost B200 per order

Inventory carrying cost 25% per annum

Cost of production B500 per unit

Normal usage 1000 units per week

Minimum usage 500 units per week

Maximum usage 2000 units per week

Lead time to supply 6 – 8 weeks

Compute from the above:

- (1) Economic order quantity. If the supplier is willing to supply quarterly 1,000 units at a discount of 5%, is it worth accepting?
- (2) Maximum level of stock.
- (3) Minimum level of stock.
- (4) Re-order level of stock.



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Answer:

- (1) Economic Order Quantity:

Annual usage of Super Z = Normal usage per week × 52 weeks = 1000 units × 52 weeks
= 52000 units.

Ordering cost per order = B200.

Inventory carrying cost per unit per annum = 25% of B500 = B125.

$$EOQ = \sqrt{\frac{2AD}{h}} = \sqrt{\frac{2 \times 200 \times 52000}{125}} = 408 \text{ (approx.)}$$

Evaluation of order size of 1,000 units at 5% discount

No. of orders = 5,200 units / 1,000 units = 5.2 units or 6 (in case of a fraction, the next whole number is considered).

Ordering cost order per year at B 200 per order = B 1200

Carrying cost of average inventory:

1,000 units / 2 × B(500 less 5%) × 25/100 = B59375

Total annual cost (excluding item cost) B 1200 + B59375 = B60575

Annual cost if EO Q (408 units) is adopted:

Ordering cost: 52000 ÷ 408 orders per year @ B 200 per order B25490

Carrying cost of average inventory 408 units

408 units / 2 × B (500) × 25/100 = B25500

Total annual cost (excluding item cost) = B25490 + B25500 = B50990

Increase in annual cost: B (60575 – 50990) = B9585.

Amount of quantity discount: 5% × B500 × 52000 units = B1300000

Since the amount of quantity discount (B1300000) is more than the increase in total annual cost (B9585.), it is advisable to accept the offer. This will result in a saving of B (1300000 - 9585) or B1290415 p.a. in inventory cost.

- (2) Maximum Level of Stock:

= Re-order level + Re-order quantity – (Minimum usage × Minimum delivery period) = 16000 units + 408 units – (500 units × 6 weeks) = 13408 units.

- (3) Minimum Level of Stock:

= Re-order level – (Normal usage × Normal delivery period) [see Note] = 16000 units – (1000 units × 7 weeks) = 9000 units. Note: Normal delivery period is taken to be the average delivery period.

- (4) Re-order Level of Stock:

= Maximum usage × Maximum delivery period = 2000 units × 8 weeks = 16000 units.

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32. “Carpet for Golden foot” company in Kashmir stocks carpet in its warehouse and sells it through an adjoining showroom. The store keeps several brands and styles of carpet in stock. The store wants to determine the optimal order size. The order quantity is received gradually over time and the inventory level is depleted at the same time it is being replenished i.e., the store here faces a non-instantaneous receipt. Estimated annual demand is 15000 yards of carpet with an annual carrying cost of B 2.50 per yard and an ordering cost B200. The manufacturing facility operates the same days the store is open (i.e. 300 days) and produces 200 yards of the carpet per day.

Determine the optimal order size, total inventory cost, the length of time to receive an order, the number of orders per year and the maximum inventory level.

Answer:

EOQ with non-instantaneous receipt

$EOQ = \sqrt{\frac{2AD}{h(1-\frac{d}{p})}}$ where A = cost of placing an order, D = annual demand, h = holding cost, d = daily rate at which inventory is demanded & p = daily rate at which the order is received over time also known as production rate.

$$EOQ = \sqrt{\frac{2 \times 200 \times 15000}{2.5 \times (1 - \frac{50}{200})}} = 1789 \text{ (Approx.)}$$

$$d = \frac{15000}{300} = 50, p = 200$$

Total minimum inventory cost:

$$TC_{min} = \frac{AD}{EOQ} + \frac{hEOQ}{2} \left(1 - \frac{d}{p}\right) = \frac{200 \times 15000}{1789} + \frac{2.5 \times 1789}{2} \left(1 - \frac{50}{200}\right) = \text{B } 3354$$

The length of time to receive an order for this type of manufacturing operation is commonly called the length of the production run.

$$\text{Production run} = \frac{EOQ}{p} = \frac{1789}{200} = 8.945 \text{ days /order}$$

The number of orders per year is actually the number of production runs that will be made. So number of production runs (from orders) = $\frac{D}{EOQ} = \frac{15000}{1789} = 9 \text{ orders (Approx)}$

$$\text{Finally the maximum inventory level is} = EOQ \left(1 - \frac{d}{p}\right) = 1789 \times \left(1 - \frac{50}{200}\right) = 1342 \text{ yards}$$

33. A contractor is evaluating its machine shop's current layout. Figure below (Table 1) shows the current layout and the adjoining table (Table II) shows the closeness matrix for the facility measured as the number of trips per day between department pairs. Safety and health regulations require the following department pairs close to each other: A & E, C & F, A & B and C & E as shown in the third table (Table III) below.

How much better is your layout than the current layout in terms of the wd score? Use rectilinear distance.

E	B	F
A	C	D

Table I

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Department	Trips Between Departments					
	A	B	C	D	E	F
A	-	9	2	-	8	5
B	-	-	-	3	-	-
C	-	-	-	-	7	8
D	-	-	-	-	-	3
E	-	-	-	-	-	4
F	-	-	-	-	-	-

Table II

E	C	F
A	B	D

Table III

Answer:

Department Pair	Current layout			Proposed Layout	
	Number of Trips (1)	Distance (2)	wd Score (1 x 2)	Distance (3)	wd score (1 X 3)
A,B	9	2	18	1	9
A,C	2	1	2	2	4
A,E	9	1	9	1	9
A,F	5	3	15	3	15
B,D	3	2	6	1	3
C,E	7	2	14	1	7
C,F	8	2	16	1	8
D,F	3	1	3	1	3
E,F	4	2	8	2	8
		Total	91		66

The above table reveals that the wd score drops from 91 from the current plan to 66 for the revised plan. So we can change the layout as proposed.

34. Baker Machine Company is a job shop that specializes in precision parts for firms in the aerospace industry. Figure (Table I) shows the current block plan for the key manufacturing centers of the 75000 sq. ft. facility. Refer to following closeness matrix (Table II) and use rectilinear distance (the current distance from inspection to shipping and receiving is three units) to calculate the change in the weighted distance, weighted score if Baker exchanges the locations of the tool crib and inspection. Put up your decision.

C	D	B
A	E	F

Table I

Department	Trips Between Departments					
	A	B	C	D	E	F
Burr & Grid (A)	-	8	3	-	9	5
Numerically Controlled Equipment (B)	-	-	-	3	-	-
Shipping & Receiving (C)	-	-	-	-	8	9
Leather & Drills (D)	-	-	-	-	-	3
Tool Crib(E)	-	-	-	-	-	3
Inspection(F)	-	-	-	-	-	-

Table II

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Answer:

Proposed Layout Plan:

C	D	B
A	F	E

Department Pair	Current layout			Proposed Layout	
	Number of Trips (1)	Distance (2)	wd Score (1 x 2)	Distance (3)	wd score (1 X 3)
A,B	8	3	24	3	24
A,C	3	1	3	1	3
A,E	9	1	9	2	18
A,F	5	2	10	1	5
B,D	3	1	3	1	3
C,E	8	2	16	3	24
C,F	9	3	27	2	18
D,F	3	2	6	3	9
E,F	3	1	3	1	3
		Total	101		107

The above table reveals that the wd score increased from 101 from the current plan to 107 for the revised plan. So we should not adopt the layout as proposed.

35. **Bharat Forge does its annual production planning over four quarters. Its demand projections for the coming year are as follows:**

Quarter	Demand (tonnes)
I	70
II	130
III	110
IV	90

Bharat's workforce can produce 60 tonnes of output/quarter. The workforce needs to be increased but that is going to be a distant plan. Overtime can be used. Of course the output rate during the overtime period is observed to be 20% greater than that during the regular time. But there is a legal cap on the overtime limiting it to a maximum time of 25% of the regular time in any quarter. Overtime costs 40% more than the regular time production. It can subcontract to smaller company at a premium of 45% of the cost of the regular production. The regular time costs are B200000/T (does not include cost of materials). Inventory carrying cost is B400000/T/year. As a management policy, no shortages allowed. Suggest an economical aggregate production plan for Bharat Forge. Assume zero inventories of the product at the beginning of the plan year. What is the total production cost for this plan?

Answer:

Regular time production cost: B200000/T

Overtime production cost: B200000/T X 1.40 = B280000/T

Subcontracting cost: B200000/T X 1.45 = B290000/T

Cost of producing in overtime and carrying the inventory to the next quarter = $200000 + 400000/4 = B300000$

The approach to the aggregate planning will be:

Produce during regular time

If this quantity is not adequate to meet the demand, produce the additional quantity in overtime

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However, the maximum overtime production possible in a quarter is 20% of the regular production capacity = $0.25 \times 60 \times 1.20 = 18T$

Hence in any quarter the maximum that can be produced in regular plus overtime would be = $60 + 18 = 78T$.

If in any quarter the demand exceeds 78T, the quantity over and above 78T will have to be subcontracted. The aggregate production plan can now be as follow:

Quarter	Output (T) obtained through			
	Regular	Overtime	Subcontract	Total
I	60	10		70
II	60	18	52	130
III	60	18	32	110
IV	60	18	12	90

There is no limit on the amount to subcontract. Therefore the last option, the most expensive one, will not be used.

The production costs for this aggregate production plan are as:

Quarter I: $(60 \times 200000) + (10 \times 280000) = B14800000$;

Quarter II: $(60 \times 200000) + (18 \times 280000) + (52 \times 290000) = B32120000$;

Quarter III: $(60 \times 200000) + (18 \times 280000) + (32 \times 290000) = B26320000$;

Quarter IV: $(60 \times 200000) + (18 \times 280000) + (12 \times 290000) = B20520000$;

36. What are the conditions to be met for Product-layout.

Answer:

- Adequate volume for reasonable equipment utilization;
- Reasonably stable product demand;
- Product Standardisation;
- Part Interchangeability;
- Continuous supply of materials;

37. With respect to forecasting choose "True" and "False" statements from the following:

- (i) Long range forecasts pertain to ongoing operation;
- (ii) Business Managers use forecasts to plan the system and to plan the use of the system;
- (iii) Business forecasting pertains to more than predicting demand;
- (iv) Short range forecasts helps planning for usage of the designed system;
- (v) Production planning is the basis for making Sales forecasting;

Answer:

i)/F, ii)/T, iii)/T, iv)/T, v)/F

38. Categorise the following into Long range forecasting and short range forecasting:

- a) Determination of Dividend Policy;
- b) Computation of overtime requirement to honour the delivery schedule;
- c) Capacity adjustment plan;
- d) Determination of working capital requirement;
- e) Determination of expected cash flows from sales

Answer:

a), c) & e) are long range forecasts

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39. Actual Demand for last 15 weeks are given in the following table:

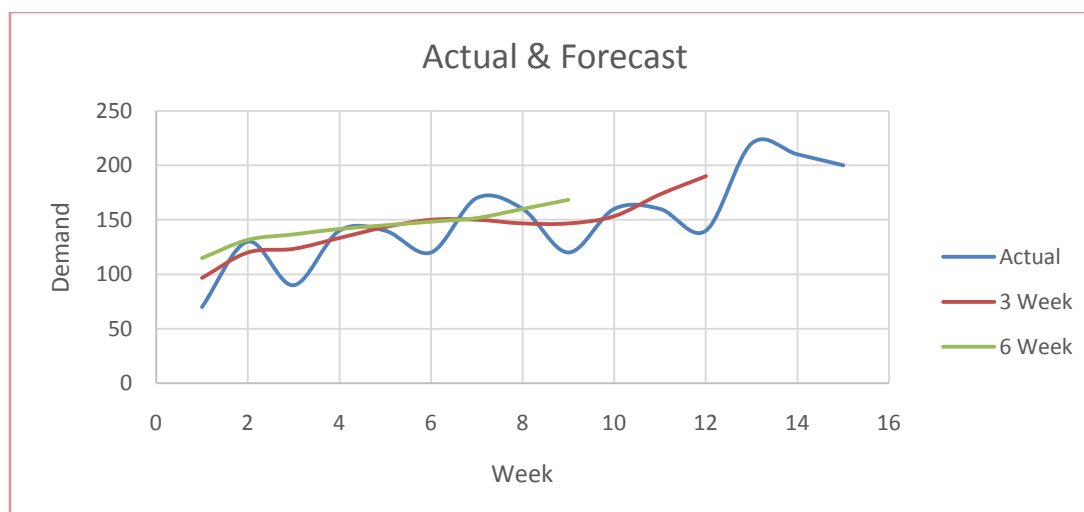
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demand	70	130	90	140	140	120	170	160	120	160	160	140	220	210	200

Compute moving average forecasts for the three and six week period and comment.

Answer:

Week	Demand	Forecast	
		3 Week	6 Week
1	70		
2	130		
3	90		
4	140	96.66667	
5	140	120	
6	120	123.3333	
7	160	133.3333	115
8	120	143.3333	131.6667
9	160	150	136.6667
10	160	150	141.6667
11	160	146.6667	145
12	140	146.6667	148.3333
13	220	153.3333	151.6667
14	210	173.3333	160
15	200	190	168.3333

The figure below shows the moving average forecasts for the 3 and 6 week period graphically. The shorter moving average period has more fluctuations and is closely following the rising trend. The longer moving average period smoothens out the random elements but lags behind the trend. If the fluctuations in the actual demand are high and there is a requirement to take these into account in the forecasts as well, a shorter moving average period is preferred. If the fluctuations are small, a longer moving average period is preferred.



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40. The data given in the following table refers to three different machines X, Y and Z. The output is expected to be 6000 units per month. Factory works for 48 hours per week. Find out the machine which will satisfy the required capacity.

Particulars	X	Y	Z
Set up time in minutes	10	7	8
Machine operation time in minutes per unit	1.5	1.8	1.4
Lot Size	500	400	300

Answer:

Machine X

Number of lots required = $6000/500 = 12$

Set up time required = $10 \times 12 = 120$ minutes

Processing time = $6000 \times 1.5 = 9000$ minutes

Total Time = $9000 + 120 = 9120$ minutes

Machine Y

Number of lots required = $6000/400 = 15$

Set up time required = $7 \times 15 = 105$ minutes

Processing time = $6000 \times 1.8 = 10800$ minutes

Total Time = $10800 + 105 = 10905$ minutes

Machine Z

Number of lots required = $6000/300 = 20$

Set up time required = $8 \times 20 = 160$ minutes

Processing time = $6000 \times 1.4 = 8400$ minutes

Total Time = $8400 + 160 = 8560$ minutes

41. Capacity of a work centre is expressed as:

(a) Capacity = Number of Machines or workers $\times$ Number of shifts $\times$ Efficiency

(b) Capacity = Number of Machines or workers $\times$ Number of shifts

(c) Capacity = Number of Machines or workers $\times$ Number of Shifts $\times \frac{\text{Utilisation Factor}}{\text{Efficiency}}$

(d) Capacity = Number of Machines or workers $\times$ Number of shifts $\times$ Utilisation Factor $\times$ Efficiency

Answer: d)

42. Define Design capacity and Effective capacity.

Answer:

Design Capacity: The maximum output rate or service capacity an operation, process or facility is designed for.

Effective Capacity: Design capacity minus allowance such as personal time and maintenance.

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Design capacity is the maximum rate of output achieved under ideal conditions, Effective capacity is always less than design capacity owing to realities of changing product mix, the need for periodic maintenance of equipment, lunch break, problems in scheduling and balancing operations etc. Actual output cannot exceed effective capacity and is often less because of machine breakdowns, absenteeism, shortages of materials and quality problems as well as factors that are outside the control of the operation managers.

43. Given the following information, compute the efficiency and the utilization of the vehicle repairing department.

Design Capacity = 80 trucks per day;

Effective Capacity = 75 trucks per day;

Actual output = 60 trucks per day;

Answer:

$$\text{Efficiency} = \frac{\text{Actual Output}}{\text{Effective Capacity}} \times 100 = \frac{60}{75} = 0.8 = 80\%$$

$$\text{Utilisation} = \frac{\text{Actual Output}}{\text{Design Capacity}} \times 100 = \frac{60}{80} \times 100 = 75\%$$

44. Match Column A with Column B

Column A	Column B
a) If the output is uniform	i) focusing exclusively on utilization of capacity will be counterproductive and leads to increase in inventory carrying costs;
b) When quality of output fails to meet standard	ii) an organization has differences in equipment capabilities among alternative pieces of equipment;
c) Scheduling problem occurs when	iii) there are more opportunities for standardization of methods and materials which leads to greater capacity;
d) Effective capacity is dependent on external factor like	iv) paperwork required by regulatory agencies controlling the product/service market
e) If demand for product is poor	v) the rate of production will be slowed by the need for inspection and rework activities

Answer:

a)/(iii), b)/(v), c)/(ii), d)/(iv), e)/(i),

45. Name steps in the Capacity planning Process.

Answer:

1. Estimate future capacity requirements;
2. Evaluate exchange capacity and facilities and identify gaps;
3. Identify alternatives for meeting requirements;
4. Conduct financial analyses of each alternative;
5. Assess key qualitative issues for each alternative;
6. Select the alternative to pursue that will be best in the long term;
7. Implement the selected alternative;
8. Monitor results;

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46. Choose "True" and "False" statements from the following:

- Long term capacity needs require forecasting demand over a time horizon and then converting those forecasts into capacity requirements;
- Combinations of cycles and trends make complex demand pattern into simple one;
- When trends are identified in demand pattern, fundamental issues are i) how long the trend might persist and ii) the slope of the trend;
- When cycles are identified fundamental issues are i) the approximate length of the cycles and ii) the amplitude of the cycle;
- Short term capacity needs are less concerned with cycles and trends than with seasonal variations and other variations from average;

Answer:

a)T, b)F, c)T, d)T, e) T;

47. Capacity requirements of products that will be processed need few information. Name these information.

Answer:

- Accurate demand forecasts for each product;
- Standard processing time per unit for each product;
- Number of workdays per year;
- Number of shifts to be used;

48. A department works one 8-hour shift, 300 days a year and has the following information for finding out the capacity requirements:

Product	Annual Demand	Standard processing Time per unit (Hr)
1	500	5
2	300	7
3	1300	2

Compute the capacity requirement—No of such type of machine required to fulfill the demand.

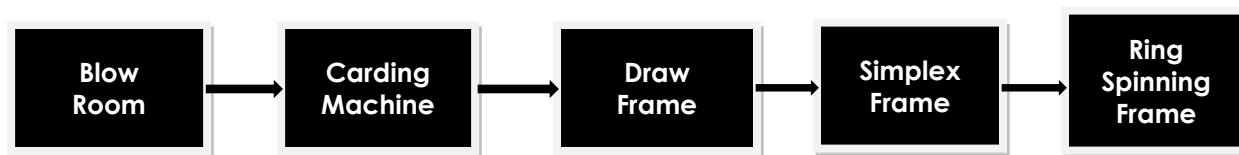
Answer:

Product	Annual Demand	Standard processing Time per unit (Hr)	Total Processing time needed (Hr)
1	500	5	500*5 =2500
2	300	7	300*7 =2100
3	1300	2	1300*2 =2600
Total Processing time needed for all products			7200

$$\text{No of Machine required in the department} = \frac{\text{Total Processing time needed}}{\text{Processing time capacity per unit}} = \frac{7200}{8 \times 300} = 3 \text{ machine}$$

49. Apsara Spinners is proposing to set up a new cotton yarn spinning unit to produce cotton yarn. The unit has been gifted 3 draw frames. A diagrammatic representation of the spinning process is given below:

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Raw cotton is sent to the blow room wherefrom after removing the fibrous part raw cotton is passed through carding machine. It disentangle the fibres of the cotton yarn. Then draw frames draw the cotton into thick strands. From here the output is passed to simplex frame where thinner strands are made. The output of the simplex is then fed to the ring frame wherefrom required quality of yarn or thread comes out.

The unit has been given a license for 4000 spindles capacity.

The technical details of the machinery working at 100% rated capacity are as follows:

Machine	Capacity per 8 hour shift	Wastage	Capacity utilization/Efficiency
Blow Room	1100 kg	6%	82%
Carding Machine	160 kg	5%	85%
Draw Frame	300 kg	2%	75%
Simplex Frame (120 spindles)	4 kg per spindle	1%	85%
Ring Spinning Frame (450 spindles)	250 gm	3%	88%

Capacity utilization of the ring spinning frame is 90%.

What equipment do you recommend purely from the technical point of view of balancing the output?

Answer:

Ring spinning frames: Each ring spinning frame has 450 spindles.

Number of ring spinning frames permissible = $\frac{4000}{450} = 8$

Each spindle on a ring spinning frame processes 250 gm at 100% capacity, but it works at 90% capacity. Total production per shift (including wastage)

$$= \text{Production} \times \text{weight} \times \text{machine efficiency} \times \text{capacity utilisation}$$

$$= 8 \times 450 \times 0.25 \times 0.88 \times 0.90 = 712.8 \text{ kg}$$

This must be the input at the ring spinning frames and should correspond to the output of the simplex frames

Simplex frames: Since there is 1% wastage at the simplex frame, its input should be

$$= \frac{712.8}{0.99} = 720 \text{ kg}$$

Let the number of simplex frame machine be S. Then

$$S \times 120 \times 4 \times 0.85 = 720$$

$$\text{So } S = 2 \text{ machines}$$

Draw frames: Since there is 2% wastage at the simplex frame, its input should be

$$= \frac{720}{0.98} = 734.69 \text{ kg}$$

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Let the number of draw frame machine be D. Then

$$D \times 300 \times 0.75 = 734.69$$

$$\text{So } D = 4 \text{ machines}$$

Carding machine: Since there is 5% wastage at the simplex frame, its input should be

$$= \frac{734.69}{0.95} = 773.36 \text{ kg}$$

Let the number of carding machine be C. Then

$$C \times 160 \times 0.85 = 773.36$$

$$\text{So } C = 6 \text{ machines}$$

Blow Rooms: Since there is 6% wastage at the simplex frame, its input should be

$$= \frac{773.36}{0.94} = 822.72 \text{ kg}$$

Let the number of carding machine be B. Then

$$B \times 1100 \times 0.82 = 822.72$$

$$\text{So } B = 1 \text{ machines}$$

50. Name three most important factors considered in planning service capacity.

Answer:

- a) There may be a need to be near customers;
- b) The inability to store services;
- c) The degree of volatility of demand;

51. A firm's manager is facing a problem to decide whether to make or buy a certain item used in the production of vending machine. You are asked to help the manager with the following information: Making the item would involve annual fixed costs of ₹150000. Cost and volume estimates are as follows:

	Make	Buy
Annual fixed cost	₹150000	Nil
Variable cost/unit	₹60	₹80
Annual Volume(units)	12000	12000

- a) Given these numbers, should the firm buy or make this item?
- b) If variable cost/unit to buy is < ₹60 will your decision in (a) above change?
- c) There is a possibility that volume could change in the future. At what volume would you be indifferent between making and buying?

Answer:

- a) The total cost of each alternative:

$$\text{Total cost} = \text{Fixed cost} + \text{Volume} \times \text{Variable cost}$$

$$\text{Total cost under make: Total cost} = 150000 + 12000 \times 60 = \text{Rs. } 870000$$

$$\text{Total cost under buy: Total cost} = 0 + 12000 \times 80 = \text{Rs. } 960000$$

Since total cost under make < total cost under buy, manager should make the item.

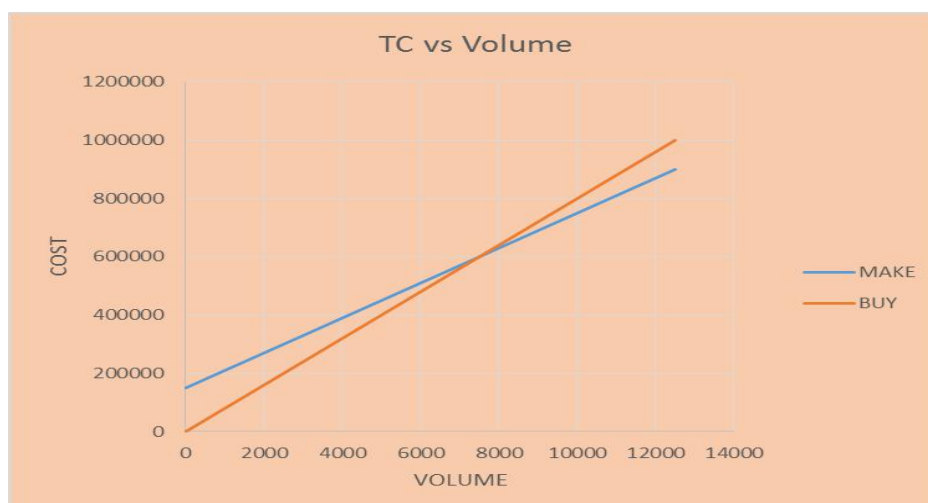
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b) If variable cost under buy option is less than ₹60 which is the variable cost under make option then we don't require to consider the fixed cost component as considered in answer to (a) above and we could safely suggest the manager to go for buying.

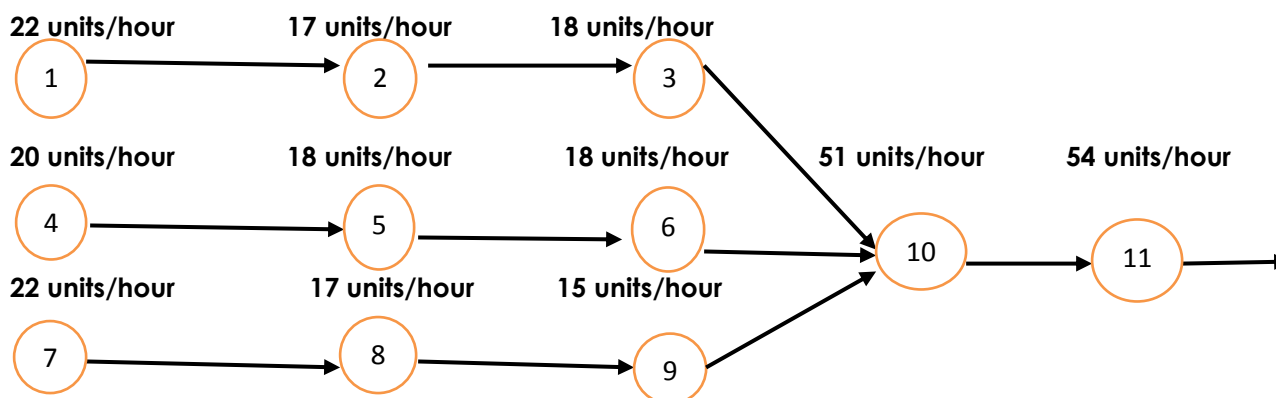
c) Indifference point is that volume (Q) where total cost under both the alternatives will be equal i.e.

$$\text{Total cost under make} = \text{Total cost under buy}$$

$$\text{Or, } 0 + Q \times 80 = 150000 + Q \times 60, \text{ Or } Q \times 20 = 150000, \text{ Or, } Q = 7500$$



52. Find the capacity of the following system:



Answer:

The attainable output of the system is equal to the output of the slowest operation

The slowest output in the 1st channel (1, 2, 3) = 17 units/hour;

The slowest output in the 2nd channel (4, 5, 6) = 18 units/hour;

The slowest output in the 3rd channel (7, 8, 9) = 15 units/hour;

Together these three portions could produce = 17 + 18 + 15 = 50 units/hour.

Although operation 10 & operation 11 could handle more than 50 units/hour, only 50 units/hour come from the preceding feeding channels of the system, so the system output could only be 50 units/hour.

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53. Say true or false:

- Product Layouts are used to achieve a smooth and rapid flow of large volumes of goods or customers through a system;
- Product layouts achieve a high degree of labour and equipment utilization which tends to result in high equipment costs;
- Process layouts are designed when variety of jobs that are processed requires frequent adjustments to equipment;
- The system in process layout is much less vulnerable to shutdown caused by mechanical failure because equipment is arranged by processing sequence;
- Maintenance costs in product layout tend to be lower than that in process layout because of less specialized type of equipment used in product layout.

Answer:

a)/T, b)/F, c)/T, d)/F, e)/F

54. Match Column A with Column B

Column A	Column B
a) Entire product layout corresponds to the technological processing requirements of the product	i) because large volumes are handled by this system;
b) In product layout the amount of work in process is often minimal	ii) because processing requirements usually exhibit too much variability;
c) Product layouts are less plentiful in service environments	iii) because only one or a few very similar items are involved;
d) In product layout material handling cost per unit is low	iv) because units here follow the same sequence of operations;
e) In product layout even a substantial investment of money in equipment becomes economical	v) because items move quickly from operation to operation;

Answer:

a)/iii, b)/v, c)/ii, d)/iv, e)/i,

55. A company must decide which type of machine to buy and how many units of that type given the following information:

Type	Cost
1	₹10000
2	₹14000

Product demand and processing times for the equipment are:

Product	Annual Demand	Processing Time/unit (minutes)	
		1	2
001	12000	4	6
002	10000	9	9
003	18000	5	3

- How many machines of each type would be required to handle demand if the machine will operate 8 hours a day, 250 days a year and what annual capacity cushion in processing time would result for each?

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- b) With high certainty of annual demand which type of machine would be chosen if that was an important consideration? With low certainty which type of machine would be chosen?
- c) If purchasing and operating costs are taken into account which type of machine would minimize total costs, given your answer for part (a)? Operating costs are ₹6/hour for type 1 and ₹5/hour for type 2.

Answer:

- a) Hour available in the year = $8 \times 250 = 2000$ hours.
Processing time required by Machines:
Machine 1: $12000 \times 4 + 10000 \times 9 + 18000 \times 5 = 228000$ minutes = 3800 hours
Machine 2: $12000 \times 6 + 10000 \times 9 + 18000 \times 3 = 216000$ minutes = 3600 hours
No of machines required:
Machine 1: $3800/2000 = 1.9 = 2$ machines
Machine 2: $3600/2000 = 1.8 = 2$ machines
Capacity Cushion available:
Machine 1 = $8 \times 250 \times 60 \times 2 - 228000 = 12000$ minutes
Machine 2 = $8 \times 250 \times 60 \times 2 - 216000 = 24000$ minutes
- b) With high certainty of annual demand a machine with low capacity cushion could be chosen. So machine 1 will be the right choice. With low certainty however high cushion machine i.e. Machine 2 is the right candidate.
- c) Total cost of machines:
Machine 1: $2 \times 10000 + 3800 \times 6 = ₹42800$
Machine 2: $2 \times 14000 + 3600 \times 5 = ₹46000$.
Machine 1 will minimize total cost.

56. Match Column A with Column B

Column A	Column B
a) Job shop	i) It is used for work that is non- routine with a unique set of objectives to be accomplished in a limited time frame;
b) Batch	ii) It is used when higher volumes of more standardized goods or services are needed;
c) Repetitive	iii) It is used when a very high volume of non-discrete, highly standardized output is required
d) Continuous	iv) It operates on a relatively small scale and used when a low volume of high variety goods or services are required;
e) Project	v) It is used when a moderate volume of goods and services is desired and a moderate varieties are handled;

Answer:

a)/(iv), b)/(v), c)/(ii), d)/(iii), e)/(i).

57. For each of the following name the basic process type.

- a) A tool and die shop;
b) Making of Rasgullas;
c) Building of bullet train railway track;
d) Manufacturing of Steel;
e) Assembly lines in Maruti Udyog Limited;

Answer:

a) Job shop, b) Batch, c) Project, d) Continuous, e) Repetitive.

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58. A producer of a printer is planning to add a new line of printers and you have been asked to balance the process, given the following task times and precedence relationships. Assume that cycle time is to be the minimum possible.

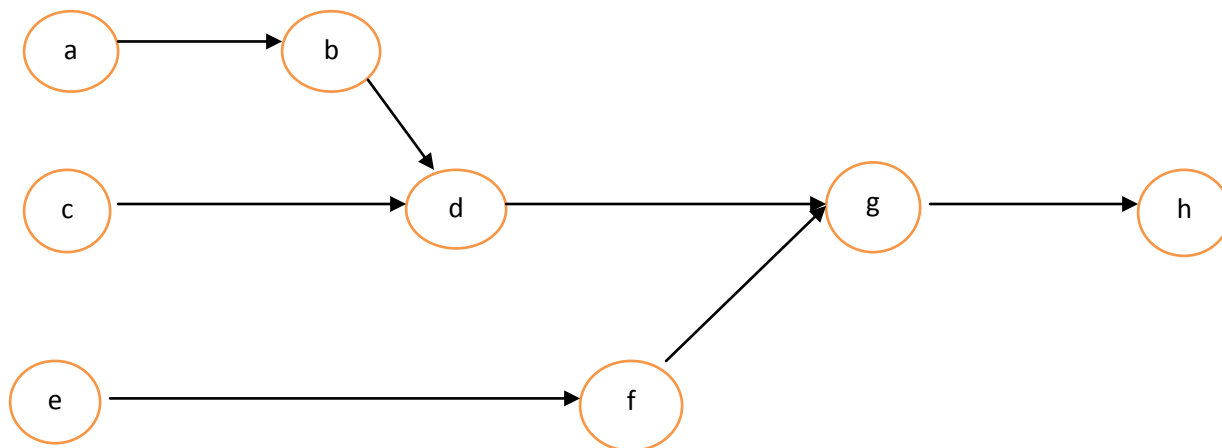
Task	Immediate predecessor	Length (minutes)
a	-	0.2
b	a	0.4
c	-	0.3
d	b, c	1.3
e	-	0.1
f	e	0.8
g	d, f	0.3
h	g	1.2

Do each of the following:

- Draw the precedence diagram.
- Assign tasks to stations in order of most following tasks. Tiebreaker: greater positional weights
- Determine the percentage of idle time.
- Compute the rate of output in printers per day that could be expected for this line assuming a 450 minute working day.

Answer:

- i) Precedence diagram



- ii) Assignment in order of most following tasks & tiebreaker: Greater positional weights

Tasks	Number of Tasks Following	Positional Weights
a	4 (b, d, g, h)	3.4
b	3 (d, g, h)	3.2
c	3 (d, g, h)	3.1
d	2 (g, h)	2.8
e	3 (f, g, h)	2.4
f	2 (g, h)	2.3
g	1 (h)	1.5
h	-	1.2

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Positional weights:

$$a = 0.2 + 0.4 + 1.3 + 0.3 + 1.2 = 3.4$$

$$b = 0.4 + 1.3 + 0.3 + 1.2 = 3.2$$

$$c = 0.3 + 1.3 + 0.3 + 1.2 = 3.1$$

$$d = 1.3 + 0.3 + 1.2 = 2.8$$

$$e = 0.1 + 0.8 + 0.3 + 1.2 = 2.4$$

$$f = 0.8 + 0.3 + 1.2 = 2.3$$

$$g = 0.3 + 1.2 = 1.5$$

$$h = 1.2$$

Cycle time = Minimum possible time = Longest task time = 1.3 minutes per unit

Station	Time remaining	Eligible	Will fit	Assign (task time)	Revised time remaining	Idle
1	1.3	a, c, e	a, c, e	a	1.1	
	1.1	b, c, e	b, c, e	b	0.7	
	0.7	c, e	c, e	c	0.4	
	0.4	d, e	e	e	0.3	
	0.3	d, f	No one	-	-	0.3
2	1.3	d, f	d, f	d	0	
3	1.3	f, g	f, g	f	0.5	
	0.5	g, h	g	g	0.2	
	0.2	h	Not fitted	-		0.2
4	1.3	h	h	h	0.1	
	0.1	No task left				0.1

In work station 1:

When a, c, e were eligible, a was assigned as a has the maximum follower

When b, c, e were eligible, b was assigned as b has the maximum positional weight even when b, c, e have the same no of followers.

When c, e were eligible, c was assigned as c has the maximum positional weight even when c, e have the same no of followers.

When d, e were eligible, e was assigned as e has the maximum follower

When d, f were eligible, no one were fit, as time remaining was not sufficient to complete any one of these tasks.

In work station 2:

When d, f were eligible, d was assigned as d has the maximum positional weight even when d, f have the same no of followers.

In work station 3:

When f, g were eligible, f was assigned as f has the maximum follower

When g, h were eligible, g was assigned as g has the maximum follower

When h was eligible it was not fitted as time remaining was not sufficient to complete this task

$$\text{iii) Total idle time} = 0.3 + 0.2 + 0.1 = 0.6$$

$$\begin{aligned} \text{Percentage of idle time} &= \frac{\text{Total idle time}}{\text{Total No of work station} \times \text{cycle time per station}} \times 100 \\ &= \frac{0.6}{4 \times 1.3} \times 100 = 11.54\% \end{aligned}$$

$$\text{iv) Output rate} = \frac{\text{Operating time per day}}{\text{Cycle time}} = \frac{450}{1.3} = 346 \text{ units per day approx}$$

Study Note – 3

DESIGNING OF OPERATIONAL SYSTEM AND CONTROL

Learning Objective: This will help to understand System Analysis and Design, which refers to the process of examining a business situation with the intent of improving it through better procedures and methods. System analysis and design relates to shaping organizations, improving performance and achieving objectives for profitability and growth.

1. Define Importance of Product Design

Answer:

Production or operations strategy is directly influenced by product design for the following reasons:

- (i) As products are designed, all the detailed characteristics of each product are established;
- (ii) Each product characteristic directly affects how the product can be made or produced (i.e., process technology and process design);
- (iii) How the product is made determines the design of the production system (production design) which is the heart of production and operations strategy;
- iv) A good product design can improve the marketability of a product by making it easier to operate or use, upgrading its quality, improving its appearance, and/or reducing manufacturing costs.

2. Which one of the following is not correct?

- a) An excellent design provides competitive advantage to the manufacturer, by ensuring appropriate quality;
- b) An excellent design provides competitive advantage to the manufacturer, by ensuring reasonable cost;;
- c) An excellent design provides competitive advantage to the manufacturer, by ensuring sustainability;
- d) An excellent design provides competitive advantage to the manufacturer, by ensuring expected product feature;

Answer: (c)

3. What Does Product Design Do?

Answer:

The activities and responsibilities of product design include the following:

- (i) Translating customer needs and wants into product and service requirements (marketing);
- (ii) Refining existing products (marketing);
- (iii) Developing new products (marketing, product design and production);
- (iv) Formulating quality goals (quality assurance, production);
- (v) Formulating cost targets (accounting);
- (vi) Constructing and testing prototype (marketing, production);
- (vii) Documenting specifications (product design);

4. What are the Reasons for Product Design or Redesign?

Answer:

The most obvious reason for product design is to offer new products to remain competitive in the market. The second most important reason is to make the business grow and increase profits. Also, when

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productivity gains result in reduction of workforce, developing new products can mean adding jobs and retaining surplus workforce instead of downsizing by layoffs/ retrenchment.

Sometimes product design is actually redesign or modification of existing design instead of an entirely new design. The reasons for this include customer complaints, accidents or injuries during product use, excessive warranty claims or low demand. Sometimes product redesign is initiated to achieve cost reductions in labour and material costs.

5. Which one of the following is not an Objective of Product Design?

- (i) To generate profit in the long run;
- (ii) To reduce the development time and cost to the minimum;
- (iii) To facilitate easy handling of the product;
- (iv) To ensure productibility or manufacturability (design for manufacturing and assembly);

Answer: (iii)

6. Match the item in column (1) to that of in column (2)

Factors Influencing Product Design	Feature
a) Customer Requirement	i) It goes hand in hand with product design and attractiveness of this enhances the sales appeal of the product;
b) Convenience of the operator	ii) the designer should have the knowledge of the this for the manufacturing facilities and specify tolerances which can be achieved by the available machines and equipments;
c) Cost/price ratio	iii) This partly depends on quality of design and partly on quality of conformance and quality policy of the firm has a say on this;
d) Work methods & equipments	iv) Designers must keep abreast of improvements on this for utilization in product design to achieve reduction in cost;
e) Trade off between function and form	v) It influences the product design so that the design suits the convenience of customers for use;
f) Process Capability	vi) it influences to make the design cost effective in a competitive market;
g) Packaging	vii) Under this the design combines both performance and aesthetics or appearance with a proper balance between the two.
h) Types of materials used	viii) This influences design of industrial products mainly;
i) Product quality	ix) This is considered to keep the cost of implementing the changes to a minimum;
j) Effect on existing product	x) Designers keep in touch with the latest developments taking place in this field and any new discovery in this improves the product design

Answer:

a)/v; b)/viii; c)/vi; d)/iv; e)/vii; f)/ii; g)/i; h)/x; i)/iii; j)/ix

7. What are the determinants of sequence of operations?

Answer:

- The nature of the product;
- The materials used;
- The quantities to be produced;
- The existing physical layout of the plant;

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8. What are the primary questions before deciding on process selection?

Answer:

- (i) How much variety of products or services will the system need to handle?
- (ii) What degree of equipment flexibility will be needed?
- (iii) What is the expected volume of output?

9. Define Process Strategy and write down its key aspects.

Answer:

A **process strategy** is an organisation's approach to process selection for the purpose of transforming resource inputs into goods and services (outputs). The objective of a process strategy is to find a way to produce goods and services that meet customer requirement and product specification (i.e., design specifications) within the constraints of cost and other managerial limitations. The process selected will have a long-term effect on efficiency and production as well as flexibility, cost, and quality of the goods produced. Hence it is necessary that a firm has a sound process strategy at the time of selecting the process.

Key aspects in process strategy include:

- (i) Make or buy decisions;
- (ii) Capital intensity;
- (iii) Process flexibility;

10. The probability that a product will function for a specific time period without failure is termed as product's:

i) Maintainability; ii) Availability; iii) Reliability; iv) Predictability;

Answer: iii

11. High reliability and maintainability of a product ensures

i) High productivity; ii) High productibility; iii) Highly standard quality; iv) High availability;

Answer: iv

12. Name the following product design activity:

It reduces variety among a group of products or parts. It results in economies of scale due to high volume of production of standard products. However it may lead to reduced choices for customers.

Answer: Standardisation:

13. Define Specification

Answer:

A specification is a detailed description of a material, part or product, including physical measures such as dimensions, volume, weight, surface finish etc. Specifications indicate tolerances on physical measures which provide production department with precise information about the characteristics of products to be produced and the processes and production equipment to be used to achieve the specified tolerances (acceptable variations). Interchangeability of parts in products produced in large volumes (mass production and flow-line production) is provided by appropriate specification of tolerances to facilitate the desired fit between parts which are assembled together.

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14. Which one of the following is correct?

To avoid damage during transportation and storage of the product i) a proper package has to be provided; ii) a proper specification has to be provided; iii) a proper transportation layout has to be provided; iv) a reliable design has to be provided:

Answer: (i)

15. Explain Process Focus Strategy.

Answer:

Majority (about 75 per cent) of global production is devoted to low volume, high variety products in manufacturing facilities called job shops. Such facilities are organised around performing processes. For example, the processes might be welding, grinding or painting carried out in departments devoted to these processes. Such facilities are **process focused** in terms of equipment, machines, layout and supervision. They provide a high degree of product flexibility as products move intermittently between processes. Each process is designed to perform a wide variety of activities and handle frequent changes. Such processes are called **intermittent processes**. These facilities have high variable costs and low utilization of facilities.

16. Say true or false:

- i) Batch process is characterized by high customization (made to order), high flexibility of equipment and skilled labour and low volume;
- ii) Under maturity stage of product life cycle the manufacturers introduce new models or adopt methods such as trading-in, etc., to promote the sale of their brands with a view to retaining their position in the market;
- iii) A product is born, grows lustily, attains a dynamic maturity, and then enters its most productive years;
- iv) Repetitive process is also referred to as line process as it include production lines and assembly lines in job production;
- v) Repetitive process is suitable to “manufacture-to-stock” strategy with standard products held in finished goods inventory;
- vi) Developing a new product is Job shop process;
- vii) In batch processing, volumes are higher because same or similar products or services are repeatedly provided;
- viii) A job shop uses a flexible flow strategy, with resources organized around the job;
- ix) In project process equipment flexibility and labour skills can range from low to high depending on the type of projects;
- x) A continuous process is the extreme end of high volume, standardised production with flexible line flows;
- xi) The process design is concerned with Kind of labour skills available, amount of labour available and their wage rates;
- xii) Capital intensity refers to the mix of equipment and material which will be used by the firm;
- xiii) Production planning and development is followed by introduction stage of product life cycle and this stage requires greater investment;
- xiv) The process design is concerned with whether the process should be capital-intensive or labor-intensive;
- xv) Batch processing is used when a high volume of goods or services is required andalso a moderate variety in products or services;

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Answer:

- i) False; ii) True; iii) False; iv) False; v) True; vi) False; vii) True;
 viii) False; ix) True; x) False; xi) True; xii) False; xiii) True; xiv) True;
 xv) False;

17. Say true or false:

- a) The general purpose equipment in process layout are not suitable because processing requires wide range of flexibility;
 b) In process layout system if equipment is arranged by processing sequence then the system becomes much more vulnerable to shut down;
 c) In process layout low volumes, special attention to each product and to customers result in higher unit costs than with product layout;
 d) In process layout there is more interdependence between successive operations than with a product layout;
 e) Job complexities in product layout often reduce the span of supervision and result in higher supervisory costs than with process layouts.

Answer:

- a)/F, b)/T, c)/T, d)/F, e)/F

18. 5 departments are to be assigned to locations B-F in the grid. (For technical reasons, department 6 must be assigned to location A). Transportation cost is Rs.3 per foot. Information on interdepartmental work flows and distances between locations is shown in the following tables.

Develop a suitable layout that minimizes transportation costs using the given information. Compute the total cost. Assume the reverse distances are the same.

From	Distance between Locations (Feet)						
↓	To →	A	B	C	D	E	F
A		-	70	120	70	100	150
B			-	70	110	60	90
C				-	160	80	70
D					-	70	140
E						-	70
F							-

From	Distance between Locations (Feet)						
↓	To →	1	2	3	4	5	6
1		-	115	52	54	15	40
2			-	10	7	16	44
3				-	2	0	20
4					-	13	2
5						-	5
6							-

A Dept. 6	B	C
D	E	F

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Answer:

Arranging the work flows from high to low we have

Department	Work Flow
1-2	115
1-4	54
1-3	52
2-6	44
1-6	40
3-6	20
2-5	16
1-5	15
4-5	13
2-3	10
2-4	7
5-6	5
3-4	2
4-6	2
3-5	0

A (Dept. 6)	B (Dept. 2)	C (Dept.5)
D (Dept.3)	E (Dept. 1)	F (Dept.4)

Position of Department 6 is fixed in location A because of technical reasons.

Departments 1-2 have the greatest interdepartmental work flow (115) so they should be placed side by side.

1-3 and 1-4 are now in the next in the ranking of work flow table.1-4 is in 2nd rank and 1-3 is in 3rd rank. So they could be placed adjacent to Department 1. Now if we place department 3 on right side of Department 1 and department 4 on left side of department 1 then distance between Department 3-6(A-F) > than that between Department 4-6(A-D). But in the work flow ranking 3-6 is much higher than that of 4-6. So it is better to place department 3 on left side of department 1 and department 4 on the right side of department 1.

So total cost table is:

Trip	Distance	Frequency	Cost = Distance x Frequency x 3
1-2	60	115	20700
1-3	70	52	10920
1-4	70	54	11340
1-5	80	15	3600
1-6	100	40	12000
2-3	110	10	3300
2-4	90	7	1890
2-5	70	16	3360
2-6	70	44	9240
3-4	140	2	840
3-5	160	0	0
3-6	70	20	4200
4-5	70	13	2730
4-6	150	2	900
5-6	120	5	1800
TOTAL			86820

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19. What are the information required for designing a process layout?

Answer:

- A list of departments or work centers to be arranged, their approximate dimensions and the dimensions of the building or buildings that will house the departments;
- A projection of future work flows between the various work centers;
- The distance between locations and the cost per unit of distance to move loads between locations;
- The amount of money to be invested in the layout;
- A list of any special considerations (e.g. operation that must be close to each other or operations that must be separated);
- The location of key utilities, access and exit points, loading docks and so on, in existing buildings;

20. Choose the correct answer:

- a) Under product and service design translating product and service specification into process specification involve
- i) Marketing functional area of an organization;
 - ii) Finance functional area of an organization;
 - iii) Accounting functional area of an organization;
 - iv) Engineering functional area of an organization;
- b) From a buyer's standpoint most purchasing decision entail
- i) 2 fundamental consideration—Cost and Quality;
 - ii) 3 fundamental consideration—Cost, Quality and Sustainability;
 - iii) 2 fundamental consideration—Cost and Quantity;
 - iv) 3 fundamental consideration—Cost, Quantity and Ethical beauty;
- c) The factor which is not responsible for bringing market opportunities and threat to product design and redesign is
- i) A need to reduce costs;
 - ii) A new regulation by Government;
 - iii) A need to increase GDP;
 - iv) A need to adopt new technology;
- d) Reverse engineering is
- i) Purchasing of an existing foreign product and adding a new feature to own product copied from the foreign product;
 - ii) Purchasing a competitor's product, dismantling it, inspect it for ways to improve own product;
 - iii) Purchasing a product at its fag end of life cycle, dismantling it, inspect it for ways to improve own product;
 - iv) Purchasing a substitute product dismantling it, inspect it for ways to improve own product;
- e) In product and service design life cycle analysis
- i) is the assessment of the environmental impact of a product or service throughout its useful life;
 - ii) is the dealing with products that have reached the end of their useful lives with an objective to reduce dumping of products;
 - iii) is an examination of the function of parts and materials in an effort to reduce the cost and/or improve the performance of a product;
 - iv) is the assessment of potential cost saving with reduction of environmental impact and with use of appropriated valued materials;

Answer:

a)/iv b)/i, c)/iii, d)/ii, e)/i.

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21. Choose the correct answer:

- a) Remanufacturing of products refers to
 - i) An examination of the function of parts and materials in an effort to reduce the cost and/or improve the performance of the product;
 - ii) Refurbishing use of products by replacing worn-out or defective components and reselling the products;
 - iii) A programme to reduce the dumping of products, particularly electronic equipment in landfills or third world countries;
 - iv) An assessment to choose products and services that have the least environmental impact while still taking into economic consideration;
- b) Reasons for recycling does not include
 - i) Cost savings;
 - ii) Environment concerns;
 - iii) Environmental regulations;
 - iv) Future sales growth;
- c) DFD means
 - i) Design for Disassembly;
 - ii) Design for Dismantling;
 - iii) Design for Destabilizing;
 - iv) Design for Detoxifying;
- d) DFR means
 - i) Design for Refurbishing;
 - ii) Design for Redesigning;
 - iii) Design for Recycling;
 - iv) Design for Reconstruction;
- e) Standardized products has a disadvantage namely
 - i) Immediate availability to customers;
 - ii) Resistance to modification of design;
 - iii) Lowers the cost of production;
 - iv) Increase productivity;

Answer:

a)/ii, b)/iv, c)/i, d)/iii, e)/ii

22. State whether the following statements are “True” or “False”

- a) All products and services go through a series of stages over their useful life, sometimes referred to as their life cycle;
- b) In the growth phase of product life cycle it is important to obtain accurate projections of the demand growth rate and how long that will persist;
- c) Style items have a life cycle more than the life cycle of cloth washers.
- d) Reliability of a product is a measure of the ability of the product to perform its intended function under any condition;
- e) Failure in product with non-modular design is easier to diagnose compared to product with modular design;

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Answer:

a)/F, b)/T, c)/F, d)/F, e)/F;

23. Match Column A with Column B

Column A	Column B
a) Feasibility Analysis	i) In this phase of product design & development collaboration between accounting and operations are needed to weigh the alternatives in terms of cost, availability of resources, profit potential and quality;
b) Product specification	ii) In this phase of product design & development based on user feedback changes may be made or forecasts refined;
c) Process specification	iii) In this phase of product design & development detailed description of what is needed to meet customer wants are made;
d) Prototype development	iv) During product design & development it is used to determine the extent of consumer acceptance;
e) Design Review	v) In this phase of product design & development demand, development costs, production costs profit potential are studied;
f) Market test	vi) In this phase of product design & development demand marketing, finance, engineering, design and operation collaborate to determine whether to proceed with the product or abandon;
g) Follow up evaluation	vii) In this phase of product design & development one or few units are made to see if there are any problems with the product or process specification

Answer:

a)/v, b)/iii, c)/i, d)/vii, e)/vi, f)/iv, g)/ii,

Study Note – 4

PRODUCTION PLANNING AND CONTROL

Learning Objective: Production planning and control is concerned with implementing the plans, i.e. the detailed scheduling of jobs, assigning of workloads to machines and people, and the actual flow of work through the system. Production is an organized activity of converting raw materials into useful products.

1. What is the meaning of Production Planning?

Answer:

Production planning is the planning of production and manufacturing modules in a company or industry. It utilizes the resource allocation of activities of employees, materials and production capacity, in order to serve different customers.

2. In a work measurement exercise, a worker was observed for 30 minutes continuously. In this period, the worker completed 42 parts. The performance rating for the worker is 130. If the company allows 15% as a fatigue and personal time allowance, what should be the
- Normal time for the job
 - Standard time for the job

Answer:

Time required by worker for completion of one part (observed time) = $30/42 = 0.714$ minute
The performance rating of the worker = 130%

So, the normal time = observed time $\times$ performance rating = $0.714 \times 1.3 = 0.9286$ min.

Company allows 15% as a fatigue and personal time allowance on normal time. i.e., (0.9286×0.15) min = 0.13929 min.

$\therefore$ Standard time for the job

= (Normal time) + (fatigue and personal allowance)
= $(0.9286 + 0.13929)$
= 1.06789 mins.

3. What Is PPC In Production?

Answer:

$$= 1 - P_0 = 1 - \left(1 - \frac{\lambda}{\mu}\right) = \frac{\lambda}{\mu} = \frac{1}{12} \div \frac{1}{4} = \frac{1}{3}$$

The PPC Cycle refers to Production Planning Control. It has three phases—preplanning, planning, controlling. The pre-planning phase consists of product development, sales forecasting, factory or plant layout, equipment selection policy, and preplanning of production just prior to large scale production.

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4. State the different options a company have in matching demand and capacity.

Answer:

There are three general categories of options used

1. Level
2. Chase and
3. Combination

Level planning approach establishes a level set of resources and implies the demand will fluctuate around those available resources, or in, some cases, attempts to alter the demand patterns themselves to more effectively match the resource levels established. This approach tends to be more common and certainly more appealing in environments where resources are difficult or expensive to alter.

Chase approach represents the other extreme, in that demand is not altered, but resources are. In fact in a "pure" chase environment the resources are continually being raised or lowered to meet the demand as it fluctuates under the normal conditions.

Combination approach is by far the most common approach. As the name implies, companies using this approach will "mix and match", altering demand and resources in such a way to maximize performance to their established criteria, including profit, inventory investment, and the impact on people.

5. If the arrival and departure rates in a public telephone booth with a single phone are $1/12$ and $1/14$ respectively, find the probability that the phone is busy.

Answer:

$$P[\text{Phone is busy}] = 1 - P[\text{No customer in the booth}]$$

$$\lambda = \text{Rate of Arrival} \quad \mu = \text{Service Rate}$$

6. Briefly describe the $M | G | 1$ queuing system. **Answer:**

Answer:

Poisson arrival / General Service / Single server queuing system.

7. Briefly describe the JIT philosophy.

Answer:

Just-in-time (JIT) inventory systems are not just a simple method that a company has to buy in to; it has a whole philosophy that the company must follow. The ideas in this philosophy come from many different disciplines including; statistics, industrial engineering, production management and behavioral science. In the JIT inventory philosophy there are views with respect to how inventory is looked upon, what it says about the management within the company, and the main principle behind JIT.

Inventory is seen as incurring costs instead of adding value, contrary to traditional thinking. Under the philosophy, businesses are encouraged to eliminate inventory that doesn't add value to the product. Secondly, it sees inventory as a sign of sub par management as it is simply there to hide problems within the production system. These problems include backups at work centres, lack of flexibility for employees and equipment, and inadequate capacity among other things.

In short, **the just-in-time inventory system is all about having "the right material, at the right time, at the right place, and in the exact amount."**

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8. Choose the correct answer:

Key to just-in-time production is

- i) The elimination of all inventories;
- ii) To rely very heavily upon purchased items rather than in-house production;
- iii) Production in large lot sizes;
- iv) The elimination of all or most product options;

Answer: i)

9. What is the difference between the Toyota Production System and Lean Manufacturing?

Answer:

For all practical purposes, the two terms mean the same thing. The term "Lean Manufacturing" was coined by James Womac and Daniel Jones in their 1990 book *The Machine That Changed the World* to describe the phenomenal success that Japanese manufacturers were having in global markets. Since the Toyota Motor Company was the most successful of these Japanese companies to explain the Japanese manufacturing philosophy with their supply base and strategic partners, the term "Toyota Production System, or TPS, was born. Regardless of what it is called, the goal is always to eliminate waste from processes in order to reduce total lead-time.

10. Choose the correct answer:

In transportation models designed in linear programming, points of demand is classified as

- a) ordination
- b) transportation
- c) destinations
- d) origins

Answer: c)

11. Jobs A through E in the aircraft repair facility must each pass through the Sheet Metal centre and then through Paint centre. The processing time for each job in each centre is shown below. Find the sequence that minimizes completion time of the job. Calculate the cumulative flow time and idle time.

Processing Time in Days

Jobs	Wc-1 (Sheet metal centre)	Wc-2 (Paint centre)
A	4	5
B	17	7
C	14	12
D	9	2
E	11	6

Answer:

JOBS	A	B	C	D	E
WC-I	4	17	14	9	11
WC-II	5	7	12	2	6

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Applying Johnson's Algorithm, we find the optional sequence as follows:

The minimum processing time for Job D (TIME: 2) is in the process of machine Wc-II. So, it should be placed at the end of the sequence. As, the job is allotted, so that is crossed out from the list.

Next, minimum processing time for job A (TIME: 4) is in the process of machine Wc-I, so, it should be placed at the beginning of the sequence. As, it is already allotted, it should be crossed out.

In the same method, the job allocation has been performed.

A	C	B	R	D
---	---	---	---	---

The optimum sequence has obtained as above.

Computation of the total elapsed time and machine idle time.

Job	M/C A		M/C B		Idle Time	
	In	Out	In	Out	M/C A	M/C B
A	0	4	4	9	0	4
C	4	18	18	30	0	9
B	18	35	35	42	0	5
E	35	46	46	52	0	4
D	46	55	55	57	0	3
					57 – 55 = 2 Hrs.	25 Hrs.

Total flow time = 57 hrs.

Idle time for Wc-I = 2 hrs.

Idle time for Wc-II = 25 hrs.

12. List TWO advantages of simulation models as compared to analytical models.

Answer:

- Simulation can be used for highly complex system where analytical models are not possible.
- Simulations are more flexible than mathematical modeling and have fewer assumptions.

13. Consider an M/M/1 queuing system with an arrival rate $\lambda = 0.4$ and service rate $\mu = 0.5$. Compute the system load and tell if the system stable or not?

Answer:

Traffic Intensity, $\rho = \lambda/\mu = 0.4/0.5 = 0.8$

The system is stable because $\rho < 1$

14. Choose the correct answer:

In transportation model analysis the stepping-stone method is used to

- a. obtain an initial optimum solution
- b. obtain an initial feasible solution
- c. evaluate empty cells for potential solution improvements
- d. evaluate empty cells for possible degeneracy
- e. balance supply and demand

Answer: c)

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15. Which one of the following is not correct?

- a) Work measurement forms a basis of comparison between work methods and performance of workers;
- b) In direct method of work measurement timings are calculated from available data and compared with observed data;
- c) Predetermined Motion Time Systems (PMTS) is one of the indirect methods of Work measurement;
- d) Incentive based compensation system can be designed by laying down achievable targets through work measurement;

Answer: (b)

16. Elemental timings (in minutes) for a four element cycle in a shop floor study are as follows:

Element	Cycle observed timings					Rating
	1	2	3	4	5	
A	0.09	0.08	0.09	0.1	0.09	90
B	0.12	0.11	0.12	0.11	0.12	110
C	0.13	0.13	0.14	0.12	0.12	100
D	0.07	0.06	0.06	0.08	0.07	120

Assuming total allowance of 15%, Calculate standard time and standard production per 8 hours shift.

Answer:

The mean observed time for element A = $\frac{0.09+0.08+0.09+0.1+0.09}{5} = 0.09$ minutes

Similarly mean observed time for element B, C and D are = 0.116 minutes, 0.128 minutes and 0.068 minutes respectively.

Basic time for any element = Mean observed time * Rating/100

Therefore

Basic time for element A = $0.09 \times 90 / 100 = 0.081$ minutes

Basic time for element B = $0.116 \times 110 / 100 = 0.1276$ minutes

Basic time for element C = $0.128 \times 100 / 100 = 0.128$ minutes

Basic time for element D = $0.068 \times 120 / 100 = 0.0816$ minutes

Total basic time for the task = $0.081 + 0.1276 + 0.128 + 0.081 = 0.4182$ minutes

Standard time = Basic time (1+Allowance) = $0.4182 (1+0.15) = 0.48$ minutes.

The standard output during an 8 hour working day will be = $\frac{8 \times 60}{0.48} = 1000$ units

17. A book binder has one printing press, one binding machine and the manuscripts of different books. The time required to perform the operation of printing and binding for each book are shown below:

Book	1	2	3	4	5	6
Printing time (hrs)	30	120	50	20	90	100
Binding time (hrs)	80	100	90	60	30	10

Determine the order in which books should be processed in order to minimize the total time required to turn out all the books.

Work Book : Operations Management & Strategic Management

Answer:

Book	Printing time (hrs)	Binding time (hrs)
1	30	80
2	120	100
3	50	90
4	20	60
5	90	30
6	100	10

Examine the column for Printing time and Binding time and find the smallest value. In this case it is binding and for manuscript 6.

Since this job falls under Machine 2(Binding) schedule this job last.

Book	Printing time (hrs)	Binding time (hrs)
1	30	80
2	120	100
3	50	90
4	20	60
5	90	30

Examine the column for Printing time and Binding time and find the smallest value. In this case it is printing and for manuscript 4. Schedule this job first.

Book	Printing time (hrs)	Binding time (hrs)
1	30	80
2	120	100
3	50	90
5	90	30

Proceeding in the same manner we get a tie for Book 1 and book 5. We could choose any one and say we have chosen 1.

Book	Printing time (hrs)	Binding time (hrs)
2	120	100
3	50	90
5	90	30

Next minimum is 5 under binding. To be done last among 2, 3, 5. Next minimum is 3 under printing .So to be placed before 2.

The final sequence will be

Order	Books
1	4
2	1
3	3
4	2
5	5
6	6

Work Book : Operations Management & Strategic Management

The total elapsed time as per this sequence is as computed below:

Book	Printing			Binding		
	Time in	Time out	Idle	Time in	Time out	Idle
4	0	20	0	20	80	20
1	20	50	0	80	160	0
3	50	100	0	160	250	0
2	100	220	0	250	350	0
5	220	310	0	350	380	0
6	310	410	10	410	420	30

18. A TV repairman finds that the time spent on repair job has an exponential distribution with mean 20 minutes. If he repairs sets on first cum first served basis and if the arrival of sets is with an average of 15 per 8 hour day, what is the repairman's expected idle time each day? Also obtain the average number of sets in the system?

Answer:

Arrival rate $A = 15/8$ per hour

Service rate $S = 60/20 = 3$ per hour.

Probability that the service is free = $1 - \frac{A}{S} = 1 - \frac{15/8}{3} = \frac{15}{24}$

Expected idle time per day = $\frac{15}{24} \times 8 = 5$ hours

Length in system = $L_s = \frac{A}{S-A} = \frac{15/8}{3-15/8} = \frac{15}{9} = 1.67$ sets

19. A repair shop attended by a single machine has an average of four customer an hour who bring small appliances for repairs. The mechanic inspects them for defects and quite often can fix them right away or otherwise renders a diagnosis. This takes him six minutes on the average. Arrivals are Poisson and service time has the exponential distribution. You are required to:
- Find the proportion of time during which the shop is empty.
 - Find the probability of finding at least one customer in the shop.
 - What is the average number of customers in the system?
 - Find the average time spent including service.

Answer:

Arrival rate $A = 4$ per hour

Service rate $S = 60/6 = 10$ per hour.

Probability that the service is free = $1 - \frac{A}{S} = 1 - \frac{4}{10} = 0.6$

Probability of finding at least one customer in the shop = $A/S = 0.4$

Length in system = Average no of customers in the system = $L_s = \frac{A}{S-A} = \frac{4}{10-4} = \frac{4}{6} = 2/3$ customers

Time in system = $W_s = \frac{1}{S-A} \times 60 = \frac{1}{10-4} \times 60 = 10$ minutes

20. The new accounts officer at State Bank of India, Park Street Branch enrolls all new customers in checking accounts. During the 3 week period in January encompassing the beginning of the New Year, the bank opens a lot of new accounts for students. The bank estimates that the arrival rate during the period will be Poisson distributed with an average of 4 customers per hour. The service time is exponentially distributed with an average of 12 minutes per customer to set up a new account. Determine the operating characteristics for this system to assess if the current person is sufficient to handle the increased traffic.

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Answer:

Operating characteristics for the single server system:

$\lambda = 4$ customers per hour arrive

$\mu = 5$ customers per hour are served.

$$P_0 = \left(1 - \frac{\lambda}{\mu}\right) = \left(1 - \frac{4}{5}\right) = 0.20 \text{ probability of no customers in the system.}$$

$$L = \frac{\lambda}{\mu - \lambda} = \frac{4}{5 - 4} = 4 \text{ customers on average in the queuing system}$$

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{4^2}{5(5 - 4)} = 3.2 \text{ customers on average waiting}$$

$$W = \frac{1}{\mu - \lambda} = \frac{1}{5 - 4} = 1 \text{ hour average time in the system}$$

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{4}{5(5 - 4)} = 0.8 \text{ Hours (48 minutes) average time waiting}$$

$$P_w = \frac{\lambda}{\mu} = \frac{4}{5} = 0.80 \text{ probability that the new accounts officer will be busy and that a customer must wait.}$$

The average waiting time of 48 minutes and the average time in the system are excessive and the bank needs to add an extra employee during the busy period.

21. City fast food restaurant has a drive through window with a single server who takes orders from an intercom and also is the cashier. The window operator is assisted by other employees who prepares the orders. Customers arrive at the ordering station prior to the drive through window every 4.5 minutes (Poisson distribute) and the service time is 2.8 minutes. Determine the average length of the waiting line and the waiting time.

Answer:

$$\lambda = \frac{60}{4.5} \text{ customers per hour arrive}$$

$$\mu = 60/2.8 \text{ customers per hour are served.}$$

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{\left(\frac{60}{4.5}\right)^2}{\frac{60}{2.8} \left(\frac{60}{2.8} - \frac{60}{4.5}\right)} = 1.02 \text{ customers on average waiting}$$

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{\frac{60}{4.5}}{\frac{60}{2.8} \left(\frac{60}{2.8} - \frac{60}{4.5}\right)} = 0.076863 \text{ Hours (4.61 minutes) average time waiting}$$

22. The ticket booth on the Eden Gardens is operated by one person who is selling tickets for the IPL game on weekend. The ticket seller can serve an average of 12 customers per hour; on average 10 customers arrive to purchase tickets each hour. Determine the average time a ticket buyer must wait and the portion of time the ticket seller is busy.

Answer:

$$\lambda = 10 \text{ customers per hour arrive}$$

$$\mu = 12 \text{ customers per hour are served.}$$

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{10^2}{12(12 - 10)} = 4.17 \text{ customers on average waiting}$$

$$P_w = \frac{\lambda}{\mu} = \frac{10}{12} = 0.83 \text{ probability that the ticket seller will be busy and that a buyer must wait.}$$

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23. South Calcutta's lake view area has one pump for gasoline, which can service 10 customers per hour. Cars arrive at the pump at a rate of 6 per hour.

Determine the average queue length, the average time a car is in the system and the average time a car must wait.

Answer:

$\lambda = 6$ cars per hour arrive

$\mu = 10$ cars per hour are served.

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{6^2}{10(10 - 6)} = 0.9 \text{ customers on average waiting}$$

$$W = \frac{1}{\mu - \lambda} = \frac{1}{10 - 6} = 0.25 \text{ hour average time in the system}$$

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{6}{10(10 - 6)} = 0.15 \text{ Hours (9 minutes) average time waiting}$$

24. A manufacturing company produces a particular product in an assembly-line operation. One of the machines on the line is a drill press that has single assembly line feeding into it. A partially completed unit arrives at the press to be worked on every 7.5 minutes, on average, according to an exponential distribution. The machine operator can process an average of 10 parts per hour (Poisson distributed). Determine average number of parts waiting to be worked on, the percentage of time the operator is working and the percentage of time the machine is idle.

Answer:

$$\lambda = \frac{60}{7.5} = 8 \text{ parts per hour arrive}$$

$\mu = 10$ parts per hour are served.

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{8^2}{10(10 - 8)} = 3.2 \text{ parts on average waiting}$$

$$P_w = \frac{\lambda}{\mu} = \frac{8}{10} = 0.80 \text{ probability that the operator will be busy and that a customer must wait.}$$

$$P_0 = \left(1 - \frac{\lambda}{\mu}\right) = \left(1 - \frac{8}{10}\right) = 0.20 \text{ probability of no customers in the system and the machine is idle.}$$

25. Match Column A with Column B

Column A	Column B
a) Pricing Differential	i) The use of this approach can be especially attractive in dealing with seasonal demand peaks;
b) Advertising	ii) Its effectiveness to shift demand from peak period to off peak period for matching demand & capacity more closely is dependent on the knowledge of price elasticity of products;
c) Back orders	iii) This method is more amenable to manufacturing than to service industries;
d) Overtime	iv) The success of this approach depends on how willing customers are to wait for delivery;
e) Inventories	v) Timing of its efforts and knowledge of response rates are needed to shift the demand effectively and conform more closely to capacity;

Answer: a)/ii, b)/v, c)/iv, d)/i, e)/iii

Work Book : Operations Management & Strategic Management

26. The materials manager of a firm wishes to determine the expected demand for a particular item in stock during the reorder lead time. The information is needed to determine how far in advance to reorder before the stock level is reduced to zero. However both the lead time in days and the demand per day of the item are random variables, described by the probability distribution given in following table:

Lead Time (Days)	Probability	Demand/Day(Units)	Probability
1	0.5	1	0.1
2	0.3	2	0.3
3	0.2	3	0.4
		4	0.2

Manually simulate the problem for ten reorders to estimate the demand during lead time. Use the random numbers 47, 45, 99, 62, 28, 40, 17, 05, 99, 92, 50, 19, 81, 53, 20, 28, 38, 14, 62, 85, 59, 47, 63, 67, 15, 43, 31, 08.

Answer:

Demand	Probability	Cumulative Probability (%)	Range
1	0.1	10	00-09
2	0.3	40	10-39
3	0.4	80	40-79
4	0.2	100	80-99

Lead Time Days	Probability	Cumulative probability (%)	Range
1	0.5	50	00-49
2	0.3	80	50-79
3	0.2	100	80-99

Day	Random no	Lead time	Demand During Lead Time			Demand During Lead Time
1	47	1	45(3)			3
2	99	3	62(3)	28(2)	40(3)	8
3	17	1	05(1)			1
4	99	3	92(4)	50(3)	19(2)	9
5	81	3	53(3)	20(2)	28(2)	7
6	38	1	14(2)			2
7	62	2	85(4)	59(3)		7
8	47	1	63(3)			3
9	67	2	15(2)	43(3)		5
10	31	1	08(1)			1
					Total	46

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27. Say true or false:

- Aggregate planners seek to match supply and demand within the constraints imposed on them by policies or agreements and at minimum cost;
- A major advantage of chase demand approach of aggregate planning is that inventories can be kept at a maximum possible level to avoid stock outs;
- In aggregate planning best pure strategy is to maintain a steady output rate (level capacity) with a level workforce;
- Aggregate plans are updated periodically often monthly to take into account updated forecasts and other changes;
- Demand strategies in the hands of aggregate planners are intended to maintain demand by altering the capacity;

Answer: a)/T, b)/F, c)/F, d)/T, e)/F

28. Quarterly demand for a company's product are shown in the following table:

Quarter	Demand (Units)
1	50000
2	150000
3	200000
4	52000

The company could meet the demand by taking either a) by maintaining average production level supported by inventory or ii) by maintaining a normal production level of 50000 units supported by overtime production and subcontracting. The cost and other details of the company are

Inventory carrying cost: ₹ 3.00 per unit;

Overtime capacity: 80000 units in a quarter;

Subcontracting capacity: 70000 units in a quarter;

Cost of regular production: ₹ 50 per unit;

Cost of overtime production: ₹ 75 per unit;

Cost of subcontracting: ₹ 85 per unit;

Assume company always adjusts inventory from beginning of first quarter to avoid maximum shortage during the period of operation, select the cheapest plan.

Answer:

The computation for plan (a) and its cost of implementation is shown below

Quarter	Demand	Average production	Inventory	Adjusted Inventory with 61000 at beginning of Q1	Cost of Holding Inventory
1	50000	113000	63000	124000	372000
2	150000	113000	26000	87000	261000
3	200000	113000	-61000	0	0
4	52000	113000	0	61000	183000
Total	452000				816000

Work Book : Operations Management & Strategic Management

Cost of Regular production (452000 * 50)	22600000
Carrying Cost (272000 * 3)	816000
Total Cost	23416000

The computation for plan (b) and its cost of implementation is shown below

Quarter	Demand	Regular	Balance	Overtime	Subcontract
1	50000	50000	0		
2	150000	50000	100000	80000	20000
3	200000	50000	150000	80000	70000
4	52000	50000	2000	2000	0
Total		200000		162000	90000

Cost of Regular production (200000*50)	10000000
Overtime cost (162000*75)	12150000
Subcontract cost (90000*85)	7650000
Total Cost	29800000

So plan (a) is accepted.

29. To stimulate interest and provide an atmosphere for intellectual discussion, the finance faculty in a management school decide to hold special seminars on four contemporary topics – leasing, portfolio management, private mutual funds, swaps and options. Such seminars should be held once per week in the afternoons. However scheduling these seminars (one for each topic and not more than one seminar per afternoon) has to be done carefully so that the number of students unable to attend is kept to a minimum. A careful study indicates that the number of students who cannot attend a particular seminar on a specific day is as follows:

Day	Leasing	Portfolio Management	Private Mutual Funds	Swaps and Options
Monday	50	40	60	20
Tuesday	40	30	40	30
Wednesday	60	20	30	20
Thursday	30	30	20	30
Friday	10	20	10	30

Find an optimal schedule of the seminars. Also find the total number of students who will be missing at least one seminar.

Work Book : Operations Management & Strategic Management

Answer:

Day	Leasing	Portfolio Management	Private Mutual Funds	Swaps & Options	Dummy
Monday	50	40	60	20	0
Tuesday	40	30	40	30	0
Wednesday	60	20	30	20	0
Thursday	30	30	20	30	0
Friday	10	20	10	30	0

Day	Leasing	Portfolio Management	Private Mutual Funds	Swaps & Options	Dummy
Monday	~~40~~	~~20~~	~~50~~	~~0~~	~~0~~
Tuesday	30	10	30	10	0
Wednesday	~~50~~	~~0~~	~~20~~	~~0~~	~~0~~
Thursday	20	10	10	10	0
Friday	~~0~~	~~0~~	~~0~~	~~10~~	~~0~~

Day	Leasing	Portfolio Management	Private Mutual Funds	Swaps & Options	Dummy
Monday	40	20	50	0	10
Tuesday	~~20~~	~~0~~	~~20~~	~~0~~	~~0~~
Wednesday	~~50~~	~~0~~	~~20~~	~~0~~	~~10~~
Thursday	~~10~~	~~0~~	~~0~~	~~0~~	~~0~~
Friday	~~0~~	~~0~~	~~0~~	~~10~~	~~10~~

Day	Leasing	Portfolio Management	Private Mutual Funds	Swaps & Options	Dummy
Monday	40	20	50	A	10
Tuesday	20	0	20	0	A
Wednesday	50	A	20	0	10
Thursday	10	0	A	0	~~0~~
Friday	A	0	~~0~~	10	10

(A is the assignment made)

No of students missing: $20 + 20 + 20 + 10 = 70$

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30. A company has four sales representatives who are to be assigned to four different sales territories. The monthly sales increase estimated for each sales representative for different sales territories (in lakhs of rupees) are shown in the following table:

Sales Representatives	Sales Territories			
	I	II	III	IV
A	200	150	170	220
B	160	120	150	140
C	190	195	190	200
D	180	175	160	190

Suggest optimal assignment and the total maximum sales increase per month

Answer:

The Sales increase monthly is as follows:

	I	II	III	IV
A	200	150	170	220
B	160	120	150	140
C	190	195	190	200
D	180	175	160	190

Since the given problem is a maximization problem it needs to be converted into a minimization problem by subtracting each element in the table above from the highest element in the table i.e. 220 and the resultant table is given below:

	I	II	III	IV
A	20	70	50	0
B	60	100	70	80
C	30	25	30	20
D	40	45	60	30

Then follow the normal assignment rule and iterations are:

	I	II	III	IV
A	20	70	50	0
B	0	40	10	20
C	10	5	10	0
D	10	15	30	0

	I	II	III	IV
A	20	65	40	0
B	0	35	0	20
C	10	0	0	0
D	10	10	20	0

Work Book : Operations Management & Strategic Management

	I	II	III	IV
A	10	55	30	0
B	~~0~~	35	~~0~~	~~30~~
C	~~10~~	~~0~~	~~0~~	~~10~~
D	~~0~~	~~0~~	10	~~0~~

The problem has two alternative solution. Alternative I arbitrarily assigned B to I and Alternative II arbitrarily assigned to III

Alternative I

	I	II	III	IV
A	10	55	30	A
B	A	35	~~0~~	30
C	10	~~0~~	A	10
D	~~0~~	A	10	~~0~~

Alternative II

	I	II	III	IV
A	10	55	30	A
B	~~0~~	35	A	30
C	10	A	~~0~~	10
D	A	~~0~~	10	~~0~~

31. Say true or false:

- Lean operations uses considerably fewer resources to achieve greater productivity, lower costs, longer cycle times and higher quality than nonlean systems;
- Lean operations are focused on waste reduction, are demand driven and have a culture that is dedicated to excellence and continuous improvement;
- The ultimate goal of a lean operation is a balanced system that is one that achieve a smooth, rapid flow of materials and/or work through the system;
- Lean system is not prone to disruptions and is flexible in terms of the product variety and range of volume that it can handle;
- The ultimate goal of a lean operation is to achieve a system that matches supply to customer demand with level production;

Answer:

a)/F, b)/T, c)/T, d)/T, e)/F

Work Book : Operations Management & Strategic Management

32. Match Column A with Column B

Column A	Column B
a) Waste Reduction	i) It enables equipment flexibility and output variety without disruption in lean system;
b) Lean Culture	ii) Lean system aims to match output and demand;
c) Quick Changeover	iii) A hallmark of lean system;
d) Demand pull	iv) Lean system through it enables variety for batch production;
e) Small lot sizes	v) Lean system through it enables efficient flow and quick assessment of operations;
f) Visual controls	vi) The entire organization embraces lean concepts and strives to achieve them;

Answer:

a)/iii, b)/ vi, c)/i, d)/iii, e)/iv, f)/v

33. What are the principles followed by a lean system?

Answer:

- a) Identify customer values;
- b) Focus on processes that create value;
- c) Eliminate waste to create flow;
- d) Produce only according to customer demand;
- e) Strive for perfection;

34. In lean philosophy there are eight wastes. Pick them up from column A and match with column B

Column A	Column B
a) Excess Inventory	i) Require rework costs and possible lost sales due to customer dissatisfaction;
b) Overproduction	ii) Increases handling, increases work in process inventory;
c) Waiting time	iii) Beyond minimal quantities an idle resources takes up floor space and adds to costs;
d) Unnecessary transporting	iv) Makes unnecessary production steps, scraps
e) Processing waste	v) Relate to mental and creative abilities as well as physical abilities
f) Inefficient work methods	vi) Requires space adds no value
g) Product defects	vii) Reduce productivity, increase scrap , increase work in process inventory;
h) Underused people	viii) Involves excessive use of manufacturing resources

Answer:

a)/iii, b)/viii, c)/vi, d)/ii, e)/iv, f)/vii, g)/i, h)/v

Work Book : Operations Management & Strategic Management

35. Say True or False:

- a) Some products are prone to complete failure after some time and must be totally replaced while some other defective products need repairs to get restored to their original performance;
- b) Consumers judge the quality of a product by comparing its performance with that of similar products offered by other competitors in the market;
- c) Serviceability of a product is an indicator of the ease with which a product can be replaced after it fails;
- d) Completeness of a service indicates the degree to which the customer is provided with everything that he or she asks for;
- e) Features of a product are primary characteristics which are in addition to the secondary characteristics covered under performance;

Answer:

a)/T, b)/T, c)/F, d)/T, e)/F

36. Match Column A with Column B

Column A	Column B
a) Cost of Reworking	i) Arises when there is a change of contract;
b) Cost of Liability	ii) Arises when products of poor quality are sold as seconds;
c) Cost of downgrading	iii) Arises due to poor organization and holding of stocks
d) Cost of wastages	iv) Arises when attempts to establish causes for failure are made;
e) Costs for failure analysis	v) arises when defective products are to be corrected;

Answer:

a)/v, b)/i, c)/ii, d)/iii, e) iv

37. Choose the correct answer

- a) Which one of the following is external failure costs:
 - i) Cost of Downgrading;
 - ii) Cost of repairing and servicing;
 - iii) Cost of re-inspecting;
 - iv) Cost of scrapping;
- b) Costs associated with inspection and evaluation of materials, processes, intermediaries, products and services to ensure conformance to design specifications are called:
 - i) Warranty Costs;
 - ii) Failure analysis costs;
 - iii) Verification costs;
 - iv) Appraisal costs;
- c) This dimensions of service quality is the ease with which a service can be availed. This is called:
 - i) Consistency;
 - ii) Reputation;
 - iii) Convenience;
 - iv) Response;

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- d) Costs to check whether the materials, process set ups, running processes, intermediaries and final products and services are as per agreed specification are called:
- i) Verification costs;
 - ii) Costs of Warranty;
 - iii) Cost of reworking;
 - iv) Costs of downgrading;
- e) This dimensions of design quality for a product refers to the probability of a product's failure within a specified time period. This is called:
- i) Performance;
 - ii) Reliability;
 - iii) Serviceability;
 - iv) Completeness;

Answer:

a)/ii, b)/iv, c)/iii, d)/I, e)/ ii

38. Choose the correct answer

- a) This is a prevention cost and it is the cost of creating systems and procedures to ensure quality. This is
- i) Appraisal cost;
 - ii) Quality planning costs;
 - iii) Quality Assurance costs;
 - iv) Quality planning and quality assurance costs;
- b) Costs incurred on the assessment and approval of suppliers of all products including materials, components and subassemblies and services are called:
- i) Training costs;
 - ii) Quality audit costs;
 - iii) Inspection costs;
 - iv) Vendor rating costs;
- c) Total quality management focuses on
- i) Product –out;
 - ii) Market-in;
 - iii) Product – in;
 - iv) Market –out;
- d) For achieving total quality management, all employees irrespective of their level or functions must aim at customer satisfaction. This is called:
- i) Product –out focus of organization;
 - ii) Market-in focus of organization;
 - iii) Product – in focus of organization;
 - iv) Market –out focus of organization;
- e) Employees of the organization tend to believe that they have only to follow production manuals and procedures with little regard to the customer or his complaints. This is called:
- i) Product –out focus of organization
 - ii) Market-in focus of organization;
 - iii) Product – in focus of organization;
 - iv) Market –out focus of organization;

Answer:

a)/iv, b)/iv, c)/ii, d) ii, e)/i



Study Note – 5

PRODUCTIVITY MANAGEMENT AND QUALITY MANAGEMENT

Learning Objective: Productivity is a tool of measurement that determines the efficiency of the organization in terms of the ratio of output produced with respect to inputs used. Various factors like technology, plant layouts, equipment, and machinery affect productivity.

Quality directly or indirectly affects productivity and cost of the product. Many researchers gave their definitions of the productivity and quality. According to a production system, it is the ratio of total output quantity to total input quantity.

1. What do you mean by Total Productivity Index and Partial Productivity Index?

Answer:

Productivity may be measured either on aggregate basis or on individual basis which are called total and partial measure

Total productivity Index/measure = Total output/ Total input
= (Total production of goods and services)/ (Labour+ material+ capital+ Energy+ management)

Partial productivity indices, depending upon factors used, it measures the efficiency of individual factor of production

Labour productivity Index /Measure = Output in unit / Man hours worked

Management productivity Index/Measure = Output / Total cost of management

Machine productivity Index/Measure = Total output/ Machine hours worked

Land productivity Index/Measure = Total output / Area of Land used

2. Find out various productivity measures like total, multifactor and partial measure based on the following information:

Output and Input Production data in Rupees

Output:

1. Finished units 10,000
2. Work in progress 2,500
3. Dividends 1,000

Input:

1. Human 3,000
2. Material 153
3. Capital 10,000
4. Energy 540
5. Other Expenses 1,500

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Answer:

Total measure = Total Output/Total Input = $13,500/15,193 = 0.89$

Multi factor measure = Total Output/ Human + Material = $13,500/3153 = 4.28$ Multi factor measure = Finished units/ Human + Material = $10000/ 3,153 = 3.17$

Partial Measure₁ = Total Output /Energy = $13500/ 540 = 25$

Partial Measure₂ = Finished Units /Energy = $10000/ 540 = 18.52$

3. What are the benefits of Quality Management System?

Answer:

1. Improvement in internal quality (reduction in scrap, rework and non-conformities in the shop)
2. Improvement in external quality (customer satisfaction, claims of non-conforming products, returned products, warranty claims, penalty claims etc)
3. Improvement in Production reliability (number of break downs, percentage down time etc)
4. Improvement in Time performance (on-time delivery, time to market etc)
5. Reduction in the cost of poor quality (external non-conformities, scrap, rework etc)

4. What are the Dimensions of Quality?

Answer:

Dimensions of Quality:

1. Features
2. Conformance
3. Reliability
4. Durability
5. Service
6. Response
7. Aesthetics
8. Reputation

5. Give the Obstacles associated with TQM implementation

Answer:

Obstacles for TQM implementation:

1. Lack of management commitment
2. Inability to change organizational culture, Improper planning
3. Lack of continuous training and education
4. Incompatible organizational structure and isolated individuals and departments
5. In-effective measurement techniques and lack of access to data and results.
6. Paying inadequate attention to internal and external customers.
7. Inadequate use of empowerment and teamwork.

6. Define Quality Costs.

Answer:

Quality Costs are defined as those costs associated with the non-achievement of product or service quality as defined by the requirements established by the organization and its contracts with customers and society.

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7. What are the goals of Quality Management System (QMS)?

Answer:

The positive effects that are valued by a certified QM system according to ISO 9001 are usually:

1. Clear responsibilities.
2. Better-understood processes that are generally better implemented.
3. Greater confidence in management.
4. Better relationships with suppliers.
5. Better understanding of customers' needs.
6. Improved starting position vis-a-vis banks and insurance companies.
7. Advantage when orders are awarded, e.g. in the case of public tenders.

8. Can the ISO 9001 certification be combined with other certifications?

Answer:

ISO 9001 is a sector-neutral standard and therefore suitable for the certification of quality management systems of all companies. Audits according to ISO 9001 can be combined with other industry-specific audits for quality management systems as well as other management systems.

Combined certifications of ISO 9001 are usually combined with the following certifications (a selection):

Quality standard ISO/TS 16949 for the automotive industry, the standards EMAS and ISO14001 for environmental management and the ISO 50001 for energy management.

9. What is ISO 9000?

Answer:

The ISO 9000 family of standards represents an international consensus on good management practices with the aim of ensuring that the organization can time and time again deliver the product or services that meet the client's quality requirements. These good practices have been distilled into a set of standardized requirements for a quality management system, regardless of what your organization does, its size, or whether it is in the private, or public sector. The family of ISO 9000 standards has been developed by ISO and it is made up of four core standards:

ISO 9000:2005—Fundamentals and Vocabulary

ISO 9001:2008—Quality Management Systems—Requirements

ISO 9004:2009—Quality Management Systems—Guidelines for performance improvements

ISO 19011: 2011—Guidelines for quality and/or environmental management systems auditing

10. What are the benefits of implementing IS/ISO 14001:2004?

Answer:

Following are the benefits to an organization by implementing IS/ISO 14001:2004:

1. Provides framework for
 - a) Pollution prevention and waste reduction
 - b) Compliance with legislative and regulatory requirements
2. Reduction in liability/risks
3. Competitive advantage for 'Green' products Globally
4. Creation of an improved community goodwill
5. Improved environmental performance

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11. Choose the correct answer:

"The degree to which a set of inherent characteristics of an object fulfils requirements" is known as:

- a) Conformity
- b) Quality
- c) Grade
- d) Capability
- e) None of the above

Answer: b)

12. Choose the correct answer:

ISO 9001:2015 requires that the quality policy:

- a) Must be reviewed for continuing suitability
- b) Must be communicated and understood within the organization
- c) Must provide a framework for establishing and reviewing quality objectives
- d) All of the above
- e) None of the above

Answer: d)

13. Choose the correct answer:

Which of the following is not one of the seven Quality Management Principles?

- a) System Approach to Management
- b) Engagement of people
- c) Leadership
- d) Customer focus
- e) None of the above

Answer: a)

14. Choose the correct answer:

Which of the following indicates that a quality system is effective?

- (a) The required system is in place and continuous improvement is evident.
- (b) An audit was conducted and no non-conformances were found.
- (c) An audit report states that the intent of the standard is being met.
- (d) No corrective action requests have been issued for a specified period of time.

Answer: a)

15. Say True or False:

- a) Productivity is an index that measures output (goods and services) relative to the input (labour, materials, energy and other resources) to produce it;
- b) Productivity growth is the increase in productivity from one period to the next relative to the productivity in the next period;
- c) For profit based organisation, higher productivity means lower costs and for non-profit organisation productivity means reliability;
- d) Productivity is particularly important for organisation that use a strategy of low cost, although it is important for all organisation;
- e) Increase in productivity add value to the economy while inflation in check and improves standard of living of its people;

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Answer:

a)/T, b)/F, c)/F, d)/T, e)/T

16. Match Column A with Column B

Column A	Column B
a) Standardizing processes	i) Can lower costs of a wide range of transactions which in turn increases productivity;
b) Layoffs	ii) Reduces variability which can have a significant benefit for productivity;
c) Use of Internet	iii) May bring productivity lag in new companies;
d) New workers	iv) Have an adverse effect on productivity signaling inefficient use of resources;
e) Scrap rates	v) May increase Productivity because same workload is carried out by fewer resources;

Answer:

a)/ii, b)/iv, c)/i, d)/iii, e)/iv.

17. Say True or False:

- Without careful planning technology can actually reduce productivity especially if it leads to inflexibility, high costs or mismatched operations;
- The surge of investment across national boundaries can dampen productivity gains by exposing firms to lower competition;
- All aspects of quality improvement have a favorable impact on different measures of productivity- both partial as well as multifactor;
- Increase in productivity is not effective if a business unit fails to sale its increased output which is the result of improved productivity;
- Productivity is a narrower concept that pertains to getting the most out of a fixed set of resources;

Answer:

a)/T, b)/F, c)/T, d)/F, e)/F

18. Match Column A with Column B

Column A	Column B
a) Continuous improvement	i) Puts decision making into the hands of those who are closest to the jobs and have considerable insight into problems and solutions;
b) Competitive benchmarking	ii) Takes advantage of group synergy, gets people involved and promotes a spirit of cooperation;
c) Quality at source	iii) Involves identifying other organisations that are best at something and studying how they do it ;
d) Employee empowerment	iv) Seeks to improve all factors related to the process of converting inputs into outputs on an ongoing basis;
e) Team approach	v) Refers to the philosophy of making each worker responsible for the quality of his or her work;

Answer:

a)/iv, b)/iii, c)/v, d)/i, e)/ii,

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19. Say True or False:

- a) TQM emphasizes top management's role in leading a total quality effort on which all employees at all levels must focus;
- b) TQM emphasizes that quality is a strategic issue and the organisation must decide what the customer wants in terms of productivity;
- c) The objective of continuous process improvement is to determine ways to improve all critical processes while increasing the quantity of the work being produced;
- d) TQM represents a set of management principles that focus on quality improvement as the driving force in all functional areas and at all levels in a company;
- e) For achieving high levels of process performance and quality TQM stresses principles related to customer satisfaction, employee involvement and continuous improvement;

Answer:

a)/T, b)/F, c)/F, d)/T, e)/T.

20. Choose the appropriate answer

- a) AQL stands for
 - i) Acceptable Quality level;
 - ii) Acceptable Quantity Loading;
 - iii) Approved Quality Level;
 - iv) Available Quantity level;
- b) Quality at the Source is
 - i) A philosophy whereby defects are put to analysis;
 - ii) A philosophy whereby defects are disposed at scrap value;
 - iii) A philosophy whereby defects are caught and corrected where they are created;
 - iv) A philosophy whereby defects are caught and put to reengineering where they are created;
- c) Internal failures occur for
 - i) Replacements;
 - ii) Warranty work,
 - iii) Loss of customer goodwill;
 - iv) Faulty equipment;
- d) ROQ stands for
 - i) Rate of Quantity;
 - ii) Return on Quality;
 - iii) Reliable Operating Quality;
 - iv) Rated Order Quantity;
- e) On a per unit basis External failure costs are typically
 - i) Much greater than internal failure costs;
 - ii) Equal to internal failure costs;
 - iii) Much lower than internal failure costs;
 - iv) Not comparable with internal failure costs;

Answer:

a)/i, b)/iii, c)/iv, d)/ii, e)/i

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21. Match Column A with Column B

Column A	Column B
a) Appraisal Costs	i) Costs associated with checking conformity of process set up with agreed specifications;
b) External Failure Costs	ii) Cost associated with interruption of production to take samples;
c) Prevention costs	iii) Costs associated with scrap and downtime;
d) Verification costs	iv) Costs associated with data collection and analysis;
e) Internal Failure costs	v) Coats associated with liability claims;

Answer:

a)/ii, b)/v, c)/iv, d)/i, e)/iii

22. What are the quality management principles under ISO 9000?

Answer:

- a) A customer focus;
- b) Leadership;
- c) Involvement of people;
- d) A process approach;
- e) A system approach to management;
- f) Continual improvement;
- g) Use of a factual approach to decision making;
- h) Mutually beneficial supplier relationships;

23. Say True or False

- a) ISO 9000 pertains to quality management;
- b) ISO 14000 concerns what an organisation does to minimize harmful effects to the environment caused by its operation;
- c) ISO 9000 standards are critical for Indian companies doing business in India only;
- d) ISO 14000 certification bear upon consumption of natural resources and energy;
- e) ISO 24700 pertains to the quality and performance of office equipment that contains reused components

Answer:

a) T, b) T, c)/F, d)/T, e)/T

24. Say true or false

- a) TQM aims at continuous value additions to products and services in order to satisfy the customers totally;
- b) The full benefit of TQM will not be realized unless it encompasses the range of all high revenue generating products and services offered by the organisation;
- c) TQM involves intensive, extensive and frequent probe into the market behavior and consumer behavior in specific;
- d) TQM is for status quo and for organization's survival in the competition with healthy existence;
- e) Depending upon organisations's chosen mission TQM is an initiative about the entire organisation's quality which refers to organizational excellence;

Answer:

a)/T, b)/F, c)/T, d)/F, e)/F

Study Note – 6

PROJECT MANAGEMENT

Learning Objective: Project management is the practice of initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria at the specified time. The primary challenge of project management is to achieve all of the project goals within the given constraints.

1. What is a Project? Name two important Project Network analysis and their features.

Answer:

A project is a carefully defined set of activities that use resources (money, people, materials, energy, space, provisions, communication, etc.) to meet the predefined objectives.

Programme Evaluation and Review Techniques (PERT) and Critical Path Method (CPM) are two important project network analysis techniques.

The use of PERT and CPM techniques is made in both planning and controlling of the projects. These techniques help the project managers to determine the expected project completion date; the scheduled start and completion time for the different activities comprising the project; the key activities of the project which must be completed at the scheduled time; the time period by which the non-key activities may be delayed without causing a delay in the completion of the whole project etc.

PERT is useful for analyzing project scheduling problems in which the completion time of the different activities and therefore the whole project is not certain. It thus emphasizes the uncertainties of the completion times of the activities. On the other hand, CPM is most appropriately used in projects in which the activity durations are known with certainty along with certain knowledge on amounts of resources required for performing each of the activities. This technique is basically concerned with obtaining the trade-offs between the project duration and cost.

2. A work project consists of twelve activities labelled A through L. Upon being asked to specify the order in which jobs had to be done, the manager answered as follows:

A, B and C are the first activities of the period and can start simultaneously and immediately. A and B precede D while B precedes E, F and H. Activities F and C precede G while E and H precede I and J. C, D, F and J precede K which in turn precedes L. Further I, G and L are the terminal activities of the project.

The completion times of the various activities are listed here:

Activity	A	B	C	D	E	F	G	H	I	J	K	L
Time(days)	6	4	10	1	1	3	14	6	9	2	7	5

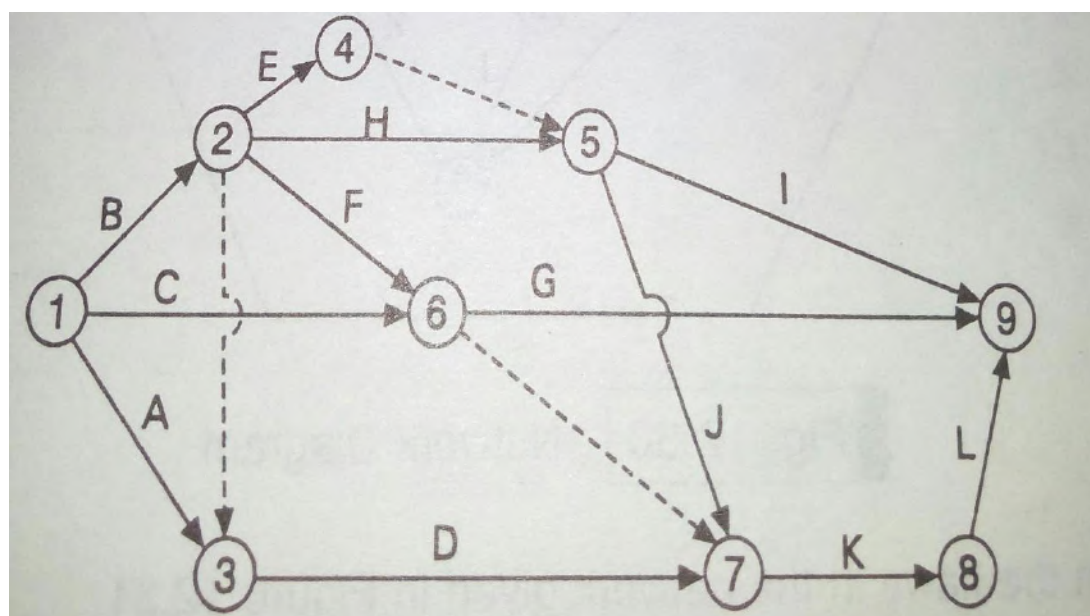
- (a) Draw a network diagram corresponding to this project;
(b) Obtain the lengths of all the paths and determine critical path.

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Answer:

The precedence relationships implied from the given information are:

Activity	Immediate Predecessor(s)	Activity	Immediate Predecessor(s)
A	-	G	C,F
B	-	H	B
C	-	I	E,H
D	A,B	J	E,H
E	B	K	C,D,F,J
F	B	L	K



The various paths and their lengths are as follows:

Path	Length
1-3-7-8-9	19
1-2-3-7-8-9	17
1-2-4-5-7-8-9	19
1-2-5-7-8-9	24* Critical
1-2-5-9	19
1-2-4-5-9	14
1-2-6-7-8-9	19
1-2-6-9	21
1-6-7-8-9	22
1-6-9	24* Critical

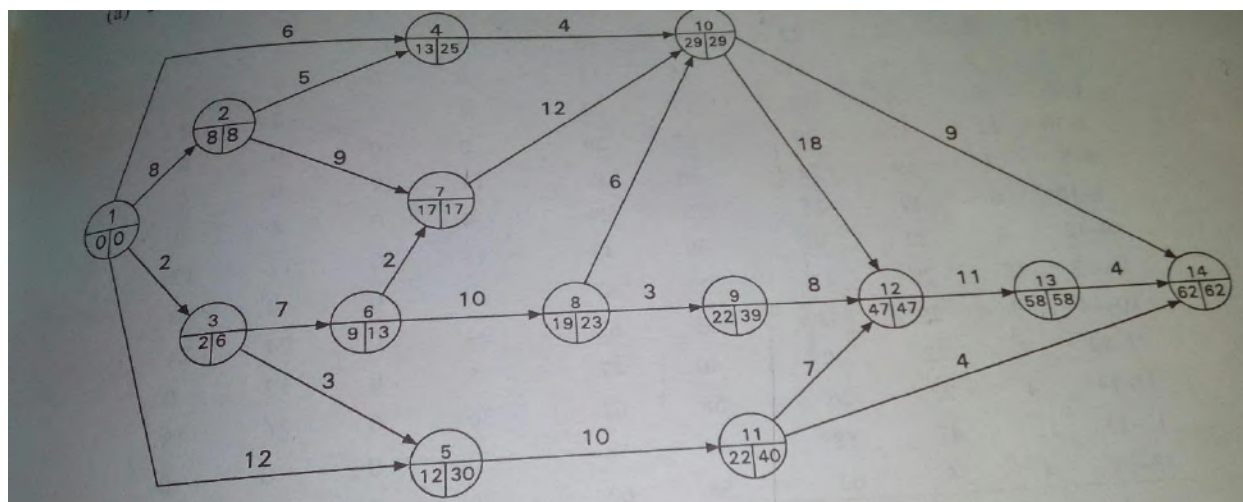
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3. a) Draw a network corresponding to the following information;
 b) Find the earliest and the latest scheduling time of various activities.
 c) Obtain the total, interfering, free and independent floats for each of the activities.
 d) Can the project be completed within 65 days?
 e) What would be the effect on the project length of reducing the resources to be used for activity 8-10 by such an amount as would increase the time for this activity by 5 days?
 f) The head of the department in which activity 6-8 is to be performed requests that he be allowed to work overtime so that the activity can be completed in 6 days. Should his request be considered in the interest of project completion at an earlier date? How about a similar request from the manager of the activity 2-7?
 g) It has come to be known that due to non-availability of resources in time, activity 3-5 would be delayed by 9 days. Will it affect (i) the project completion time? (ii) the start of its successor activity? By how much?

Activity	Time (Days)	Activity	Time(Days)
1-2	8	6-8	10
1-3	2	7-10	12
1-4	6	8-9	3
1-5	12	8-10	6
2-4	5	9-12	8
2-7	9	10-12	18
3-5	3	10-14	9
3-6	7	11-12	7
4-10	4	11-14	4
5-11	10	12-13	11
6-7	2	13-14	4

Answer:

The network diagram is shown the following figure:



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b) and c): The earliest and the latest starting and finishing times of various activities are indicated in the figure and are given in the following table. Also given in the table are the floats.

d) Yes the project can be completed in 65 days.

e) Since the activity 8-10 has a total float equal to 4 days, a delay by 5 days in it would increase the project length by one day.

f) The activity 6-8 is non-critical and has a total float equal to 6 days. Therefore it is no use working overtime on it as a decrease in its time would not cause a change in the project duration. However activity 2-7 is worthwhile working overtime on. This is because activity 2-7 is a critical one.

g) (i) The activity has a total float equal to 25 days. A delay of 9 days would not affect the project completion time. However the delay of 9 days, would ii) affect the start of its successor activity by 2 days because it has free float equal to 7 days.

Determination of scheduling time and floats

Activity	Time	Earliest		Latest		Float			
		Start	Finish	Start	Finish	Total	Int.	Free	Indep.
1-2	8	0	8	0	8	0	0	0	0
1-3	2	0	2	4	6	4	4	0	0
1-4	6	0	6	19	25	19	12	7	7
1-5	12	0	12	18	30	18	18	0	0
2-4	5	8	13	20	25	12	12	0	0
2-7	9	8	17	8	17	0	0	0	0
3-5	3	2	5	27	30	25	18	7	3
3-6	7	2	9	6	13	4	4	0	0
4-10	4	13	17	25	29	12	0	12	0
5-11	10	12	22	30	40	18	18	0	0
6-7	2	9	11	15	17	6	0	6	2
6-8	10	9	19	13	23	4	4	0	0
7-10	12	17	29	17	29	0	0	0	0
8-9	3	19	22	36	39	17	17	0	0
8-10	6	19	25	23	29	4	0	4	0
9-12	8	22	30	39	47	17	0	17	17
10-12	18	29	47	29	47	0	0	0	0
10-14	9	29	38	53	62	24	0	24	24
11-12	7	22	29	40	47	18	0	18	0
11-14	4	22	26	58	62	36	0	36	18
12-13	11	47	58	47	58	0	0	0	0
13-14	4	58	62	58	62	0	0	0	0

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4. What is the difference between a Project and a Process?

Answer:

A project is a temporary and one-time endeavor undertaken to create a unique product or service, which brings about beneficial change or added value. This property of being a temporary and one-time undertaking contrasts with processes, or operations, which are permanent or semi-permanent ongoing functional work to create the same product or service over and over again.

5. What are the challenges of Project Management?

Answer:

- To make sure that a project is delivered within defined constraints;
- To optimize allocation and integration of inputs needed to meet predefined objectives;

6. Say True or False

- a) Horizontal lines in Gantt chart divide the chart into sections which can represent various work tasks (work schedule) or work centers (load schedule);
- b) The critical path can be located by all those activities or events for which slack time is either zero or float time is the least;
- c) For calculation of Earliest Finish time, Total project time is required;
- d) Total float is the maximum amount by which duration time of an activity can be increased by increasing the total duration time of the project;
- e) Free Float is that fraction from total float of an activity which can be used for rescheduling the activity without affecting the succeeding activity;

Answer:

- a) T; b) T; c) F; d) F; e) T;

7. How float information is helpful in decision making?

Answer:

The float information can be used in decision-making in the following ways:

- Total float can affect both the previous and the subsequent activities;
- Total float can be used without affecting the subsequent activities;
- Independent float can be used in allocating the resources elsewhere and increasing the time of some noncritical activities;
- Negative float signifies reduction in target time to finish the work in time;

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8. The following table gives the activities in a construction project and other relevant information:

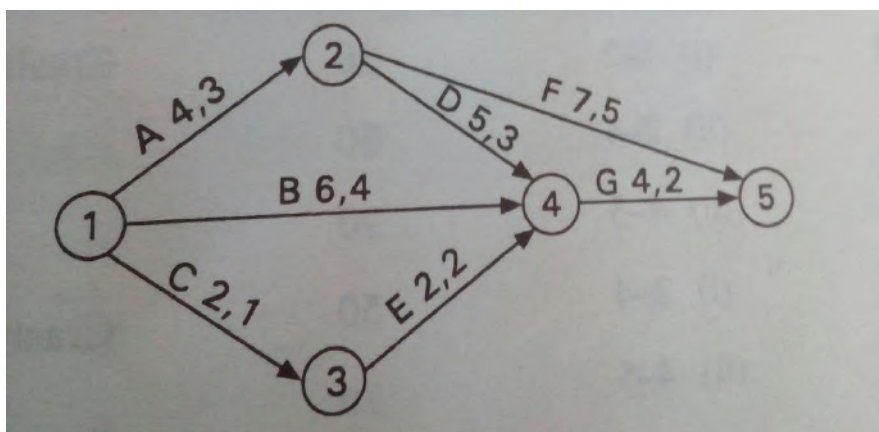
Activity	Immediate Predecessors(s)	Time (days)		Direct Cost (B)	
		Normal	Crash	Normal	Crash
A	-	4	3	60	90
B	-	6	4	150	250
C	-	2	1	38	60
D	A	5	3	150	250
E	C	2	2	100	100
F	A	7	5	115	175
G	D,B,E	4	2	100	240

Indirect costs vary as follows:

Days	Costs(B)
15	600
14	500
13	400
12	250
11	175
10	100
9	75
8	50
7	35
6	25

- Draw an arrow diagram for the project;
- Determine the project duration which will return in minimum total project cost

Answer:



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From the diagram we have

Path	Length	
	Normal time	Crash Time
1-2-5	11	8*(Critical)
1-2-4-5	13*(Critical)	8*(Critical)
1-4-5	10	6
1-3-4-5	8	5

Thus the normal duration is 13 days while the minimum completion time of the project is 8 days.

$$\text{Crashing Cost} = \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Time} - \text{Crash time}}$$

Accordingly for activity A, we have

$$\text{Crashing Cost} = \frac{90 - 60}{4 - 3} = \text{Rs. } 30/\text{day}$$

For various activities the crashing costs are:

Activity	Node	Cost /day(B)
A	1-2	30
B	1-4	50
C	1-3	22
D	2-4	50
E	3-4	-
F	2-5	30
G	4-5	70

The step wise crashing is given in following table while the cost of completing the project in 13, 12... Days is given in next to next table:

Crashing	Critical path(s)	Options	Cost	Decision	Duration after crashing
I	1-2-4-5	(i) 1-2 (ii) 2-4 (iii) 4-5	30 50 70	Crash 1-2	12
II	1-2-4-5	(i) 2-4 (ii) 4-5	50 70	Crash 2-4	11
III	1-2-4-5	(i) 2-4 (ii) 4-5	50 70	Crash 2-4	10
IV	1-2-5 1-2-4-5 1-4-5	(i) 2-5,4-5	100	Crash 2-5,4-5	9
V	1-2-5 1-2-4-5 1-4-5	(i) 2-5,4-5	100	Crash 2-5,4-5	8

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The length of various paths after each crashing is given here:

Path	Normal length	Length after crashing				
		I	II	III	IV	V
1-2-5	11	10	10	10	9	8
1-2-4-5	13	12	11	10	9	8
1-4-5	10	10	10	10	9	8
1-3-4-5	8	8	8	8	7	6

Determination of total cost

Project Duration (Days)	Direct Cost			Indirect Cost	Total Cost (B)
	Normal	Crashing	Total		
13	713	0	713	400	1113
12	713	30	743	250	993
11	713	80	793	175	968
10	713	130	843	100	943*(Min)
9	713	230	943	75	1018
8	713	330	1043	50	1093

9. Match Column A with Column B

Column A	Column B
a) Project Initiating	i) Includes completion of activities, consumption of resources with attainment of milestones;
b) Project Executing	ii) Includes defining the major project goals and choosing a project manager;
c) Project Planning	iii) Involves comparing actual progress with planned progress and undertakes corrective action if needed;
d) Project Controlling	iv) Checks the corrective actions on deviations to make sure it achieves desired effect;
e) Project Monitoring	v) Provides details on deliverables, scope of the project, the budget, the schedule and milestones, performance objectives, resources needed, a quality plan and a plan for handling risks;

Answer: a)/ii, b)/i, c)/v, d)/iii, e)/iv

10. Choose the appropriate answer

- a) Project management is not different from general operations management with respect to
- Time frame;
 - Objectives;
 - Bureaucracy;
 - Quality;

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b) Which one of the following is not the key metrics in Project management?

- i) Profit;
- ii) Time;
- iii) Cost;
- iv) Performance objectives;

c) Gantt Charts in Project Management is

- i) A big picture visual aid to estimate project duration;
- ii) A planning tool that is needed to develop a list of activities;
- iii) An aid to assess potential failures or problems in projects;
- iv) A visual aid to plan and monitor individual activities;

Answer:

a)/iv, b)/i, c)/iv

11. Say true or false

- a) Organisations use a matrix organization as it allows them to integrate the activities of a variety of specialists within a functional framework;
- b) A matrix organization works quite well with people who can function effectively only with a particular project manager;
- c) A matrix organization allows long term working relationships to develop between a project manager and people working under him;
- d) Matrix organization brings uncertainty with respect to employee evaluation and accountability;
- e) In a matrix organization functional and project managers share workers but not facilities;

Answer:

a)/T, b)/F, c)/F, d)/T, e)/F

12. Choose the appropriate answer

a) Project manager while effectively managing a project is not responsible

- i) For giving direction to people working in the project;
- ii) For keeping the project within the budget;
- iii) For realization of objectives for which the project is meant for;
- iv) For communication so that everybody has the information needed to do the work;

b) Project champions are

- i) People usually within the company who works under the project manager;
- ii) People usually within the company who promote and support the project;
- iii) People usually outside the company who sponsor the project;
- iv) People usually within the company who have eligibility to get selection as project manager;

c) Workers engaged in a project are evaluated

- i) On individual contribution;
- ii) On project's compliance to time schedule;
- iii) On project's compliance to budget limit;
- iv) On Project team's overall contribution relative to project metrics;

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- d) Gantt Chart enables manager
 - i) To plan and schedule simple projects;
 - ii) To initially schedule project activities;
 - iii) To monitor progress over time by comparing planned progress to actual progress;
 - iv) All the above;
- e) By using PERT and CPM managers are able to obtain
 - i) A graphical display of projects' outcomes;
 - ii) The actual completion time of a project;
 - iii) An indication of which activities are the most critical to timely project completion;
 - iv) An indication of how quickly an activity can be completed to complete a project well before schedule;

Answer:

a)/iii, b)/ii, c)/iv, d)/iv, e)/iii.

13. Say true or false

- a) Paths in a network diagram that are shorter than the critical path can experience some delays;
- b) Slack of a given path in a network diagram reflects the difference between the length of a given path and the length of the critical path;
- c) If time estimates in a network diagram can be made with a high degree of confidence that actual times are fairly certain estimates are significantly probabilistic;
- d) Knowledge of slack times in a network diagram provides managers with information for directing control efforts towards those activities that are least susceptible to delaying the project;
- e) In a network diagram the expected time of an activity is a weighted average of the three time estimates – Optimistic time, Realistic time, Pessimistic time;

Answer:

a)/T, b)/T, c)/F, d)/F, e)/F

14. Say true or false

- a) Activities on the critical path are potential candidates for crashing because shortening critical activities would not have an impact on total project duration;
- b) Crashing needs to be continued as long as cost to crash becomes equal to the benefits derived from crashing;
- c) Crashing analysis requires only crash time and costs for each activity, path lengths and identification of critical activities;
- d) In project management both PERT & CPM techniques depict sequential relationships that exist among activities;
- e) Closing phase in life cycle of a project involves handling of the project deliverables, obtaining customer acceptance, documenting lessons learned and releasing resources;

Answer:

a)/F, b)/F, c)/F, d)/T, e)/T.

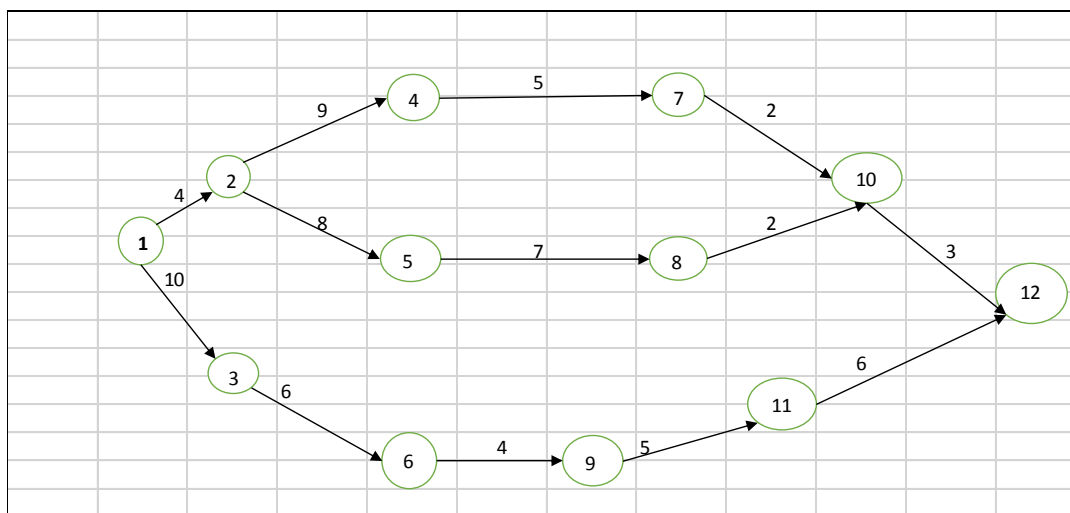
15. For each of the following network diagram, determine both the critical path and the expected project duration. The numbers on the arrows represent expected activity times:

- a) AOA diagram; b) AON diagram

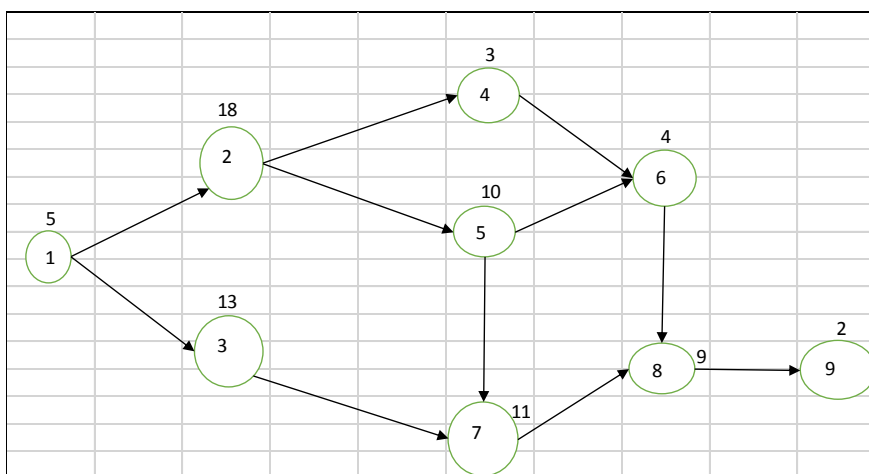
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(In the AOA diagram the arrows represent activities and they show the sequence in which certain activities must be performed.

In the AON the arrows show only the sequence in which certain activities must be performed while the nodes represent the activities)



(a)



(b)

Answer:

Expected project duration and critical path indicated as (*)

a)

Path	Expected Duration
1-2-4-7-10-12	$4+9+5+2+3 = 23$
1-2-5-8-10-12	$4+8+7+2+3 = 24$
1-3-6-9-11-12	$10+6+4+5+6 = 31^*$

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b)

Path	Expected Duration
1-2-4-6-8-9	$5+18+3+4+9+2=41$
1-2-5-6-8-9	$5+18+10+4+9+2=48$
1-2-5-7-8-9	$5+18+10+11+9+2=55^*$
1-3-7-8-9	$5+13+11+9+2=40$

16. Match Column A with Column B

Column A	Column B
a) A path	i) The difference in time length of any path and the critical path;
b) Critical path	ii) Used when two activities have the same starting and finished points;
c) Dummy Activity	iii) A sequence of activities in a project;
d) Crashing	iv) Shortening an activity by allocating additional resources;
e) Path Slack	v) The longest time sequence of activities in a project;

Answer:

a)/iii, b)/v, c)/ii, d)/iv, e)/i.

17. A project has the following characteristics

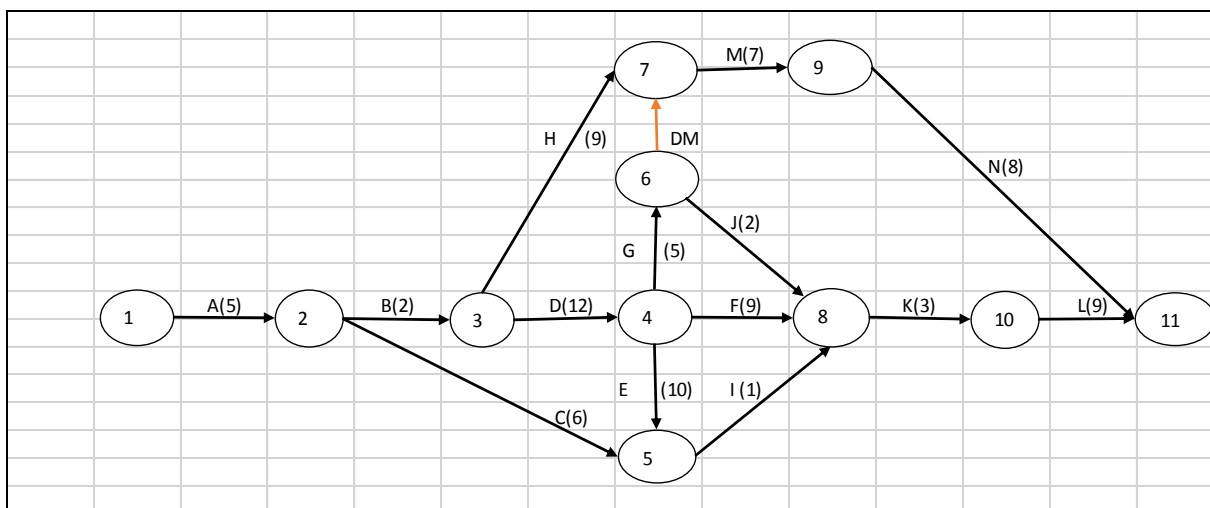
Activity	Preceding Activity	Expected Completion Time (in weeks)
A	None	5
B	A	2
C	A	6
D	B	12
E	D	10
F	D	9
G	D	5
H	B	9
I	C,E	1
J	G	2
K	F,I,J	3
L	K	9
M	H,G	7
N	M	8

- Draw a PERT network for this project.
- Find the critical path and the project completion time.
- Prepare an activity schedule showing ES, EF, LS and slack for each activity.
- Will the critical path change if activity G takes 10 weeks instead of 5 weeks? If so, what will be the new critical path?

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Answer:

a) DM is the dummy activity



b)

Path	Expected Duration
1-2-5-8-10-11	24
1-2-3-7-9-11	31
1-2-3-4-6-7-9-11	39
1-2-3-4-6-8-10-11	38
1-2-3-4-8-10-11	40
1-2-3-4-5-8-10-11	42*

* Critical path

c)

Activity	Duration	ES	EF	LS	LF	Slack
A	5	0	5	0	5	0
B	2	5	7	5	7	0
C	6	5	11	23	29	18
D	12	7	19	7	19	0
E	10	19	29	19	29	0
F	9	19	28	21	30	2
G	5	19	24	22	27	3
H	9	7	16	18	27	11
I	1	29	30	29	30	0
J	2	24	26	28	30	4
K	3	30	33	30	33	0
L	9	33	42	33	42	0
M	7	24	31	27	34	3
N	8	31	39	34	42	3

d) if activity G (4-6) takes 10 weeks instead of 5, the lengths of the paths 1-2-3-4-6-7-9-11 & 1-2-3-4-6-8-10-11 would become 44 and 43 weeks respectively. In that case 1-2-3-4-6-7-9-11 would become critical.

Study Note – 7

ECONOMICS OF MAINTENANCE AND SPARES MANAGEMENT

Learning Objective: Spare Parts Management (SPM) is an important branch of management which could lead the company to success or bankruptcy. It is also full of potential improvements that can increase the company profits, productivity, and reliability. Wise inventory management would eliminate all the delay risks of unplanned breakdowns, and reduce process time and cost.

1. Explain breakdown maintenance & Preventive maintenance

Answer:

Here the production facility is run without much routine maintenance until it breakdown. Once the machine breakdown it is taken for repair and inspected to find out the defects. After identifying the defect, the required repair is planned and the spares are procured to repair the machine. As the breakdowns are random in nature and the machine cannot be used during the repair period, production hours are lost hence the productivity is reduced. Repair maintenance is not a recommended practice, in general, but many a time many organizations prefer this, because they do not want to keep the machine idle for maintenance. But they ignore the fact that the break down repair costs more than the regular maintenance practice. It is however, an economical way of maintaining certain non-critical items whose repair and down time costs are less this way than with any other system of maintenance.

Preventative maintenance (or preventive maintenance) is maintenance that is regularly performed on a piece of equipment to lessen the likelihood of it failing. Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly. Replacement of candle in water filters in every 6 months.

2. Which one of the following is not correct in respect of preventive maintenance?

- a) It locates weak parts in all equipment, provides them regular inspection and minor repairs thereby reducing the danger of unanticipated breakdowns;
- b) This reduces the unanticipated breakdowns, increases the availability of the equipment, maintain optimum productive efficiency of equipment and machinery;
- c) The system of preventive maintenance varies from plant to plant depending on the requirement of the product and services;
- d) As the preventive maintenance is a costly affair, it is better to maintain records of cost (both labour, materials used and spares used);

Answer : (c)

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3. Say true or false:

- a) Effectiveness of breakdown maintenance planning = (Labour hours on scheduled maintenance) / (Total available hours spent);
- b) Preventive maintenance results in less standby or reserve equipment or spares;
- c) Preventive maintenance is done while the equipment is running or during preplanned shut-downs;
- d) Under Shifting production during breakdown method spare capacity is maintained in the form of standby machines;
- e) A proper stores management is essential as a backup service of good maintenance;
- f) Preventive maintenance policy is justified only when the average downtime and its cost is less than the average time taken to carry out breakdown repairs;

Answer:

a) F; b) T; c) F; d) F; e) T; f) T;

4. Write down the objectives of maintenance.

Answer:

- To keep all the production facilities and other allied facilities such as building and premises, power supply system, etc in an optimum working condition;
- To ensure specified accuracy to products and time schedule of delivery to customers;
- To keep the down time of the machine at minimum, so that the production program is not disturbed;
- To keep the production cycle within the stipulated range;
- To modify the machine tools to meet the augmented need for production;
- To improve productivity of existing machine tools and to avoid sinking of additional capital;
- To keep the maintenance cost at a minimum as far as possible, thereby keeping the factory Overheads at minimum;
- To extend the useful life of plant and machinery, without sacrificing the level of performance;

5. What are the requirements for getting full benefits of effective maintenance?

Answer:

- Good Supervision and administration of maintenance department;
- Good and clear instructions to be given to maintenance crew regarding the repair;
- Proper control of work in coordination with production department;
- Good training should be given to the maintenance personnel;
- Good scheduled maintenance program should be chalked out;
- Proper maintenance record keeping is a must;
- There should be adequate stock of spare parts, particularly insurance spares;

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6. Assume the following three breakdown probability distribution

Month following Maintenance	Probability of Breakdown		
	(1)	(2)	(3)
1	0.5	0.1	0.1
2	0.1	0.1	0.1
3	0.1	0.1	0.5
4	0.1	0.1	0.1
5	0.1	0.2	0.1
6	0.1	0.4	0.1

Which, if any, of these distributions lend themselves to a preventive maintenance program? Why?

Answer:

Policy 1:

Month following Maintenance (i)	Probability of Breakdown (p)	Average free run time (i* p)
1	0.5	0.5
2	0.1	0.2
3	0.1	0.3
4	0.1	0.4
5	0.1	0.5
6	0.1	0.6
		$\Sigma 2.5 \text{ months/breakdown/machine}$

Therefore the average number of breakdowns for the pool of say 100 machines per month will be:

For 1 machine in 2.5 months 1 breakdown

So for 1 machine in 1 month (1/2.5) breakdown

So for 100 machines in 1 month (100/2.5) = 40 breakdowns

Policy 2:

Month following Maintenance (i)	Probability of Breakdown (p)	Average free run time (i* p)
1	0.1	0.1
2	0.1	0.2
3	0.1	0.3
4	0.1	0.4
5	0.2	1.0
6	0.4	2.4
		$\Sigma 4.4 \text{ months/breakdown/machine}$

Therefore the average number of breakdowns for the pool of say 100 machines per month will be:

For 1 machine in 4.4 months 1 breakdown

So for 1 machine in 1 month (1/4.4) breakdown

So for 100 machines in 1 month (100/4.4) = 22.73 breakdowns

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Policy 3:

Month following Maintenance (i)	Probability of Breakdown (p)	Average free run time (i* p)
1	0.1	0.1
2	0.1	0.2
3	0.5	1.5
4	0.1	0.4
5	0.1	0.5
6	0.1	0.6
		$\Sigma 3.3 \text{ months/breakdown/machine}$

Therefore the average number of breakdowns for the pool of say 100 machines per month will be:

For 1 machine in 3.3 months 1 breakdown

So for 1 machine in 1 month (1/3.3) breakdown

So for 100 machines in 1 month (100/3.3) = 30.30 breakdowns

Preventive maintenance programs are generally applicable to breakdown distributions with low variability. Policy 2 has the lowest variability as no of breakdowns in a month for a pool of say 100 machines are 22.73---the lowest among three policies.

Therefore we may conclude that policy 2 could lead to a preventive maintenance program.

7. **Refer Q6. Let us take Average Repair Cost on breakdown $C_R = ₹90$ & Cost of Preventive maintenance $C_{PM} = ₹30$**

Could you prove your conclusion given in Answer 6 for a pool of 100 machines?

Answer:

Repair Policy Cost of Policy 1 = Average number of repairs per month X Average repair cost on breakdown = $40 \times 90 = ₹3600$



Data taken from Answer 6.

Preventive Maintenance Costs for the Six Preventive Maintenance Cycles: Table-I

Preventive Maintenance Cycle (n), months	Expected Breakdowns in PM Cycle	Average No of Breakdowns per month (Col.2/Col.1)	Expected Monthly Breakdown Cost (Col.3 x ₹90)	Expected Monthly PM Cost (₹30 x 100)/ Col.1	Expected Monthly Cost of each PM cycle (Col.4 + Col.5)
1	50	50	4500	3000	7500
2	85	42.5	3825	1500	5325
3	117.5	39.17	3525.3	1000	4525.3
4	152.25	38.06	3425.4	750	4175.4
5	191.38	38.28	3445.2	600	4045.2
6	236.16	39.36	3542.4	500	4042.4

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Computation of Col.2:

Month 1: $100 \times 0.5 = 50$

Month2: $100 \times (0.5 + 0.1) + 50 \times 0.5 = 85$

Month3: $100 \times (0.5 + 0.1 + 0.1) + 50 \times 0.1 + 85 \times 0.5 = 117.5$

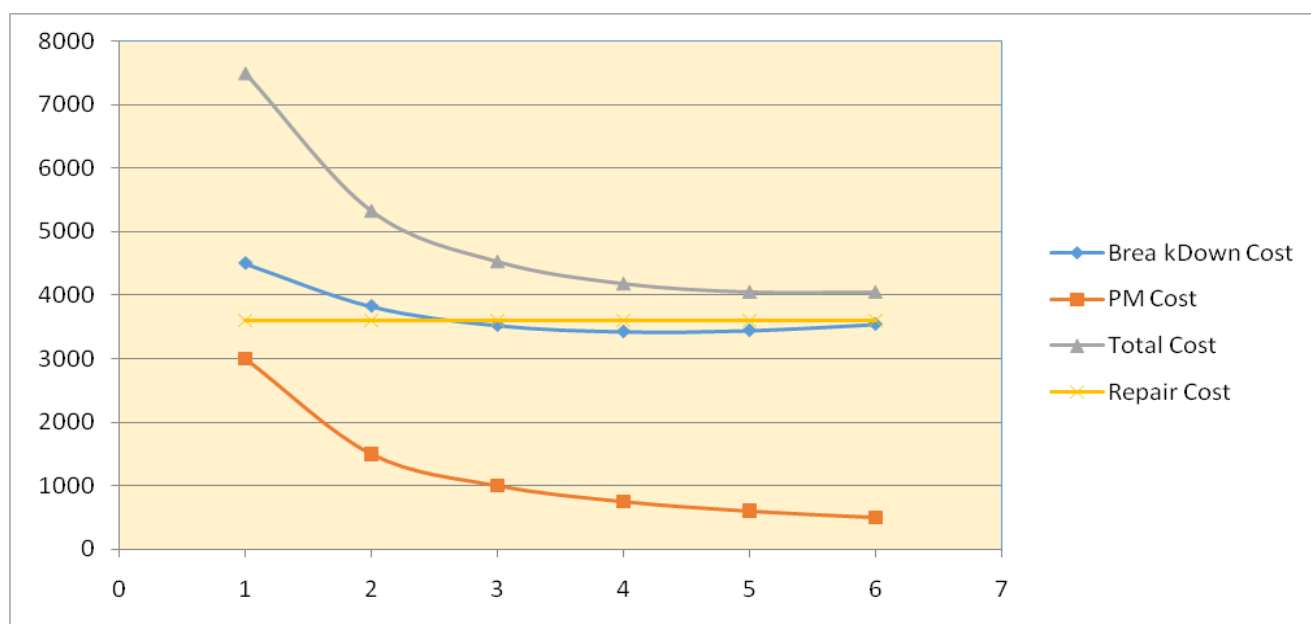
Month4: $100 \times (0.5 + 0.1 + 0.1 + 0.1) + 50 \times 0.1 + 85 \times 0.1 + 117.5 \times 0.5 = 152.25$

Month5: $100 \times (0.5 + 0.1 + 0.1 + 0.1 + 0.1) + 50 \times 0.1 + 85 \times 0.1 + 117.5 \times 0.1 + 152.25 \times 0.5 = 191.38$

Month6: $100 \times (0.5 + 0.1 + 0.1 + 0.1 + 0.1 + 0.1) + 50 \times 0.1 + 85 \times 0.1 + 117.5 \times 0.1 + 152.25 \times 0.1 + 191.38 \times 0.5 = 236.16$

Graphical Representation Policy 1:

Fig-I



Repair Policy Cost of Policy 2 = Average number of repairs per month X Average repair cost on breakdown = $22.73 \times 90 = ₹2045.7$



Data taken from Answer 6.

Preventive Maintenance Costs for the Six Preventive Maintenance Cycles

Preventive Maintenance Cycle (n), months	Expected Breakdowns in PM Cycle	Average No of Breakdowns per month (Col.2/Col.1)	Expected Monthly Breakdown Cost (Col.3 x ₹90)	Expected Monthly PM Cost (₹30 x 100)/ Col.1	Expected Monthly Cost of each PM cycle (Col. 4 + Col.5)
1	10	10	900	3000	3900
2	21	10.5	945	1500	2445
3	33.1	11.03	992.7	1000	1992.7
4	46.41	11.60	1044	750	1794
5	71.05	14.21	1278.9	600	1878.9
6	119.16	19.86	1787.4	500	2287.4

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Computation of Col.2:

Month 1: $100 \times 0.1 = 10$

Month2: $100 \times (0.1 + 0.1) + 10 \times 0.1 = 21$

Month3: $100 \times (0.1 + 0.1 + 0.1) + 10 \times 0.1 + 21 \times 0.1 = 33.1$

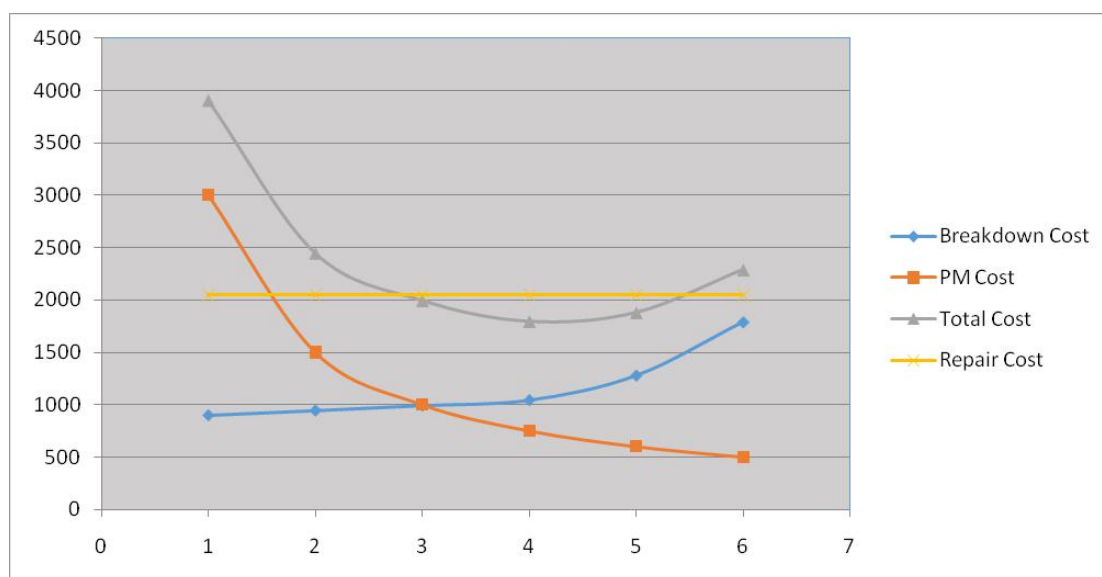
Month4: $100 \times (0.1 + 0.1 + 0.1 + 0.1) + 10 \times 0.1 + 21 \times 0.1 + 33.1 \times 0.1 = 46.41$

Month5: $100 \times (0.2 + 0.1 + 0.1 + 0.1 + 0.1) + 10 \times 0.1 + 21 \times 0.1 + 33.1 \times 0.1 + 46.41 \times 0.1 = 71.05$

Month6: $100 \times (0.4 + 0.2 + 0.1 + 0.1 + 0.1 + 0.1) + 10 \times 0.2 + 21 \times 0.1 + 33.1 \times 0.1 + 46.41 \times 0.1 + 71.05 \times 0.1 = 119.16$

Graphical Representation Policy 2:

Fig-II



Repair Policy Cost of Policy 3 = Average number of repairs per month X Average repair cost on breakdown = $30.30 \times 90 = ₹ 2727$



Data taken from Answer 6.

Preventive Maintenance Costs for the Six Preventive Maintenance Cycles

Preventive Maintenance Cycle (n) , months	Expected Breakdowns in PM Cycle	Average No of Breakdowns per month (Col.2/Col.1)	Expected Monthly Breakdown Cost (Col.3 x ₹90)	Expected Monthly PM Cost (₹30 x 100)/ Col.1	Expected Monthly Cost of each PM cycle (Col.4 + Col.5)
1	10	10	900	3000	3900
2	21	10.5	945	1500	2445
3	73.1	24.37	2193.3	1000	3193.3
4	94.41	23.60	2124	750	2874
5	118.25	23.65	2128.5	600	2728.5
6	160.92	26.82	2413.8	500	2913.8

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Computation of Col.2:

Month 1: $100 \times 0.1 = 10$

Month2: $100 \times (0.1 + 0.1) + 10 \times 0.1 = 21$

Month3: $100 \times (0.5 + 0.1 + 0.1) + 10 \times 0.1 + 21 \times 0.1 = 73.1$

Month4: $100 \times (0.1 + 0.5 + 0.1 + 0.1) + 10 \times 0.5 + 21 \times 0.1 + 73.1 \times 0.1 = 94.41$

Month5: $100 \times (0.1 + 0.1 + 0.5 + 0.1 + 0.1) + 10 \times 0.1 + 21 \times 0.5 + 73.1 \times 0.1 + 94.41 \times 0.1 = 118.25$

Month6: $100 \times (0.1 + 0.1 + 0.1 + 0.5 + 0.1 + 0.1) + 10 \times 0.1 + 21 \times 0.1 + 73.1 \times 0.5 + 94.41 \times 0.1 + 118.25 \times 0.1 = 160.92$

Graphical Representation Policy 3:

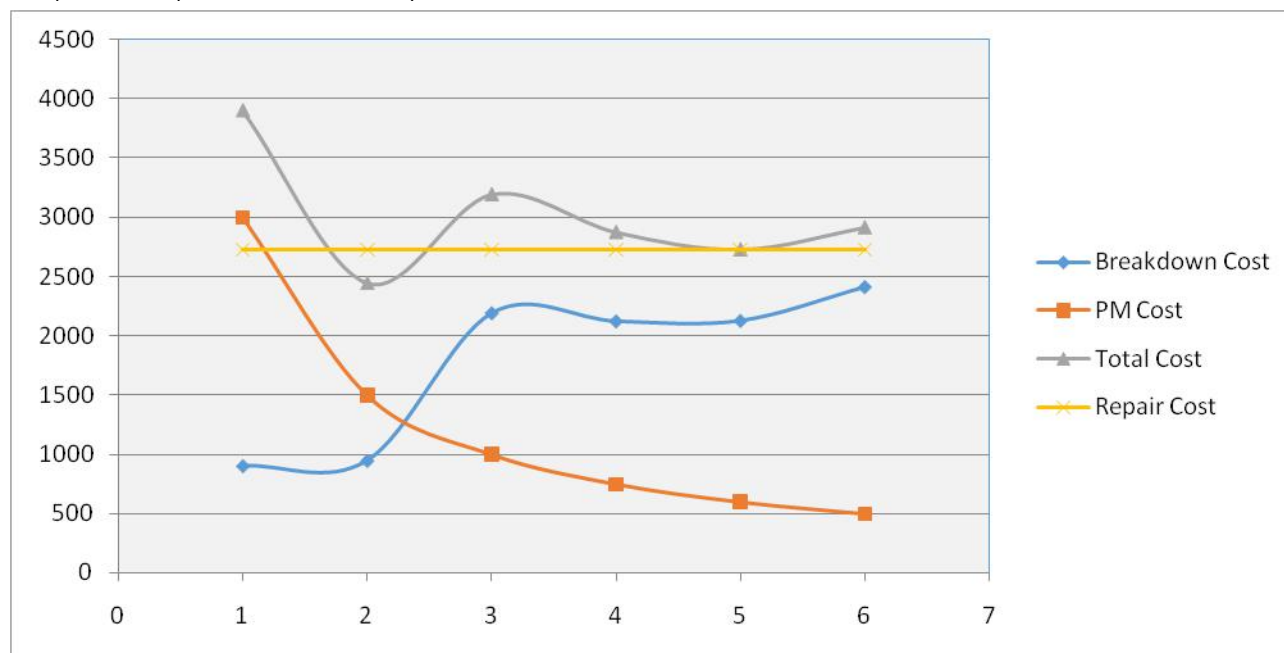


Fig-III

If we refer three graphs it is clear that –

Under Policy 1 (Fig –I) Repair cost ₹3600 is always less than cost of all PM cycles -Refer Col.6 of Table-I. Therefore if breakdown probability distribution is like under Policy 1, management will opt for policy of repairing machine when it breaks down.

Under Policy 2 (Fig –II) PM cycle of 4 months with the cost of ₹ 1794 -Refer Col. 6, Row 4 of Table-II, is less than Repair cost ₹2045.7. Therefore if breakdown probability distribution is like under Policy 2, management will opt for PM policy of 4 months instead of going for policy of repairing machine when it breaks down. This way management can save ₹ 251.7

On similar logic under policy 3 PM is preferable to Repair as and when required policy. But in comparison to policy 2, policy 3 is inferior as

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Repair cost under policy 2- ₹ 2045.7 < Repair cost under policy 3- ₹ 2727

PM policy Cost under policy 2- ₹ 1794 < PM policy Cost under policy 3- ₹ 2445

The decision concerning preventive maintenance versus Repair depends on i) factor costs C_R and C_{PM}
ii) the breakdown probability distribution; besides other sensitivities.

8. Choose the appropriate answer

a) Option to deal with breakdown or other problems when they occur is associated with

- i) Preventive maintenance;
- ii) Spare parts maintenance;
- iii) Breakdown maintenance;
- iv) Replacements;

b) Managers usually schedule preventive maintenance using

- i) The result of planned inspections that reveal a need for maintenance;
- ii) The calendar (passage of time);
- iii) A predetermined number of operating hours as base;
- iv) A combination of all the above;

c) Availability of a system is

- i) The probability that the system will be capable of rendering adequate performance during certain period;
- ii) The certainty that the system will be capable of rendering adequate performance at randomly selected time;
- iii) The probability that the system will be capable of rendering adequate performance at randomly selected time;
- iv) The probability that the system will be capable of rendering adequate performance with lowest mean time requirement for maintenance;

d) Maintainability of a system is

- i) The probability that the system can be restored to operational effectiveness within a given period with prescribed maintenance procedures;
- ii) The probability that the system can be restored to operational effectiveness within a randomly selected time period with prescribed maintenance procedures;
- iii) The probability that the system can be restored to operational effectiveness within a randomly selected time period with or without prescribed maintenance procedures;
- iv) The certainty that the system can be maintained at optimal cost of maintenance with prescribed maintenance procedures;

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e) Reliability of a product is

- The probability of its successful performance over a specific period of usage under specified conditions;
- The probability of its successful performance over a specific period of usage under any conditions;
- The probability of its reasonable performance over a specific period of usage under specified conditions;
- The probability of its useful performance over a specific period of usage under simulated conditions

Answer:

a)/i, b)/iv, c)/iii, d)/I, e)/i

9. The probability that equipment used in a hospital lab will need recalibration is given in the following table. A service firm is willing to provide maintenance and provide any necessary calibration for a fee of ₹600 per month. Recalibration costs ₹300 per time. Which approach would be most cost effective, recalibration as needed or the service contract?

Number of recalibration	0	1	2	3	4
Probability of occurrence	0.15	0.05	0.40	0.23	0.17

Answer:

Number of recalibration	Probability of occurrence	Expected Number of Recalibrations
0	0.15	0
1	0.05	0.05
2	0.40	0.80
3	0.23	0.69
4	0.17	0.68
	1.00	2.22

So expected cost of recalibration = $2.22 \times 300 = ₹666/\text{month}$

Service contract ₹600/month

So service contract is cost effective

10. The simple engineering company has a machine whose purchase price is ₹80000. the expected maintenance costs and resale price in different years are as given below:

Year	1	2	3	4	5	6	7
Maintenance Cost (₹)	1000	1200	1600	2400	3000	3900	5000
Resale Value ('000 ₹)	75	72	70	65	58	50	45

After what time interval should the machine be replaced?

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Answer:

Year	Maintenance Cost	Cumulative Maintenance Cost	Purchase Price-Resale value	Column (iii) + Column (iv)	Column (v)/n
1	1000	1000	5000	6000	6000
2	1200	2200	8000	10200	5100
3	1600	3800	10000	13800	4600
4	2400	6200	15000	21200	5300
5	3000	9200	22000	31200	6240
6	3900	13100	30000	43100	7183
7	5000	18100	35000	53100	7586

Here minimum cost is ₹4600 for n =3years. The machine should therefore be replaced in every three years

11. Match Column A with Column B

Column A	Column B
a) Maintenance Spares	i) Are high reliability spares and have relatively higher purchase cost than the breakdown spares;
b) Insurance Spares	ii) Provide a guard against the relatively remotely possible breakdown or failure of an equipment/component;
c) Capital Spares	iii) Resemble the regular inventory items in their consumption patterns;
d) Rotable Spares	iv) have more than one life;

Answer:

a)/iii, b)/ii, c)/i, d)/iv

12. Say True or False

- An insurance product is to be procured only if the expected value of the down time costs exceeds or equals the purchase value of the spare;
- On an average the reliability of Breakdown spares for a machinery has been observed to be as high 95 to 99% over the life span of the machinery;
- The objective of maintenance is to facilitate the optimal use of capital equipment through replacement;
- In maintenance hyper exponential distribution shows a steep fall in the probability density function as the time to failure increases;
- Reliability of a plant depends upon the design of the plant system that is the way various equipment are linked functionally with each other;

Answer:

a)/T, b)/F, c)/F, d)/T, e)/T



Study Note – 8

STRATEGIC MANAGEMENT - INTRODUCTION

Learning Objective: *Strategic management is the continuous planning, monitoring, analysis and assessment of all that is necessary for an organization to meet its goals and objectives.*

1. Explain the phases of strategic management.

Answer:

As managers attempt to better deal with the changing world, a firm generally evolves through the following four phases of strategic management.

Phase 1- Basic financial planning: Managers initiate serious planning when they are requested to propose the following year's budget. Projects are proposed on the basis of very little analysis, with most information coming from within the firm. The sales force usually provides the small amount of environmental information. Such simplistic operational planning only pretends to be strategic management, yet it is quite time consuming. Normal company activities are often suspended for weeks while managers try to cram ideas into the proposed budget. The time horizon is usually one year.

Phase 2- Forecast-based planning: As annual budgets become less useful at stimulating long term planning, managers attempt to propose five-year plans. At this point they consider projects that may take more than a year. In addition to internal information, managers gather any available environmental data and extrapolate current trends five years into the future. The phase is also time consuming, often involving a full month of managerial activity to make sure all the proposed budgets fit together. The process gets very political as managers compete for larger shares of funds. The time horizon is usually three to five years.

Phase 3- Externally oriented (strategic) planning: Frustrated with highly political yet ineffectual five –year plans, top management takes control of the planning process by initiating strategic planning. The company seeks to increase its responsiveness to changing markets and competition by thinking strategically. Planning is taken out of the hands of lower level managers and concentrated in a planning staff whose task is to develop strategic plans for the corporation. Consultants often provide the sophisticated and innovative techniques that the planning staff uses to gather information and forecast future needs. Such top down planning emphasises formal strategy formulation and leaves the implementation issues to lower management levels.

Phase 4 – Strategic Management: Realising that even best strategic plans are worthless without the input and commitment of lower-level managers, top management forms planning group of managers and key employees at many levels, from various departments and work groups. They develop and integrate a series of strategic plans aimed at achieving the company's primary objectives. Strategic

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plans at this point detail the implementation, evaluation and control issues. Rather than attempting to perfectly forecast the future, the plans emphasise probable scenarios and contingency strategies. The sophisticated five year strategy plan is replaced with strategic thinking at all levels of the organisation throughout the year. Strategic information, previously available centrally to top management, is available via local area networks and intranets to people throughout the organisation. Instead of a large centralised planning staff, internal and external planning consultants are available to help guide group strategy discussions. Although top management may still initiate strategic planning process, the resulting strategies may come from anywhere in the organisation. Planning is typically interactive across levels and no longer top down. People at all levels are now involved.

2. What do you mean by a learning organisation?

Answer:

A learning organisation is an organisation skilled at creating, acquiring, and transferring knowledge and at modifying its behaviour to reflect new knowledge and insights. Organisational learning is a critical component of competitiveness in a dynamic environment. It is particularly important in innovation and new product development.

3. What is environmental scanning?

Answer:

It is the monitoring, evaluating and disseminating of information from the external and internal environments to key people within the corporation. Its purpose is to identify the strategic factors. The simplest way to conduct environmental scanning is through SWOT analysis.

4. Explain procedures.

Answer:

It is sometimes termed as Standard Operating Procedures (SOP), are a system of sequential steps or techniques that describe in detail how a particular task or job is to be done. They typically detail the various activities that must be carried out in order to complete the corporation's program.

5. What is meant by a triggering event? Give some examples.

Answer:

A triggering event is something that acts as a stimulus for change in strategy. Some possible triggering events are new CEO, external intervention, threat of a change in ownership, performance gap, strategic inflection point, etc. A strategic inflection point is what happens to a business when a major change takes place due to the introduction of new technologies, a different regulatory environment, a change in customer's values, or a change in what the customers prefer.

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6. Fill in the blanks with the appropriate word(s).
- a. _____ is something that acts as a stimulus for change in strategy.
 - b. A system of sequential steps or techniques that describe in detail how a particular task or job is to be done is called _____.
 - c. The monitoring, evaluating and disseminating of information from the external and internal environments to key people within the corporation is called _____.
 - d. A _____ is an organisation skilled at creating, acquiring, and transferring knowledge and at modifying its behaviour to reflect new knowledge and insights.
 - e. _____ is sometimes termed as Standard Operating Procedures.
 - f. A _____ is a statement of the activities or steps needed to support a strategy.
 - g. A _____ is a broad guideline for decision making that links the formulation of a strategy with its implementation.
 - h. A _____ mission statement also assists companies in capitalizing on changes in their environment.
 - i. A _____ business definition focuses on the characteristics of the products sold and the markets served.
 - j. Well conceived visions are _____ and _____ to a particular organisation.
 - k. The _____ is concerned with the impact on strategy of the external environment, internal resources and competences, and the expectations and influence of stakeholders.
 - l. _____ involve understanding the underlying bases for future strategy at both the corporate and business unit levels.
 - m. Strategy into _____ is concerned with ensuring that strategies are working in practice.
 - n. _____ is routinised, operationally specific and has short term implications.
 - o. Unplanned responses to unforeseen circumstances are called _____.
 - p. Matching the resources and activities to the environment in which it operates is sometimes known as the search of _____.
 - q. The strategy that does not come about in practice or only partially so is called _____.
 - r. _____ an expression of interest of desired strategic direction deliberately formulated or planned by managers.

Answers:

- a. triggering event
- b. procedures
- c. environmental scanning
- d. learning organisation
- e. Procedures
- f. Program
- g. Policy
- h. customer-oriented
- i. product-oriented
- j. distinctive, specific
- k. strategic position
- l. Strategic choices
- m. Action
- n. Operational management
- o. Emergent strategy
- p. strategic fit
- q. unrealised strategy
- r. Intended strategy

Study Note – 9

STRATEGIC ANALYSIS AND STRATEGIC PLANNING

Learning Objective: *Strategic management is the comprehensive collection of ongoing activities and processes that organizations use to systematically coordinate and align resources and actions with mission, vision and strategy throughout an organization. Strategic management activities transform the static plan into a system that provides strategic performance feedback to decision making and enables the plan to evolve and grow as requirements and other circumstances change.*

A strategic plan is a document used to communicate with the organization the organizations goals, the actions needed to achieve those goals and all of the other critical elements developed during the planning exercise.

1. What do you understand by Cross Border Acquisitions?

Answer:

Acquisitions made between companies with headquarters in different countries are called cross – border acquisitions. Example of cross border acquisition is the purchase of UK carmakers Jaguar Land Rover by India's Tata Motors.

2. Why more and more Indian companies are going for cross – border acquisitions?

Answer:

Firms headquartered in India are completing more and more cross – border acquisitions than in the past largely because of weakening US dollar and more favourable government policies toward cross – border acquisitions. This will make Indian companies global powerhouses.

In addition to rapid market entry, Indian companies seek access to product innovation capabilities and new brands and distribution channels when acquiring firms outside their domestic market.

3. What are the problems in achieving acquisition success?

Answer:

The following are some of the reasons that could come in the way of achieving acquisition success:

a. Integration Difficulties

Integrating two companies following an acquisition can be quite difficult. Blending two corporate cultures, linking different financial and control systems, building effective working relationships and resolving problems regarding the status of the newly acquired firm's executives are examples of integration challenges firms often face.

b. Inadequate Evaluation of Target

The failure to complete an effective due diligence process may easily result in the acquiring firm paying an excessive premium for the target company. Due diligence refers to a process through which a potential acquirer evaluates a target firm for acquisition. In an effective due diligence process, hundreds of items are examined in areas as diverse as financing for the intended transaction, differences in cultures between the acquiring and target firm, tax consequences of the transaction and actions that would be necessary to successfully meld the two workforces.

c. Large or extraordinary debt

Firms using an acquisition strategy must be certain that their purchases do not create a debt load that overpowers the company's ability to remain solvent. It is often observed that in order to finance acquisitions, some companies significantly increased their levels of debt. High debt can have several negative effects on the firm such as increases the likelihood of bankruptcy, lead to downgrade in the firm's credit rating. In other instances, a firm may have to divest some assets to relieve its debt burden, or even go back on the merger.

d. Inability to Achieve Synergy

Synergy exists when assets are worth more when used in conjunction with each other when they are used separately. Synergy is created by the efficiencies derived from economies of scale and economies of scope and by sharing resources across the businesses in the merge firm. A firm develops a competitive advantage through an acquisition strategy only when a transaction generates private synergy. Private synergy is created when combining and integrating the acquiring and the acquired firms assets yield capabilities and core competencies that could not be developed by combining and integrating either firm's assets with another company. A firm's ability to account for costs that are necessary to create anticipated revenue- and cost –based synergies affects its efforts to create private synergy. Firms experience several expenses when trying to create private synergy through acquisitions. The high cost of acquisition at times results in inability of firm's to create private synergy.

e. Too Much Diversification

Diversification strategies can lead to strategic competitiveness and above average returns. At some point, firms can become over-diversified. The level at which over diversification occurs varies across companies because each firm has different capabilities to manage diversification. Over diversification leads to decline in performance leading to business units often divested.

f. Managers Overly Focused on Acquisitions

Company experiences show that participating in and overseeing the activities required for making acquisitions can divert managerial attention from other matters that are necessary for long-term competitive success, such as identifying and taking advantage of other opportunities and interacting with important external stakeholders. Managers tend to be more involved in the process of making, acquisitions largely because of the thrill of selecting, chasing and seizing a target.

g. Too large

Most acquisitions create a larger firm, which should help increase its economies of scale. These economies of scale can lead to more efficient operations. Many firms seek increases in size because of the potential economies of scale and enhanced market power. At some level, the additional costs required to manage the larger firm will exceed the benefits of the economies of scale and additional market power, often referred as diseconomies of scale. The complexities generated by the larger size often lead managers to implement more bureaucratic controls to manage the combined firm's operations. This leads to diminished flexibility and standardised managerial behaviour. The scope of innovation is less when such bureaucratic controls exist.

4. Distinguish between downsizing and downscoping.

Answer:

Downsizing is a reduction in the number of firm's employees and, sometimes, in the number of its operating units, but it may or may not change the composition of businesses in the company's portfolio. Downsizing is often a part of acquisitions that fail to create the value anticipated when the transaction was completed. Downsizing is often used when the acquiring firm paid too high of a premium to acquire the target firm. Once thought to be an indicator of organisational decline, downsizing is now recognised as a legitimate restructuring strategy. Managers should remember that as a strategy, downsizing will be far more effective when they consistently use human resource practices that ensure procedural justice and fairness in downsizing decisions.

Downscoping refers to divestiture, spin off, or some other means of eliminating businesses that are unrelated to the firm's core businesses. Downscoping has a more positive effect on firm performance than does downsizing because firms commonly find that downscoping causes them to refocus on their core business. Managerial effectiveness increases because the firm has become less diversified, allowing the top management team to better understand and manage the remaining businesses.

Firms often use the downscoping and downsizing strategies simultaneously. However, when doing this, firms avoid layoffs of key employees, in that such layoffs might lead to a loss of one or more core competencies. Instead, a firm that is simultaneously downscoping and downsizing becomes smaller by reducing the diversity of businesses in its portfolio. Generally, the downscoping and downsizing releases funds to be used in their core business to strengthen it.

5. What is meant by leveraged buyouts?

Answer:

A leveraged buyout (LBO) is a restructuring strategy whereby a party (typically a private equity firm) buys all of a firm's assets in order to take the firm private. Once the transaction is completed, the company's stock is no longer traded publicly. Traditionally, leveraged buyouts were used as a restructuring strategy to correct for managerial mistakes or because the firm's managers were making decisions that primarily served their own interests rather than those of shareholders. However, some firms use buyouts to build firm resources and expand rather than simply restructure distressed assets.

Significant amounts of debt are commonly incurred to finance a buyout, hence, the term leveraged buyout. To support debt payments and to downscope the company to concentrate on firm's core businesses, the owners may immediately sell a number of assets. It is not uncommon for those buying a firm through an LBO to restructure the firm to the point that it can be sold at a profit within a five to eight year period. Leveraged buyouts have not been popular in India.

6. What are the different types of leveraged buyouts?

Answer:

Management buyouts (MBOs), employee buyouts (EBOs) and whole firm buyouts, in which one company or partnership purchase an entire company instead of a part of it, are the three types of LBOs.

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7. Fill in the blanks with the appropriate word(s).

- a. A _____ is a restructuring strategy whereby a party (typically a private equity firm) buys all of a firm's assets in order to take the firm private.
- b. _____ refers to divestiture, spin off, or some other means of eliminating businesses that are unrelated to the firm's core businesses.
- c. _____ is a reduction in the number of firm's employees and, sometimes, in the number of its operating units.
- d. Acquisitions made between companies with headquarters in different countries are called _____.
- e. Diversification strategy can be broadly classified into _____ diversification and _____ diversification.
- f. _____ is a corporate level strategy that is based on development beyond current products and markets, but within the value system or 'industry' in which it operates.
- g. _____ diversification is a corporate level strategy based on multi business model whose goal is to increase profitability through the use of generic organisational competences.
- h. _____ is a process of entering new industries, distinct from a company's core or original industry.
- i. Forces likely to affect the structure of an industry, sector or market are called _____.
- j. _____ are companies that sell products that add value to the products of companies in industry because when used together, the products better satisfy customer demands.
- k. _____ substitution occurs where products or services compete for disposable income.
- l. _____ refer to the products of different businesses or industries that can satisfy similar customer needs.
- m. The _____ refers to the ability of suppliers to raise input prices or to raise the costs of the industry in other ways.
- n. The _____ refers to the ability of buyers to bargain down prices charged by companies in the industry.
- o. Competitive _____ are organisations with similar products and services aimed at the same customer group.
- p. _____ exists when assets are worth more when used in conjunction with each other when they are used separately.
- q. _____ can lead to strategic competitiveness and above average returns.

Answers:

- a. leveraged buyout
- b. Downscoping
- c. Downsizing
- d. cross – border acquisitions
- e. related (concentric), unrelated (conglomerate)
- f. Related (concentric) diversification
- g. Unrelated (conglomerate)
- h. Diversification strategy
- i. Structural Drivers of Change
- j. Complementors
- k. Generic
- l. Substitute products
- m. bargaining power of the suppliers
- n. bargaining power of the buyers
- o. rivals
- p. Synergy
- q. Diversification strategies

Study Note – 10

FORMULATION AND IMPLEMENTATION OF STRATEGY

Learning Objective: *Strategy Formulation includes planning and decision-making involved in developing organization's strategic goals and plans. Strategy Formulation is placing the Forces before the action. In short, Strategy Implementation is managing forces during the action.*

1. What is organisational structure?

Answer:

Organisational structure specifies the firm's formal reporting relationships, procedures, controls and authority and decision making processes.

2. Explain the importance of organisational structure on the organisation's effectiveness.

Answer:

Developing an organisational structure that effectively supports the firm's strategy is difficult, especially because of the uncertainty or unpredictable variation) about cause-effect relationships in the global economy's rapidly changing, and dynamic competitive environment. When the structure's elements are properly aligned with one another, the structure facilitates effective use of the firm's strategies. A firm's structure specifies the work to be done and how to do it, given the firm's strategy or strategies. Thus, organisational structure influences how managers work and the decisions resulting from that work. Thus, organisational structure is a critical component of effective strategy implementation processes.

3. Distinguish between structural stability and structural flexibility.

Answer:

Structural stability provides the capacity the firm requires to consistently and predictably manage its daily work routines.

Structural flexibility provides the opportunity to explore competitive possibilities and then allocate resources to activities that will shape the competitive advantages the firm will need to be successful in the future. An effectively flexible organisational structure allows the firm to exploit current competitive advantage while developing new ones that can potentially be used in the future.

4. Explain the different types of organisational structure.

Answer:

Firms choose from among three major types of organisational structures namely, simple, functional and multidivisional structures to implement strategies.

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Simple structure

The simple structure is a structure in which the owner- manager makes all major decisions and monitors all activities while the staffs serves as an extension of the manager's supervisory authority. Typically, the owner manager actively works in the business on a daily basis. Local restaurants, repair businesses and other specialised enterprises are examples of firms using the simple structure.

Functional structure

It consists of a chief executive officer and a limited corporate staff, with functional line managers in dominant organisational areas such as production, accounting, marketing, R&D, engineering and human resources. This structure allows functional specialisation, thereby facilitating active sharing of knowledge within each functional area. The functional structure supports implementing business level strategies and some corporate level strategies with low levels of diversification. When changing from a simple to a functional structure, firms want to avoid introducing value destroying bureaucratic procedures, particularly those failing to promote innovation and creativity.

Multidivisional Structure (M-form)

With continuing growth and success, firms often consider greater levels of diversification. Successfully using a diversification strategy requires analysing substantially greater amounts of data and information when the firm offers the same production in different markets or offers different products in several markets. In addition, trying to manage high levels of diversification through functional creates serious coordination and control problems, a fact that commonly leads to a new structural form. The multidivisional structure consists of a corporate office and operating divisions, each operating division representing a separate business or profit center in which the top corporate officer delegates responsibilities for day-to- day operations and business unit strategy to division managers.

5. How is strategy and structure related to one other?

Answer:

Strategy and structure have a reciprocal relationship. This relationship highlights the interconnectedness between strategy formulation and strategy implementation. In general, this reciprocal relationship finds structure flowing from or following selection of the firm's strategy. Once in place though, structure can influence current strategic actions as well as choices about future strategies. The general nature of the strategy/structure relationship means that changes to the firm's strategy create the need to change how the organisation completes its work. Regardless of the strength of the reciprocal relationship between strategy and structure, those choosing the firm's strategy and structure should be committed to matching each strategy with a structure that provides the stability needed to use current competitive advantages as well as the flexibility required to develop future advantages. Therefore, when changing strategies, the firm should simultaneously consider the structure that will be needed to support use of the new strategy; properly matching strategy and structure can create a competitive advantage.

6. Explain strategic network.

Answer:

A strategic network is a group of firms that has been formed to create value by participating in multiple cooperative arrangements. An effective strategic network facilitates discovering opportunities beyond those identified by individual network participants. A strategic network can be a source of competitive advantage for its members when its operations create value that is difficult for competitors to duplicate and that network members can't create by themselves. Strategic networks are used to implement business-level, corporate level and international cooperative strategies.

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7. What is strategic center firm? What are the primary tasks of strategic center firm?

Answer:

A strategic network is a loose federation of partners participating in the network's operations on a flexible basis. At the core or center of the strategic network, the strategic center firm is one around which the network's cooperative relationships revolve. Because of its central position, the strategic center firm is the foundation for the strategic network's structure. Concerned with various aspects of organisational structure, such as formal reporting, relationships and procedures, the strategic center firm manages what are often complex, cooperative interactions among network partners. To perform the tasks, the strategic center firm must make sure that incentives for participating in the network are aligned so that network firms continue to have a reason to remain connected. At the strategic center firm is engaged in the following four primary tasks as it manages the strategic network and controls its operations.

a. Strategic outsourcing

The strategic center firm outsources and partners with more firms than other network members. At the same time, the strategic center firm requires network partners to be more than contractors. Members are expected to find opportunities for the network to create value through its cooperative work.

b. Competencies

To increase network effectiveness, the strategic center firm seeks ways to support each member's efforts to develop core competencies with the potential of benefiting the network.

c. Technology

The strategic center firm is responsible for managing the development and sharing of technology based ideas among network members. The structural requirement that members submit formal reports detailing the technology oriented outcomes of their efforts to strategic center firm facilitates this activity.

d. Race to learn

The strategic center firm emphasises that the principal dimensions of competition are between value chains and between networks of value chains. Because of this interconnection, the strategic network is only as strong as its weakest value-chain link. With its centralised decision making authority and responsibility, the strategic center firm guides participants in efforts to form network-specific competitive advantages. The need for each participant to have capabilities that can be the foundation for network's competitive advantages encourages friendly rivalry among participants seeking to develop the skills needed to quickly form new capabilities that create value for the network.

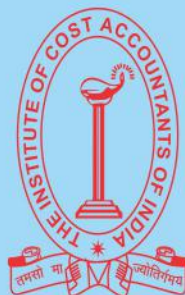
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8. Fill in the blanks with the appropriate word(s).

- a. A _____ is a loose federation of partners participating in the network's operations on a flexible basis.
- b. Information technology is a form of both _____ and _____.
- c. _____ are activities or processes that critically underpin an organisation's competitive advantage.
- d. _____ are those product features which are particularly valued by a group of customers and, therefore, where the organisation must excel in order to outperform competition.
- e. _____ are fundamental resources of an organisation.
- f. Ohmae's three Cs are _____, _____ and _____.
- g. The _____ firm is responsible for managing the development and sharing of technology based ideas among network members.
- h. A strategic network is a _____ that has been formed to create value by participating in multiple cooperative arrangements.
- i. Strategic networks are used to implement _____, _____ and _____.
- j. _____ and _____ have a reciprocal relationship.
- k. _____ provides the capacity the firm requires to consistently and predictably manage its daily work routines.
- l. _____ provides the opportunity to explore competitive possibilities and then allocate resources to activities.
- m. A structure in which the owner- manager makes all major decisions and monitors all activities while the staffs serves as an extension of the manager's supervisory authority is called a _____.
- n. The three major types of organisational structures to implement strategies are _____, _____ and _____ structures.
- o. _____ specifies the firm's formal reporting relationships, procedures, controls and authority and decision making processes.

Answers:

- a. strategic network
- b. behaviour control, output control
- c. Core competences
- d. Critical Success Factors
- e. Core skills
- f. Customers, competition and corporation
- g. strategic center
- h. group of firms
- i. business-level, corporate level, international cooperative strategies
- j. Strategy, structure
- k. Structural stability
- l. Structural flexibility
- m. Simple structure
- n. simple, functional and multidivisional
- o. Organisational structure



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