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IES | GATE | PSU

INDUSTRIAL ENGINEERING

For

MECHANICAL ENGINEERING

INDUSTRIAL ENGINEERING

SYLLABUS

Production Planning and Control: Forecasting models, aggregate production planning, scheduling, materials requirement planning.
Inventory Control: Deterministic and probabilistic models; safety stock inventory control systems
Operations Research: Linear programming, simplex and duplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

ANALYSIS OF GATE PAPERS

Exam Year	1 Mark Ques.	2 Mark Ques.	Total
2003	1	6	13
2004	3	6	15
2005	3	7	17
2006	2	7	16
2007	-	4	8
2008	2	6	14
2009	2	5	12
2010	4	4	12
2011	2	2	6
2012	1	2	5
2013	2	1	4
2014 Set-1	2	1	4
2014 Set-2	2	2	6
2014 Set-3	1	3	7
2014 Set-4	2	3	8
2015 Set-1	1	2	5
2015 Set-2	3	1	5
2015 Set-3	1	2	5
2016 Set-1	-	2	4
2016 Set-2	1	2	5
2016 Set-3	1	1	3
2017 Set-1	0	2	4
2017 Set-2	2	1	4

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1 FORECASTING

1.1 DEFINITION

Forecasting is defined as an estimate of sales in physical units or monetary value for a specified period.

1.2 TYPE OF FORECASTING

The forecasting may be classified on the basis of time span or range of forecasting. There are three categories as follows:

1.2.1 LONG RANGE FORECASTING

Long range forecasting consists of time period of more than 5 years. Mostly qualitative techniques are used for long range forecasting.

Applications:
i) Power generation
ii) Cement Industry
iii) Sugar Industry
iv) Petroleum Industry

1.2.2 MEDIUM RANGE FORECASTING

The range of medium range forecasting is generally 1 to 5 years. Medium range forecasting needs combination of collective opinion, regression analysis, correlation of different index and inflation etc.

Applications:
i) Inventory planning
ii) Sales planning
iii) Enrolment of students in college etc.

1.2.3 SHORT RANGE FORECASTING

Short range forecasting covers a period typically from one hour to one year. In most cases, it is for one season, a few months or a few weeks. For this exponential smoothing, graphical projections etc. are used.

Application:
i) Monthly forecast of sales

1.3 CATEGORIES OF FORECASTING METHOD

Forecasting can also be classified into two categories:
i) Qualitative Method
ii) Quantitative Method

1.3.1 QUALITATIVE METHOD

Qualitative methods are needed in forecasting when data necessary to use time series are not available .for example , when a new product is to be launched in the market , its past demand data are not available
In such cases human judgment, expert opinion, market research etc. are required for forecasting.

1.3.1.1 TYPE OF QUALITATIVE FORECASTING

1) Delphi Method
2) Market Research
3) Historical Estimates

1.3.2 QUANTITATIVE METHOD

When past data are available then with the help of mathematical equations forecasting can be done. Such method of forecasting is known as quantitative method. It is done for small to medium range forecasting.

1.3.2.1TYPES OF QUANTITATIVE METHOD OF FORECASTING

1) Least square or Regression analysis
2) Time series analysis

1.3.2.2LEAST SQUARE or REGRESSION ANALYSIS

This is the mathematical method of obtaining the line of best fit between the dependent variable & independent variable .In a simple regression analysis, the relationship between the dependent variable y and some independent variable x can be represented by a straight line.

y= a +bx

Where a = y intercept

b = Slope of the line

The values of 'a' & 'b' are determined from two simultaneous equations

$\sum y = na + b\sum x$ ... (i)

$\sum xy = a\sum x + b\sum x^2$ ... (ii)

By solving equation (i) & (ii), we get

$$a = \frac{1}{n}\left(\sum y - b\sum x\right)$$

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

Where n = No of observations

1.3.2.3 TIME SERIES ANALYSIS

1) **Simple Moving Average Method:** This method of forecasting uses past data to calculate a rolling average for a period.

$$\text{Moving Average}(y) = \frac{\text{Sum of demands for periods}}{\text{Chosen number of peridos}} = \frac{D_1 + D_2 + D_3 + \ldots.. + D_n}{n}$$

2) **Weighted Moving Average:** As compared to simple moving average which gives equal effect to each component of the data base, weighted moving average can give any amount of weights for each element, where the sum of all weight should be one.

In simple moving average, equal weightage is given to 1st month, 2nd month and 3rd month in a three month moving average. But the organization wants to attach more weightage to the third month and least to the first month. For example, depending upon the importance it assigns weightage e.g. 0.2 to 1st period 0.3 to second and 0.5 to the third. The sum of these weights should be equal to one.

Example: The past data on the load on the weaving machines is shown below:

Month	Load(hrs)
May-96	
June-96	585
July-96	610
Aug-96	675
Sep-96	750
Oct-96	860
Nov-96	970

a) Compute the load on the weaving machine centre using 5th moving average for the months of December 1996.

b) Compute a weight three months moving average for December, 1996 where the weightage are 0.5 for the latest month, 0.3 and 0.2 for the other months respectively.

Solutions:

a) Five months moving average forecast for Dec.1996

$$= \frac{\text{D Nov.} + \text{D Oct} + \text{D Sep} + \text{D Aug} + \text{D July}}{5}$$

$$= \frac{970 + 860 + 750 + 675 + 610}{5}$$

$$= 773\text{hrs}$$

b) A three month weight moving average forecast for Dec. 1996

$$= \frac{(\text{W Nov.D Nov}) + (\text{W oct} + \text{D Oct}) + (\text{W Sep.D Sep})}{W_{Nov} + W_{Oct} + W_{Sep}}$$

$$= \frac{(970 \times 0.5) + (660 \times 0.3) + (750 \times 0.2)}{0.5 + 0.3 + 0.2}$$

=947.8 machine hours.

1) Exponential Smoothing Method: The Moving Average Method of forecasting requires maintaining the data for all the previous years. This method overcomes the limitations of moving average and eliminates the requirement of keeping past record. It represents a weighted average for the past observation. The most recent observation is given highest weightage and it decreases in the form of geometric progression when move for older observations. Forecast for the period $t(f_t)$ is given by

$$f_t = f_{t-1} + \alpha\left(D_{t-1} - f_{t-1}\right)$$

Where f_{t-1} =Last period forecasted demand

D_{t-1} =Last period actual demands

α =Smoothing constant which lies between 0-1

Note:

When demand is very stable α = 0.1 to 0.3

When demand is slightly unstable α = 0.4 to 0.6

1.4 FORECASTING ERROR

1.4.1 MEAN ABSOLUTE DEVIATION (MAD)

This is calculated as the average of absolute value of difference between actual and forecasted value.

$$MAD = \frac{\sum_{t=I}^{n}\left|D_t - F_t\right|}{n}$$

Where D_t = Actual demand for period t

F_t = Forecasted demand for period t

n = Number of periods considered for calculating the error

1.4.2 MEAN SUM OF SQUARE ERROR (MSE)

The average of square of all errors in the forecast is termed as MSE. Its interpretation is same as MAD.

$$MSE = \frac{\sum_{t=I}^{n}\left(D_t - F_t\right)^2}{n}$$

1.4.3 BIAS

Bias is measure of overestimation or underestimation

$$Bias = \frac{\sum_{t=I}^{n}\left(D_t - F_t\right)}{n}$$

1.4.4 TRACKING SIGNAL (TS)

It is used to identify those items, which do not keep pace with either positive or negative bias or trend.

$$TS = \frac{\sum_{t=I}^{n}\left(D_t - F_t\right)}{\left(MAD\right)_n}$$

Where

$\left(MAD\right)_n$ = Mean absolute deviation till period n.

$\left(BIAS\right)_n$ = Bias till period n.

GATE QUESTIONS

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1 FORECASTING

Q.1 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

[GATE–2001]

Q.2 The sales of cycles in a shop in four consecutive months are given as 70, 68, 82, 95. Exponentially smoothing average method with a smoothing factor of 0.4 is used in forecasting. The expected number of sales in the next month is

a) 59 b) 72
c) 86 d) 136

[GATE–2003]

Q.3 For a product, the forecast and the actual sales for December 2002 were 25 and 20 respectively. If the exponential smoothing constant (a) is taken as 0.2, then forecast sales for January 2003 would be

a) 21 b) 23
c) 24 d) 27

[GATE–2004]

Q.4 The sales of a product during the last four years were 860, 880, 870 and 890 units. The forecast for the fourth year was 876 units. If the forecast for the fifth year, using simple exponential smoothing, is equal to the forecast using a three period moving average, the value of the exponential smoothing constant α is

a) $\frac{1}{7}$ b) $\frac{1}{5}$
c) $\frac{2}{7}$ d) $\frac{2}{5}$

[GATE–2005]

Q.5 In an MRP system, component demand is

a) forecasted
b) established by the master production schedule
c) calculated by the MRP system from the master production schedule
d) ignored

[GATE–2007]

Q.6 A moving average system is used for forecasting weekly demand $F_1(t)$ and $F_2(t)$ are sequences of forecasts with parameters m_1 and m_2, respectively, where m_1 and $m_2 (m_1 > m_2)$ denote the numbers of weeks over which the moving averages are taken. The actual demand shows a step increase from d_1 to d_2 at a certain time. Subsequently,

a) neither $F_1(t)$ nor $F_2(t)$ will catch up with the value d_2
b) both sequences $F_1(t)$ and $F_2(t)$ will reach d_2 in the same period
c) $F_1(t)$ will attain the value d_2 before $F_2(t)$
d) $F_2(t)$ will attain the value d_2 before $F_1(t)$

[GATE–2008]

Q.7 Which of the following forecasting methods takes a fraction of forecast error into account for the next period forecast?

a) Simple average method
b) Moving average method
c) Weighted moving average method
d) Exponential smoothening method

[GATE–2009]

Q.8 The demand and forecast for February are 12000 and 10275, respectively. Using single exponential smoothening method (smoothening coefficient = 0.25), forecast for the month of March is

a) 431 b) 9587
c) 10706 d) 11000

[GATE–2010]

Q.9 In simple exponential smoothing forecasting, to give higher weight age to recent demand information, the smoothing constant must be close to

a) –1 b) zero
c) 0.5 d) 1.0

[GATE–2013]

Q.10 In exponential smoothening method, which one of the following is true?

a) $0 \le \alpha \le 1$ and high value of α is used for stable demand
b) $0 \le \alpha \le 1$ and high value of α is used for unstable demand
c) $\alpha \ge 1$ and high value of α is used for stable demand
d) $\alpha \le 0$ and high value of α is used for unstable demand

[GATE-2014(1)]

Q.11 The actual sales of a product in different months of a particular year are given below:

September	October	November	December	January	February
180	280	250	190	240	?

The forecast of the sales, using the 4 month moving average method , for the month of the February is ______

[GATE-2014(3)]

Q.12 For a canteen, the actual demand for disposable cups was 500 units in January and 600 units in February. The forecast for the month of January was 400 units. The forecast for the month of March considering smoothing coefficients as 0.75 is ___

[GATE-2015(1)]

Q.13 Sales data of a product is given in the following table :

Month	January	February	March	April	May
Number of unit sold	10	11	16	19	25

Regarding forecast for the month of June, which one of the following statements is TRUE?

a) Moving average will forecast a higher value compared to regression
b) Higher the value of order N, the greater will be the forecast value by moving average.
c) Exponential smoothing will forecast a higher value compared to regression.
d) Regression will forecast a higher value compared to moving average

[GATE-2015(2)]

Q.14 The demand for a two-wheeler was 900 units and 1030 units in April 2015 and May 2015, respectively. The forecast for the month of April 2015 was 850 units. Considering a smoothing constant of 0.6, the forecast for the month of June 2015 is

a) 850 units b) 927 units
c) 965 units d) 970 units

[GATE-2016(3)]

ANSWER KEY:

1	2	3	4	5	6	7	8	9	10	11	12	13	14
(d)	(b)	(c)	(c)	(c)	(d)	(d)	(c)	(d)	(b)	239	560.75	(d)	(d)

EXPLANATIONS

Q.1 (d)

The simple moving average method can be used if the underlying demand pattern is stationary. This method include new demand data in the average after discarding some of the earlier demand data.

Let m_t = moving average at time t

y_t= demand in time t and

n = moving average period

$$m_{t+1} = \frac{y_{t+1} - y_{t-n+1}}{n}$$

Q.2 (b)

We know, from the exponential and smoothing average method, the exponential smoothed average $u_{(t+1)}$ which is the forecast for the next period (t+1) is given by

$u_{(t+1)}=au_t+a(1-a)U_{t-1}+...a(1-a)^nU_{t\,N}+...\infty$

Now, for sales of the fifth month put t = 4 in the above equation,

So,

$u_S=au_4+a(1-a)u_3+a(1-a)^2u_2+a(1a)^2u_1$

Where, u_1, u_2, u_3 and u_4 are 70, 68, 82 and 95 respectively and a = 0.4

Hence

$$u_s = 0.4\times95 + 0.4(1-0.4)82 + 0.4(1-0.4)^2$$
$$\times68 + 0.4(1-0.4)3\times70$$

u_S = 38+19.68+9.792+6.048=73.52

Q.3 (c)

Given:

Forecast sales for December u_t = 25

Actual sales for December X_t = 20

Exponential smoothing constant a= 0.2

We know that, Forecast sales for January is given by

$$U_{t+1} = U_t + a[X_t - u_t]$$

= 25 + 0.2 (20 – 25)

= 25 + 0.2×(-5) = 25 – 1 =24

Hence, Forecast sales for January 2003 would be 24.

Q.4 (c)

Gives:

Sales of product during four years were 860, 880, 870 and 890 units.

Forecast for the fourth year u_4= 876

Forecast for the fifth year, using simple exponential smoothing, is equal to the forecast using a three period moving average.

So, $u_s = \frac{1}{3}(880+870+890) \Rightarrow u_s=880$unit

By the exponential smoothing method.

$$u_s = u_4 + a(u_4 - u_4)$$

880 = 876 + a(890 – 876)

4 = a(14)

$$a = \frac{4}{14} = \frac{2}{7}$$

Q.5 (c)

MRP (Material Requirement Planning):

MRP function is a computational technique with the help of which the master schedule for end products is converted into a detailed schedule for raw materials and components used in the end product.

Input to MRP

i) Master production schedule.

ii) The bill of material

iii) Inventory records relating to raw materials.

Q.6 (d)

Here $F_1(t)$ & $F_2(t)$ = Forecasting

m_1 & m_2 = Number of weeks

A higher value of m results in better smoothing. Since here m_1>m_2 the weight age of the latest demand would be more in $F_2(t)$.

Hence, $F_2(t)$ will attain the value of d_2 before $F_1(t)$

Q.7 (d)

Exponential smoothing method of forecasting takes a fraction of forecast error into account for the next period forecast.

The exponential smoothed average u_t, which is the forecast for the next period $(t+1)$ is given by.

$$u_t = \alpha y_t + \alpha(1-\alpha)y_{t-1} + \ldots \alpha(1-\alpha)^n y_{t-n} + \infty$$

$$= ay_t + (1-a)\left[ay_{t-1} + a(1-a)y_{t-2} + \ldots\right.$$

$$\left. + a(1-a)^n y_{t-(n-1)} + ..\right]3$$

$$= u_{t-1} + a(y_t - u_{t-1})$$

$$= u_{t-1} + a\,e_t$$

Where $e_t = (y_t - u_{t-1})$ is called error and is the difference between the last Observation y_t and its forecast a period earlier, u_t-1.

The value of α lies between 0 to 1.

Q.8 (c)

Given, forecast for February

F_{t-1} = 10275

Demand for February

D_{t-1} = 12000

Smoothing coefficient

α = 0.25

Which is the forecast for the next period is given by,

$F_1 = \alpha(D_{t-1}) + (1-\alpha)\times F_{t-1}$

=0.25

$(12000) + (1-0.25)\times(10275)$

= 10706.25≃10706

Hence, forecast for the month of March is 10706.

Q.9 (d)

Height weight given to recent demand, the fore $F_t = D_t$

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

$or = F_{t-1}(1-\alpha) + D_t$

Thus from the given condition

$F_{t-1}(1-\alpha) = 0$

Or = 1

The values of smoothing constant (α) lie between 0 and 1.

A low value of α gives more weightage to the past series and less weightage to the recent demand information. Hence, in simple exponential smoothing forecasting, higher value of α , i.e. 1, gives higher weight age to recent demand information and less weight age to the past series.

Q.10 (b)

0≤α≤2

High value of 'α' means more weightage f or immediate forecast.

Less value of 'α' means relatively less weightage for immediate forecast, or almost equal weightage for all previous forecast.

Hence high value of forecast is only chosen when nature of demand is not reliable rather unstable.

Q.11 239 to 241

Number of periods = 4, then the past 4 months average sales is fore cast for next 4 months.

So, $\dfrac{280+250+190+240}{4} = 240.$

Q.12 560.75

Forecast for

$= 400 + \alpha(500-400) = 400 + .25\times 100 = 475$

Forecast march

$= 475 + \alpha(600-475) = 560.75$

Q.13 (d)

Q.14 (d)

Month	Demand	Forecast $(=\alpha D_{t-1} + (1-\alpha)F_{t-1})$
April	900	850
May	1030	$= 0.6\times 900 + 0.4\times 850 = 880$
June		$= 0.6\times 1030 + 0.4\times 880 = 970$

$\therefore\ F_{june} = 970$ units

ASSIGNMENT QUESTIONS

Q.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

Q.2 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

Q.3 Which one of the following methods can be used for forecasting when a demand pattern is consistently increasing or decreasing?
a) Regression analysis
b) Moving average
c) Variance analysis
d) Weighted moving average

Q.4 Which one of the following forecasting techniques is most suitable for making long range forecasts?
a) Time series analysis
b) Regression analysis
c) Exponential smoothing
d) Market surveys

Q.5 Which one of the following is not a purpose of Long-term forecasting?
a) To plan for the new unit of production
b) To plan the long-term financial requirement
c) To make the proper arrangement for training the personnel
d) To decide the purchase programme

Q.6 Which one of the following is not a technique of Long Range Forecasting?
a) Market Research & Market Surve
b) Delphi
c) Collective Opinion
d) Correlation and Regression

Q.7 Which of the following is the measure of forecast error?
a) Mean absolute deviation
b) Trend value
c) Moving average
d) Price fluctuation

Q.8 For sales forecasting, pooling of expert opinions made use of in
a) Statistical correlation
b) Delphi technique
c) Moving average method
d) Exponential smoothing

Q.9 Which of the following is not the characteristic of exponential smoothing? method of forecasting?
a) This represents a weighted average of the past observations.
b) All observations are assigned equal weightage.
c) If smoothening coefficient is 1 then the latest forecast would be equal to previous period actual demand.
d) The technique is not simple as compared to moving average method.

Q.10 The interchange ability can be achieved by
a) standardization
b) better process planning
c) bonus plan
d) better product planning

Q.11 Standardization of products is done to

a) eliminate unnecessary varieties in design
b) simplify manufacturing varieties in design
c) make interchangeable manufacture possible
d) reduce material cost

Q.12 The standard time of an operation while conducting a time study is
a) mean observed time + allowances
b) normal time - allowances
c) mean observed time x rating factor +allowances
d) normal time x rating factor + allowances

Q.13 In time study, the rating factor is applied to determine
a) standard time of a job
b) merit rating of the worker
c) fixation of incentive rate
d) normal time of job

Q.14 Work study is mainly aimed at
a) determining the most efficient method of performing a job
b) establishing the minimum time of completion of job
c) developing the standard method and standard time of a job
d) economizing the motions involved on the part of worker while performing a job

Q.15 Which one of the following is not a technique of PMTS?
a) Synthetic data
b) Stopwatch time study
c) Work-factor
d) MTM

Q.16 In performing a task, motion economy refers to the manner in which
a) human energy can be conserved
b) electric energy can be conserved
c) machine movements can be reduced
d) material movements can be reduced

Q.17 In the Kendall's notation for representing queuing models the first position represents
a) Probability law for the arrival
b) Probability law for the service
c) Number of channels
d) Capacity of the system

Q.18 In a single server queuing system with arrival rate of λ and mean service time of 'μ' the expected number of customers in the system is $\frac{\lambda}{\mu-\rho}$ What is the expected waiting time per customer in the system?
a) $\frac{\lambda^2}{\mu-\lambda}$
b) $\frac{\lambda}{\mu-\lambda}$
c) $\frac{1}{\mu-\lambda}$
d) $\frac{(\mu-\lambda)}{\lambda}$

Q.19 Flexible manufacturing systems are generally applied in
a) high variety and low volume production
b) medium volume and medium variety production
c) low v3.riety and low volume production
d) high variety and high volume production

Q.20 Vehicle manufacturing assembly line is an example of
a) product layout b) process layout
c) manual layout d) fixed layout

Q.21 Transfer lines are mostly used
a) Aero industries
b) Ship building
c) Automobile industries
d) Machine tool manufacturing

Q.22 Which one of the following types of layout is used for the manufacture of huge Aircrafts?
a) Product layout
b) Process layout
c) Fixed position layout
d) Combination layout

EXPLANATIONS

Q.1 (d)

Q.2 (d)
Opinion survey method is relatively simple and practical method for forecasting demands and especially for new products.

Q.3 (a)
Linear Regression Analysis: This method is very useful forecasting techniques if the past data appear to fall about a straight line. The general equation for the regression line is given by: y = a + bx, where ‘a and b are constants.

Q.4 (d)
Time series analysis (Regression Analysis, Exponential smoothing) are quantitative analysis of forecasting and suitable for short range while market survey is a long range forecasting.

Q.5 (c)

Q.6 (d)
Correlation and Regression method is used for short and medium range forecasting.

Q.7 (a)

Q.8 (b)

Q.9 (b)

Q.10 (a)

Q.11 (c)
Standardization is done to make manufacturing simplicity ie., the subassemblies can be made somewhere, where it can be made easily and assembling in done somewhere else.

Q.12 (c)

Q.13 (d)
A rating factor is a factor by which the observed time is multiplied in order.
To adjust for differences in operator’s performance.
Normal time = observed time performance rating factor.

Q.14 (c)
Work study investigates work done in an organization and it aims at finding the best and most efficient way of using available resources.

Q.15 (a)
Techniques of PMTS are:
1. Method Time Measurement (MTM)
2. Work Factor System (WFS)
3. Basic Motion Time Study (BMTS)

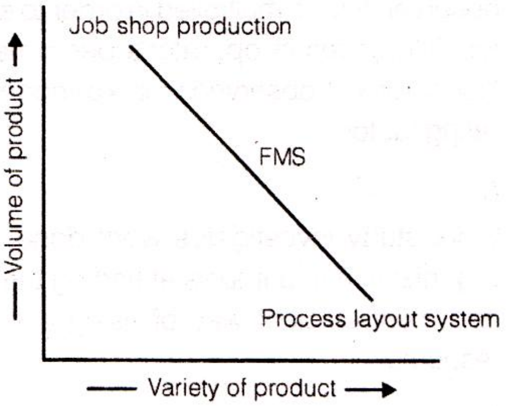
Q.16 (a)
Principle of motion economy: A worker while performing a task makes use of number of motions or movements.The careful examination of these motions may reveal that some of these motions
- are unnecessary and can be eliminated
- can be simplified by effective changes in the work place layout
- can be performed more efficiently by other members of the body.

Q.17 (a)

Q.18 (c)
Waiting time in system.

$$= \frac{\lambda}{(\mu-\lambda)} \times \frac{1}{\lambda} = \frac{1}{\mu-\lambda}$$

Q.19 (b)



Job shop production is used for mass production i.e., high volume low variety, process less out is used for low volume high variety of product while flexible manufacturing system is used for mid volume mid variety product.

Q.20 (a)

Q.21 (c)

Q.22 (c)

Process layout: It is characterized by keeping similar machines or similar operation at one location.

Process layout: Implies that various operations on raw material are performed in a sequence and the machine are placed along the product flow line, i.e. , machines are arranged in the sequence in which raw material will be operated upon.

Fixed position layout: In this case men and equipment are moved to the material, which remain at one place and product in completed at that place where material lies. It is used in ship building, aircraft manufactured big pressure vessel fabrication etc.

Q.23 (a)

Q.24 (a)

Q.25 (a)

Q.26 (a)

The number of pieces inspected per lot is generally more in single sampling than double sampling.

Q.27 (b)

Q.28 (d)

Simplex method of linear programming is an iterative procedure.

Q.29 (b)

In a Transportation Problem, if the number of non-negative independent allocations is less than m + n - 1 there exists a degeneracy. where
m = no. of rows
n = no. of columns

Q.30 (c)

Degeneracy arises when number of allocation are less than 3÷5 -1 = 7

Q.31 (b)

Q.32 (b)

Q.33 (d)

Q.34 (a)

Two costs are involved in inventory control viz. carrying cost & ordering cost.

Q.35 (c)

For economic order quantity
Holding cost = ordering cost

Q.36 (c)

Q.37 (a)

$$EOQ = \sqrt{\frac{2RC_0}{C_C}}$$

$$= \sqrt{\frac{2\times(60\times12)\times12}{(10\times12)}} = 12$$