

THEORY & OBJECTIVE

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FORECASTING

THEORY

1.1 | FORECASTING

Forecasting means estimation of type, quantity and quality of future works e.g. sales etc. It is a calculated economic analysis.

1.1.1 Basic Elements of Forecasting

- Trends
- Cycles
- Seasonal Variations
- Irregular Variations

1.2 | SALES FORECASTING TECHNIQUES

- Historic Estimation
- Sales Force Estimation
- Trend Line (or Time-series Analysis) Technique
- Market Survey
- Delphi Method
- Judge Mental Techniques
- Prior Knowledge
- Forecasting by Past Average
- Forecasting from Last Period's Sales
- Forecasting by Moving Average
- Forecasting by Weighted Moving Average
- Forecasting by Exponential Smoothing
- Correlation Analysis
- Linear Regression Analysis.

1.2.1 Average Method

Forecast sales for next period = Average sales for previous period

$$F_{t+1} = \frac{S_t + S_{t-1} + \dots + S_1}{t}$$

Where,

F_{t+1} = Forecast sales for next period

S_t, S_{t-1}, \dots, S_1 are sales of t number of periods.

Example:

Period No.	1	2	3	4	5	6
Sales	7	5	9	8	5	8

Forecast sales for Period No

$$F_{6+1} = \frac{7+5+9+8+5+8}{6} = 7$$

1.2.2 Forecast by Moving Average

In this method the forecast is neither influenced by very old data nor does it solely reflect the figures of the previous period.

Example:

Year	Period	Sales	Four-period average forecasting
1987	1	50	
	2	60	
	3	50	
	4	40	
1988	1	50	Forecast for 1988 period $1 = \frac{50+60+50+40}{4} = 50$
	2	55	Forecast for 1988 period $2 = \frac{60+50+40+50}{4} = 50$

1.2.3 Weighted Moving Average

A weighted moving Average allows any weights to be placed on each element, providing of course, that the sum of all weights equals one.

Example:

Period	Sales
Month-1	100
Month-2	90
Month-3	105
Month-4	95
Month-5	110

Forecast (weights 40%, 30%, 20%, 10% of most recent month)

Forecast for month-5 would be:

$$F_5 = 0.4 \times 95 + 0.3 \times 105 + 0.2 \times 90 + 0.1 \times 100 = 97.5$$

Forecast for month-6 would be:

$$F_6 = 0.4 \times 110 + 0.3 \times 95 + 0.2 \times 105 + 0.1 \times 90 = 102.5$$

1.2.4 Exponential Smoothing

New forecast = α (latest sales figure) + (1 - α) (old forecast) [VIMP]

$$F_{t+1} = \alpha d_t + (1 - \alpha) F_t$$

Where,

α is known as the smoothing constant.

The size of α should be chosen in the light of the stability or variability of actual sales, and is normally from 0.1 to 0.3.

The smoothing constant, α , that gives the equivalent of an N-period moving average can be calculated

as follows, $\alpha = \frac{2}{N+1}$

For e.g. if we wish to adopt an exponential smoothing technique equivalent to a nine period moving

average then, $\alpha = \frac{2}{9+1} = 0.2$

Basically, exponential smoothing is an average method and is useful for forecasting one period ahead. In this approach, the most recent past period demand is weighted most heavily. In a continuing manner the weights assigned to successively past period demands decrease according to exponential law.

1.2.5 Generalized Equation

$$F_t = \alpha (1 - \alpha)^0 d_{t-1} + \alpha (1 - \alpha)^1 d_{t-2} + \alpha (1 - \alpha)^2 d_{t-3} + \dots + \alpha (1 - \alpha)^{k-1} d_{t-k} + (1 - \alpha)^k F_{t-k}$$

[Where k is the number of past periods]

It can be seen from above equation that the weights associated with each demand of equation are not equal but rather the successively older demand weights decrease by factor $(1 - \alpha)$. In other words, the successive terms $\alpha (1 - \alpha)^0$, $\alpha (1 - \alpha)^1$, $\alpha (1 - \alpha)^2$, $\alpha (1 - \alpha)^3$ decreases exponentially.

This means that the more recent demands are more heavily weighted than the remote demands.

Exponential smoothing method of Demand Forecasting:

- Demand for the most recent data is given more weightage.
- This method requires only the current demand and forecast demand.
- This method assigns weight to all the previous data.

Regression Analysis:

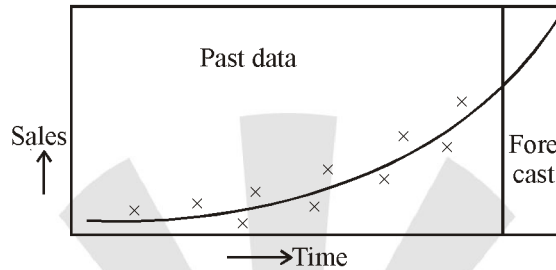
Regression analysis is also known as method of curve fitting. On this method the data on the past sales is plotted against time, and the best curve called the 'Trend line' or 'Regression line' or 'Trend curve'. The forecast is obtained by extrapolating this trend line or curve.

For linear regression

$$y = a + bx$$

$$a = \frac{\sum y - b \sum x}{n}$$

$$b = \frac{n \sum xy - (\sum x)(\sum y)}{n \sum x^2 - (\sum x)^2}$$



$$\text{Standard error} = \sqrt{\frac{\sum (x - y_1)^2}{(n - 2)}}$$

Example: What are moving average and exponential smoothing models for forecasting? A dealership for Honda city cars sells a particular model of the car in various months of the year. Using the moving average method, find the exponential smoothing forecast for the month of October 2010. Take exponential smoothing constant as 0.2:

Jan.	2010	80 cars
Feb.	2010	65 cars
March	2010	90 cars
April	2010	70 cars
May	2010	80 cars
June	2010	100 cars
July	2010	85 cars
Aug.	2010	65 cars
Sept.	2010	75 cars

Solution: (i) **Moving average model for forecasting:** Refer theory part of this book.
 (ii) **Exponential smoothing model for forecasting:** Refer theory part of this book

Months	Sells cars	Forecast demand (n = 3)
Jan.	80	
Feb.	65	
March	90	
April	70	(80 + 65 + 90)/3 = 78.33
May	80	(65 + 90 + 70)/3 = 75

June	100	$(90 + 70 + 80)/3 = 80$
July	85	$(70 + 80 + 100)/3 = 83.33$
Aug.	60	$(80 + 100 + 85)/3 = 88.33$
Sep.	75	$(100 + 85 + 60)/3 = 81.67$

Forecast of oct. by exponential smoothing method

$$F_{\text{Oct}} = F_{\text{Sep}} + \alpha (D_{\text{Sep}} - F_{\text{Sep}})$$

$$\alpha = 0.2 \quad F_{\text{Sep}} = 81.67 \quad D_{\text{Sep}} = 75$$

$$F_{\text{Oct}} = 81.67 + 0.2 (75 - 81.67)$$

$$F_{\text{Oct}} = 80.33 \approx 81$$

Forecast for the month of October using moving average

$$F_{\text{Oct}} = \frac{D_{\text{July}} + D_{\text{Aug}} + D_{\text{Sep}}}{3}$$

$$= \frac{75 + 60 + 80}{3} = 71.67$$

Example: Explain the need for sales forecasting. How are forecasting methods classified?

The past data about the load on a machine centre is as given below:

Month	Load, Machine-Hours
1	585
2	611
3	656
4	748
5	863
6	914
7	964

- (i) If a five month moving average is used to forecast the next month's demand, compute the forecast of the load on the centre in the 8th month.
- (ii) Compute a weighted three month moving average for the 8th month, where the weights are 0.5 for the latest month, 0.3 and 0.2 for the other months, respectively.

Solution: Most organizations are not in a position to wait until orders are received before they begin to determine what production facilities, process, equipment, manpower, or materials are required and in what quantities. Most successful organizations anticipate the future and for their products and translate that information into factor inputs required to satisfy expected demand. Forecasting provides a blue print for managerial planning. Forecasting is the estimation of the future on the basis of the past.

In many organizations, sales forecasts are used to establish production levels, facilitate scheduling, set inventory levels, determine man power loading, make purchasing decisions, establish sales conditions (pricing and advertising) and aid financial planning (cash budgeting and capital budgeting).

A good forecast should have the following attributes. It should be accurate, simple, easy, economical, quick and upto date. Following are the basic steps involved in a systematic demand forecast.

- (i) State objectives
- (ii) Select method
- (iii) Identify variables
- (iv) Arrange data
- (v) Develop relationship
- (vi) Prepare forecast and interpret
- (vii) Forecast in specific units.

(i) Forecast for 8th month on the basis of five month moving average

$$= (964 + 914 + 863 + 748 + 656)/5 = 829$$

(ii) Forecast for 8th month on the basis of weighted average

$$= 0.5 \times 964 + 0.3 \times 914 + 0.2 \times 863 = 928.8$$

Example: (i) List common time-series forecasting models. Explain simple exponential smoothing method of forecasting demand. What are its limitations?

(ii) The monthly forecast and demand values of a firm are given below:

Month	Forecast units	Demand units
Jan	100	97
Feb	100	93
Mar	100	110
Apr	100	98
May	102	130
Jun	104	133
Jul	106	129
Aug	108	138
Sep	110	136
Oct	112	124
Nov	114	139
Dec	116	125

Calculate Tracking Signal for each month. Comment on the forecast model.

Solution: (i) Component of time series models

- (1) Trend (T)
- (2) Cyclic variation (C)
- (3) Seasonal variation (S)
- (4) Random variation (R)

Exponential Smoothing

This is similar to the weighted average method. The recent data is given more weightage and the weightages for the earlier periods are successfully being reduced. Let x_t is the actual (historical) data of demand during the period t . Let \pm is the weightage given for the period t and F_t is the forecast for the time t then forecast for the time $(t + 1)$ will be given as

$$(ii) \text{ Tracking signal} = \frac{\text{Cumulative deviation}}{MAD} = \frac{\sum(x_t - F_t)}{MAD}$$

Where,

MAD = Mean Absolute deviation

$$= \frac{\text{Sum of absolute deviations}}{\text{Total number of datas}} = \frac{\sum(x_t - F_t)}{n}$$

Month	Forecast	Demand	($x_t - F_t$)	MAD		T.S. = $\frac{\sum(x_t - f_t)}{MAD}$
January	100	97	-3	3	-3	-1
February	100	93	-7	5	-10	-2
March	100	110	10	6.67	0	0
April	100	98	-2	5.5	-2	-0.3636
May	102	130	28	10	26	2.6
June	104	133	29	13.167	55	4.177
July	106	129	23	14.571	78	5.353
August	108	138	30	16.5	108	6.545
September	110	136	26	17.55	134	7.635
October	112	124	12	17	146	8.588
November	114	139	25	17.727	171	9.646
December	116	125	9	17	180	10.588

$$\text{Mean square error (MSE)} = \frac{\sum |x_t - F_t|^2}{n} = \frac{4742}{12} = 395.167$$

$$\text{Upper limit} = 3 \times \sqrt{MSE} = 3 \times \sqrt{395.167} = 59.636$$

Since upper limit of T.S < 59.636 hence model should not be revised.

Example: Demand for a certain item has been as shown below:

The forecast for April was 100 units with a smoothing constant of 0.20 and using first order exponential smoothing what is the July forecast? What do you think about a 0.20 smoothing constant?

Time	Actual Demand
April	200
May	50
June	150

Solution: Using exponential smoothing average:

$$\begin{aligned}F_{\text{may}} &= \alpha \times D_{\text{April}} + (1 - \alpha) F_{\text{April}} \\ &= 0.2 \times 200 + (1 - 0.2) \times 100 = 120\end{aligned}$$

$$\begin{aligned}F_{\text{June}} &= \alpha \times D_{\text{May}} + (1 - \alpha) F_{\text{may}} \\ &= 0.2 \times 50 + (1 - .2) \times 120 = 106\end{aligned}$$

$$\begin{aligned}F_{\text{july}} &= \alpha \times D_{\text{june}} + (1 - \alpha) \times F_{\text{june}} \\ &= 0.2 \times 150 + 0.8 \times 106 = 114.8 = 115\end{aligned}$$

Example: In a time series forecasting model, the demand for five time periods was 10, 13, 15, 18 and 22. A linear regression fit results in an equation $F = 6.9 + 2.9t$ where F is the forecast for period t . The sum of absolute deviation for the five data is?

Solution: Sum of absolute deviation

$$\begin{aligned}&= |D_1 - F_1| + |D_2 - F_2| + |D_3 - F_3| + |D_4 - F_4| + |D_5 - F_5| \\ &= |10 - 6.9 - 2.9 \times 1| + |13 - 6.9 - 2.9 \times 2| + |15 - 6.9 - 2.9 \times 3| \\ &\quad + |18 - 6.9 - 2.9 - 2.9 \times 4| + |22 - 6.9 - 2.9 \times 5| \\ &= 0.2 + 0.3 + 0.6 + 0.5 + 0.6 = 2.2\end{aligned}$$



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PRACTICE SHEET

1. Which one of the following forecasting techniques is not suited for making forecasts for planning production schedules in the short range?
 - (a) Moving average
 - (b) Exponential moving average
 - (c) Regression analysis
 - (d) Delphi

2. When using a simple moving average to forecast demand, one would.
 - (a) Give equal weight to all demand data
 - (b) Assign more weight to the recent demand data
 - (c) Include new demand data in the average without discarding the earlier data
 - (d) Include new demand data in the average after discarding some of the earlier demand data

3. In a forecasting model, at the end of period 13, the forecasted value for period 14 is 75. Actual value in the periods 14 to 16 are constant at 100. If the assumed simple exponential smoothing parameter is 0.5, then the MSE at the end of period 16 is:

(a) 820.31	(b) 273.44
(c) 43.75	(d) 14.58

4. The most commonly used criteria for measuring forecast error is:
 - (a) Mean absolute deviation
 - (b) Mean absolute percentage error
 - (c) Mean standard error
 - (d) Mean square error

5. In a time series forecasting model, the demand for five time periods was 10, 13, 15, 18 and 22. A linear regression fit resulted in an equation $F = 6.9 + 2.9t$ where F is the forecast for period t . The sum of absolute deviations for the five data is:

(a) 2.2	(b) 0.2
(c) -1.2	(d) 24.3

6. **Assertion (A):** Time series analysis technique of sales-forecasting can be applied to only medium and short-range forecasting.

Reason (R): Qualitative information about the market is necessary for long-range forecasting.

 - (a) Both A and R are individually true and R is the correct explanation of A
 - (b) Both A and R are individually true but R is **not** the correct explanation of A
 - (c) A is true but R is false
 - (d) A is false but R is true

7. Given T = Underlying trend, C = Cyclic variations within the trend, S = Seasonal variation within the trend and R = Residual, remaining or random variation, as per the time series analysis of sales forecasting, the demand will be a function of:

(a) T and C	(b) R and S
(c) T, C and S	(d) T, C, S and R

8. Which one of the following methods can be used for forecasting the sales potential of a new product?
 - (a) Time series analysis
 - (b) Jury of executive opinion method
 - (c) Sales force composite method
 - (d) Direct survey method

9. Match List-I with List-II and select the correct answer using the codes given below the lists:

<p style="text-align: center;">List-I</p> <p>A. Decision making under complete certainty</p> <p>B. Decision making under risk</p> <p>C. Decision making under complete uncertainty</p> <p>D. Decision making based on expert opinion</p>	<p style="text-align: center;">List-II</p> <ol style="list-style-type: none"> 1. Delphi approach 2. Maximax criterion 3. Transportation mode 4. Decision tree
---	--

Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	4	3	2	1
(c)	3	4	2	1
(d)	4	3	1	2

10. Match List-I (Methods) with List-II (Problems) and select the correct answer using the codes given below the lists:

List-I

- A. Moving average
- B. Line balancing
- C. Economic batch size
- D. Johnson algorithm

List-II

- 1. Assembly
- 2. Purchase
- 3. Forecasting
- 4. Sequencing

Codes: **A** **B** **C** **D**

- (a) 1 3 2 4
- (b) 1 3 4 2
- (c) 3 1 4 2
- (d) 3 1 2 4

11. A company intends to use exponential smoothing technique for making a forecast for one of its products. The previous year's forecast has been 78 units and the actual demand for the corresponding period turned out to be 73 units. If the value of the smoothening constant \pm is 0.2, the forecast for the next period will be:

- (a) 73 units
- (b) 75 units
- (c) 77 units
- (d) 78 units

12. For sales forecasting, pooling of expert opinions is made use of in.

- (a) Statistical correlation
- (b) Delphi technique
- (c) Moving average method
- (d) Exponential smoothing

13. To meet short range changes in demand of a product, which of the following strategies can be considered?

- 1. Overtime
- 2. Subcontracting
- 3. Building up inventory
- 4. New investments

Select the correct answer from the codes given below:

- (a) 1, 2 and 3
- (b) 1, 3 and 4
- (c) 2 and 3
- (d) 1 and 2



ANSWER SHEET

1. *Ans. (d)*

Moving, average, Exponential moving average is used for short range. Regression is used for short and medium range. Delphi is used for long range forecasting.

2. *Ans. (d)*

3. *Ans. (b)*

Period	14.0	15.00	16.000
X_t	100.0	100.00	100.000
F_t	75.0	87.50	93.750
$(X_t - F_t)$	25.0	12.50	6.250
$\alpha(X_t - F_t)$	12.5	6.25	3.125
F_{t+1}	87.5	93.75	96.875
$(X_t - F_t)^2$	625	156.25	39.0625

$$\Sigma(X_t - F_t)^2 = 820.31$$

$$\text{Mean squared error, MSE} = \frac{820.31}{3} = 273.44$$

4. *Ans. (d)*

5. *Ans. (a)*

Sum of absolute deviation

$$\begin{aligned} &= (D_1 - F_1) + (D_2 - F_2) + (D_3 - F_3) + (D_4 - F_4) \\ &\quad + (D_5 - F_5) \\ &= (10 - 6.9 - 2.9 \times 1) + (13 - 6.9 - 2.9 \times 2) \\ &\quad + (15 - 6.9 - 2.9 \times 3) + \dots \end{aligned}$$

6. *Ans. (b)*

7. *Ans. (c)*

Sales forecasting should not be influenced by the random variations in demand.

8. *Ans. (d)*

9. *Ans. (c)*

10. *Ans. (d)*

11. *Ans. (c)*

New forecast

$$\begin{aligned} &= \text{Old forecast} + \alpha(\text{actual demand} - \text{old forecast}) \\ &= 78 + 0.2(73 - 78) = 77 \end{aligned}$$

12. *Ans. (b)*

13. *Ans. (b)*



ENGINEERS ACADEMY

PRACTICE SHEET

1. A machine is purchased for Rs. 32,000, and its assumed life is 20 years. The scrap value at the end of its life is Rs. 8,000. If the depreciation is charged by the diminishing balance method, then the percentage reduction in its value, at the end of the first year is: [GATE-1997]

- (a) 6.7% (b) 7.1%
(c) 7.2% (d) 7.6%

2. Six jobs arrived in a sequence as given below:

[GATE-2009]

Jobs	Processing Time (days)
I	4
II	9
III	5
IV	10
V	6
VI	8

Average flow time (in days) for the above jobs using Shortest Processing Time rule is:

- (a) 20.83 (b) 23.16
(c) 125.00 (d) 139.00

3. A set of 5 jobs is to be processed on a single machine. The processing time (in days) is given in the table below. The holding cost for each job is Rs. K per day. [GATE-2008]

Job	Processing time
P	5
Q	2
R	3
S	2
T	1

- (a) T-S-Q-R-P (b) P-R-S-Q-T
(c) T-R-S-Q-P (d) P-Q-R-S-T

4. Capacities of production of a item over 3 consecutive months in regular time are 100, 100

and 80 and in overtime are 20, 20 and 40. The demands over those 3 months are 90, 130 and 110. The cost of production in regular time and overtime are respectively Rs. 20 per item and Rs. 24 per item. Inventory carrying cost is Rs. 2 per item per month. The levels of starting and final inventory are nil. Backorder is not permitted. For minimum cost of plan, the level of planned production in overtime in the third month is: [GATE-2007]

- (a) 40 (b) 30
(c) 20 (d) 0

5. A stockist wishes to optimize the number of perishable items he needs to stock in any month in his store. The demand distribution for this perishable item is: [GATE-2006]

Demand (in units)	2	3	4	5
Probability	0.10	0.35	0.35	0.20

The stockist pays Rs. 70 for each item and he sells each at Ra. 90 . If the stock is left unsold in any month, he can sell the item at Rs. 50 each. There is no penalty for unfulfilled demand. To maximize the expected profit, the optimal stock level is:

- (a) 5 units (b) 4 units
(c) 3 units (d) 2 units

6. A company used 2555 units of an item annually. Delivery lead time is 8 days. The reorder point (in number of units) to achieve optimum inventory is: [GATE-2009]

- (a) 7 (b) 8
(c) 56 (d) 60

7. The distribution of lead time demand for an item is as follows:

Lead time demand	Probability
80	0.20
100	0.25
120	0.30
140	0.25

72. In the Capital Budget, which one of the following project expenditures CANNOT be called capital spending? [IAS-2001]
- (a) Building new dams
 - (b) Building new roads
 - (c) Expenditure on disaster management
 - (d) Purchases of aircraft for defense
73. Assertion (A): Companies investing in countries with high inflation rates use payback period method for capital budgeting. [IAS-2003]
- Reason (R): The operating cash flows in such investments are precisely and easily determined.
- (a) Both A and R are individually true and R is the correct explanation of A
 - (b) Both A and R are individually true but R is not the correct explanation of A
 - (c) A is true but R is false
 - (d) A is false but R is true



ANSWER SHEET

1. Ans. (a)

$$\text{Book value after } k^{\text{th}} \text{ year, } B_k = P \left(\frac{S}{P} \right)^{k/n}$$

Where P = Purchase value

S = Scrape value

n = Life period in years

Given P = Rs. 32,000; S = Rs. 8000; n = 20 years

$$\begin{aligned} \therefore B_k &= 32000 \left(\frac{8000}{32000} \right)^{1/20} \\ &= 32000 (0.933) \end{aligned}$$

Reduction in value = $1 - 0.9333 = 0.067$

% reduction in value = 6.7%

2. Ans. (a)

$$\text{Mean flow time} = \frac{125}{6} = 20.83$$

3. Ans. (a)

4. Ans. (b)

5. Ans. (b)

6. Ans. (c)

7. Ans. (d)

8. Ans. (c)

Number of total observations in 10 days = $11 \times 10 = 110$

Number of observation when studying = 71

$$\therefore p = \text{probability of studying} = \frac{71}{110} = 0.6455$$

Total studying hour in 10 days = $(2.5 \text{ hours}) \times 10 = 25 \text{ hours}$

Hence, minimum number of hours of studying in

10 days = $(25 \text{ hours}) \times p$

$$= 25 \times 0.6455$$

$$= 16.13 \text{ hours}$$

9. Ans. (c)

10. Ans. (a)

$$\text{Mean, } \mu = np = 900 \times 0.1 = 90$$

$$\text{Standard deviation, } \sigma = np^2 = 900 \times 0.1 \times 0.1 = 9$$

11. Ans. (d)

Analysis of variance is used in comparing two or more populations, e.g. different types of manures for yielding a single crop.

12. Ans. (a)

During the test, 10 components are tested for 750 hours.

$$\therefore \text{Total time, } T = 10 \times 750 = 7500 \text{ unit hours.}$$

$$\text{Total operating time} = 7500 - 350 = 7150 \text{ hours.}$$

$$\text{Number of failures/hour} = \frac{1}{7150} = 0.000141$$

13. Ans. (d)

$$\text{Probability } {}^5C_1 (0.01)^1 (0.99)^4 = 5 \times (0.99)^4 (0.01)$$

14. Ans. (a)

15. Ans. (c)

16. Ans. (a)

17. Ans. (a)

18. Ans. (d)

19. Ans. (b)

20. Ans. (b)

21. Ans. (c)

22. Ans. (b)

23. Ans. (a)

24. Ans. (c)

Assuming 50 – 50; Under Halsey Plan

$$\text{Wage}(W) = R.T + \frac{P}{100} (S - T).R = 20 \times 2 +$$

$$\frac{(3 - 2) \times 20}{2} = \text{Rs. } 50/-$$

R = base rate = Rs. 20/- hrs.

T = actual time = 2 hrs.

S = standard time = 3 hrs.

25. Ans. (c)

For the maintenance section, it is desirable that worker does the job assigned fast and is rewarded suitably. Thus bonus plan is best suited.

26. Ans. (b)

27. Ans. (d)

28. Ans. (c)

Rate of depreciation = $1 - \left(\frac{S}{C}\right)^{1/T}$

$$\left(\frac{S}{C}\right)^{1/T} = 1 - \left(\frac{20}{120}\right)^{1/10} = 0.164$$

$$\begin{aligned} \text{Book value at the end of six years} &= C(1 - p)^t \\ &= 120(1 - 0.164)^6 = \text{Rs. } 40.95 \end{aligned}$$

29. Ans. (c)

$$\text{Economic repair life, } x = \sqrt{\frac{2(C - s)}{b}}$$

Where, C = Initial cost of the machine = Rs. 2000

s = Scrap value of machine = Rs. 200

$$\therefore x = \sqrt{\frac{2(2000 - 200)}{40}} = \sqrt{90} = 9\frac{1}{2} \text{ years.}$$

30. Ans. (c)

31. Ans. (a)

32. Ans. (b)

33. Ans. (b)

Handle product in as large a unit as practical.

34. Ans. (b)

Production cost refers to prime cost plus factory and administrative overheads.

35. Ans. (c)

36. Ans. (c)

37. Ans. (d)

MARR: Minimum attractive rate of return or minimum acceptable rate of return, is the minimum return on a project a manager is willing to accept before starting a project. The MARR generally increases with increased risk.

38. Ans. (d)

39. Ans. (d)

40. Ans. (b)

41. Ans. (b)

In straight line depreciation method. Annual depreciation is constant during the production life of the product. Thus the annual depreciation change is given by $\frac{P - L}{N}$, where L is the salvage value.

42. Ans. (c)

43. Ans. (d)

44. Ans. (d)

45. Ans. (b)

SPT minimize MFT & ML and EDD minimize only ML

46. Ans. (a)

47. Ans. (a)

48. Ans. (d)

49. Ans. (d)

50. Ans. (d)

Actual material cost = Rs. $1.8 \times 12 = \text{Rs. } 21.6$

Standard material cost = Rs. 20

Variance = Rs. 1.60 adverse

51. Ans. (c)

52. Ans. (c)

53. Ans. (d)

54. Ans. (a)

Terotechnology: Economic management of asset

Climograph: Graphical depiction of a monthly prediction and temperature of a place.

55. Ans. (c)

56. Ans. (d)

57. Ans. (d)

58. Ans. (b)

59. Ans. (d)

$$\text{No of product per year} = \frac{200000}{10} = 20000 \text{ units.}$$

$$\text{Therefore overhead cost per unit} = \frac{120000}{20000}$$
$$= 6 \text{ per unit.}$$

$$\text{Total cost} = \text{Labour cost} + \text{Material cost} + \text{Overhead cost} = 5 + 10 + 6 = 21$$

60. Ans. (b)

61. Ans. (c)

62. Ans. (c)

63. Ans. (d)

64. Ans. (a)

65. Ans. (b)

66. Ans. (a)

Fast output and low labour cost are more important characteristics for mass production shop.

67. Ans. (b)

68. Ans. (c)

69. Ans. (a)

70. Ans. (b)

71. Ans. (a)

72. Ans. (c)

73. Ans. (c)

Job enlargement involves adding new tasks to a job in order to make it less boring and more challenging.

- It is especially useful for assembly-line jobs that are repetitive and monotonous and do not involve the worker's mental processes.

Job rotation among management trainees has been practiced for many years to give them an overall view of the firm's operations and to prepare them for promotion.

Job enrichment is the process of redesigning jobs to satisfy higher-level needs and organizational needs by improving worker satisfaction and task efficiency.

- It gives workers more responsibility, authority, and autonomy in planning and doing their work.

**ENGINEERS ACADEMY**



PRACTICE SHEET

OBJECTIVE QUESTIONS

1. Which of following application is associated with long-range forecasting ?
 - (a) Productions planning
 - (b) Purchasing
 - (c) New product planning
 - (d) Inventory planning

2. In which forecasting method, a panel of outside experts is identified and they are given a series of structured questionnaires ?
 - (a) Delphi method
 - (b) Market research
 - (c) Extrapolation
 - (d) Historical analogy

3. Consider following statements.
 1. Smaller is the value of α (smoothing constant), more is the smoothing effect in forecast.
 2. Higher value of α gives more robust forecast and response more quickly to changes.
 3. Higher value of α gives more weightage to past data as compared to smaller value of α .

Which of following statement are true ?

 - (a) 1,2
 - (b) 1,3
 - (c) 2,3
 - (d) 1,2,3

4. What is the forecast for the 4th period, according to data given below ?

Period	Actual Demand	Weightage
1	100	0.1
2	105	0.3
3	112	0.6

 - (a) 105.7
 - (b) 108.7
 - (c) 102.7
 - (d) 121

5. For a M/M/1: ∞ /FCFS queuing system, If arrival rate is 4 per hour and service rate is 5 per hour, the probability of the queue size being greater than 3 is :
 - (a) 0.59
 - (b) 0.64
 - (c) 0.410
 - (d) 0.512

6. The number of customers arriving at a railway reservation counter is poisson distributed with an arrival rate of eight customers per hour. The reservation clerk at this counter takes six minutes per customer on an average, with an exponentially distributed service time. Average waiting time of an arrival who waits is
 - (a) 25 min
 - (b) 15 min
 - (c) 30 min
 - (d) 20 min

7. Six jobs A,B,C,D,E and F have arrived at one time to be processed on a single machine. Assuming that no new jobs arrive thereafter, what will be mean flow time as per shortest processing time (SPT) rule ?

Job Processing :	A	B	C	D	E	D
Time in minutes :	7	8	6	4	5	3

 - (a) 33
 - (b) 16.33
 - (c) 5.5
 - (d) 18

8. Five jobs 1,2,3,4,5 are to be processed on a single machine. The processing time and due dates are represented in table below.

Job :	1	2	3	4	5
Processing time (in min.)	6	9	7	4	11
Due Date (in min.)	16	11	16	26	21

The true statements are :

- (a) 1, 2, 4 (b) 1, 3, 4
 (c) 1, 2, 3, 4 (d) 1, 2, 3

42. Consider following statements :

1. Every basic solution of a problem is an extreme point of the convex set of feasible solutions.
2. Simplex method provides an algorithm which consists in moving from one vertex to another in feasible region.
3. Slack variables represent unutilised capacity or resources.

Correct statements are :

- (a) 1, 2, 3 (b) 1, 3
 (c) 1, 2 (d) 2, 3

43. The objective function is maximization type (Z_{max}). By performing iteration to get an optimal solution results in the following table :

		2	3	10	
	Basis	x_1	x_2	x_3	R.H.S.
10	x_3	1/2	0	1	0
3	x_2	-1/2	1	0	1

Optimal solution can be given as :

1. $Z_{max} = 3$
2. Degenerate solution
3. Alternate solution

Which of following correctly represent complete optimal solution ?

- (a) 2 (b) 1 and 2
 (c) 3 (d) 1 and 3

44. **Assertion (A)** : In the optimal simplex table, if a non-basic variable has zero coefficient in the $C_j - Z_j$ row, there exist an alternate optimal solution.

Reason (R) : Non-basic variable can enter the basis without changing the value of Z , but causing a change in the value of the basic variables.

(a) Both A and R are individually true and R is the correct explanation of A.

(b) Both A and R are individually true but R is not the correct explanation of A.

(c) A is true but R is false

(d) A is false but R is true

Common data questions 45 and 46

The demand for five consecutive weeks for a product is as follows : 105, 108, 112, 116, 120. Exponential smoothing constant is 0.1.

45. Mean absolute deviation (MAD) of this type forecasting is :

- (a) 6.55 (b) 6.75
 (c) 7.1 (d) 5.9

46. Standard error of the estimate is

- (a) 11.5 (b) 9.6
 (c) 10.40 (d) 8.7

Linked Question 47 and 48

A small project consists of seven activities for which the relevant data is given below :

Activity	Preceding activities	Duration (Days)
A	—	4
B	—	7
C	—	6
D	A,B	5
E	A,B	7
F	C,D,E	6
G	C,D,E	5

47. Critical path of this project is

- (a) B-E-G (b) B-E-F
 (c) B-D-F (d) A-E-F

48. Free float of activity E is

- (a) 0 (b) 3
 (c) 7 (d) 2

Common data questions 49 and 50

Consider following simplex table for L.P. maximization problem.

	C_j	2	5	0	0	0	
C_B	Basis	x_1	x_2	s_1	s_2	s_3	b
0	s_1	1	4	1	0	0	24
0	s_2	3	1	0	1	0	21
0	s_3	1	1	0	0	1	9

49. Which one of following correctly indicates the combination of entering and leaving variables ?

- (a) x_2 and s_1 (b) x_2 and s_2
(c) x_1 and s_1 (d) x_1 and s_2

50. If two unit of x_2 is introduced into the solution, what will be net marginal improvement or net contribution in the value of the objective function?

- (a) 6 (b) 5
(c) 10 (d) 4



ANSWER SHEET

1. *Ans (c)*
2. *Ans (a)*
3. *Ans (d)*
4. *Ans (b)*

Job	Processing time	Due time	Flow time
2	9	11	9
1	6	16	15
3	7	16	22
5	11	21	33
4	4	26	37

$$F_4 = \frac{0.1 \times 100 + 0.3 \times 105 + 0.6 \times 112}{(0.1 + 0.3 + 0.6)}$$

$$= 108.7$$

Average in-process inventory

$$= \frac{5 \times 9 + 4 \times 6 + 3 \times 7 + 2 \times 11 + 1 \times 4}{37}$$

$$= 3.14 \text{ Jobs}$$

5. *Ans (d)*

$$\rho = \frac{4}{5} = 0.8$$

9 *Ans (c)*

probability of queue size > 3 is given by
 $\rho^3 = 0.8^3 = 0.512$

6. *Ans (c)*

$$\lambda = 8/\text{hour}$$

$$\mu = \frac{60}{6} = 10/\text{hour}$$

$$W_s = \frac{1}{\mu - \lambda} = \frac{1}{10 - 8} = 0.5 \text{ hour}$$

$$= 30 \text{ min}$$

Job	Turning		Threading	
	IN	OUT	IN	OUT
4	0	3	3	10
1	3	7	10	19
3	7	13	19	29
2	13	26	29	40
5	26	36	40	44
6	36	48	48	50

% utilization of threading

$$m/c = \frac{(10-3) + (19-10) + (29-10) + (40-29) + (44-40) + (50-48)}{50}$$

$$= 0.86 = 86\%$$

7. *Ans (b)*

As per SPT rule optimal sequence is

Job : F - D - E - C - A - B

Processing time :

3 4 5 6 7 8

Flow time :

3 7 12 18 25 33

$$\text{Mean flow time} = \frac{3+7+12+18+25+33}{6}$$

$$= \frac{98}{6} = 16.33 \text{ minutes}$$

8. *Ans (c)*

10 *Ans (a)*

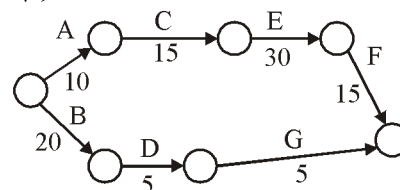
Effective shift = 7 hours

No. of product in one shift in one work

$$\text{Station} = \frac{7 \times 60}{42} = 10 \text{ product}$$

$$\text{So no. of work stations} = \frac{60}{10} = 6$$

11 *Ans (a)*



Task :	A	B	C	D	E	F	G
Time:	10	20	15	5	30	15	5
Weight:	70	30	60	10	45	15	5

Sequence :

$$\frac{A \quad C}{25} \quad \frac{E}{30} \quad \frac{B}{20} \quad \frac{F \quad D \quad G}{25}$$

Line efficiency

$$= \frac{\text{Total work time}}{\text{cycle time} \times \text{no. of work station}} \times 100$$

$$= \frac{100}{30 \times 4} \times 100 = 83.33\%$$

$$\therefore \text{Balance delay} = 100 - \text{L.E.} = 100 - 83.33 = 16.67\%$$

12 *Ans (c)*

$$Q = \frac{F}{S - V} = \frac{5000}{25 - 15} = 5000 \text{ units}$$

13 *Ans (c)*

$$800 + Q \times 0.1 = 1200 + Q \times 0.08$$

$$Q = \frac{400}{0.02} = 20000 \text{ parts}$$

14 *Ans (a)*

15 *Ans (d)*

16 *Ans (b)*

17 *Ans (a)*

$$\mu = 30 \text{ customers/hour}$$

$$t = 5 \text{ minutes}$$

$$= \frac{5}{60} \text{ hour} = \frac{1}{12} \text{ hour}$$

\therefore probability that a customer will be free withing

$$5 \text{ minutes} = 1 - e^{-\mu t} = 1 - e^{-30 \times \frac{1}{12}} = 0.918$$

18 *Ans (d)*

There are two critical path.

$$\text{so } \sigma \text{ for path 1-2-4-5-6} = \sqrt{1+1.36+0.11+0.44} = 1.70$$

$$\sigma \text{ for path 1-2-4-5-6} = \sqrt{1+2.8+0+0.11+0.44} = 2.08$$

$\therefore \sigma = 2.08$ is chosen as it is higher of the two values.

19 *Ans (c)*

20 *Ans (d)*

21 *Ans (b)*

$$\text{average inventory} = \frac{Q}{2} = \frac{6000/12}{2} = 250$$

22 *Ans (b)*

EOQ for unit price of

$$\text{Rs. } 960 = \sqrt{\frac{2RC_o}{C_c}} = \sqrt{\frac{2 \times 50000 \times \frac{2500}{360}}{\frac{0.15}{100} \times 960}}$$

$$= 694.4 \text{ units (not feasible)}$$

Total cost per day for order quantity of 1000 units

$$= \frac{q}{2} CI + \frac{R}{q} \times C_o + CR$$

$$= \frac{1000}{2} \times 960 \times \frac{0.15}{100}$$

$$+ \frac{2500}{360 \times 1000} \times 50000$$

$$+ 960 \times \frac{2500}{360}$$

$$= 720 + 347.22 + 6666.67$$

$$= \text{Rs. } 7733.89$$

EOQ for unit price of

$$\text{Rs. } 1000 = \sqrt{\frac{2RC_o}{C_c}} = \sqrt{\frac{2 \times \frac{2500}{360} \times 50000}{\frac{0.15}{100} \times 1000}}$$

$$= 680 \text{ units}$$

Total cost per day for order quantity of 680 units

$$= \frac{680}{2} \times 1000 \times \frac{0.15}{100}$$

46 *Ans (c)*

$$\text{Std} = \sqrt{\frac{(D_t - F_t)^2}{n-2}} = \sqrt{\frac{324.19}{5-2}} = 10.40$$

47 *Ans (b)*48 *Ans (a)*49 *Ans (a)*50 *Ans (c)*

$(C_j - Z_j)$ row coefficient represent net contribution per unit in the value of objective function. coeff. of x_2 in $(C_j - Z_j)$ is 5 so for two unit net contribution will be 10.



NOTES

