2019

RANK IMPROVEMENT WORKBOOK

Mechanical Engineering

Industrial Engineering

Answer Key of Objective & Conventional Questions

MADE EASY Publications

1 Forecasting

LEVEL 1 Objective Questions

1.	(b)
2.	(101.5)
3.	(a)
4.	(b)
5.	(b)
6.	(50)
7.	(d)
8.	(d)
9.	(c)
10.	(c)
11.	(b)
12.	(a)
13.	(c)
14.	(a)

LEVEL 2 Objective Questions

15.	(b)
16.	(2)
17.	(10.4)
18.	(d)
19.	(a)
20.	(b)
21.	(596)
22.	(666.67)
23.	(a)
24.	(a)
25.	(c)

■■■■

LEVEL 3 Conventional Questions

Solution : 26

$$\text{forecast of 2011, } y_{x=6} = 31{,}200$$
$$\text{forecast of 2012, } y_{x=7} = 33200$$
$$r = 0.88735$$

Solution : 27

$$F_{\text{August}} = 116.33$$
$$\text{BIAS} = 16.336$$

As the BIAS is positive, so the forecast is under estimated.

Solution : 28

(i) Daily, using a simple five-week moving average.

Days	**This week**
MON	2500
TUE	2320
WED	2720
THU	2640
FRI	2480
SAT	—
SUN	2940

(ii) Daily, using a weighted average of 0.3, 0.25, 0.2, 0.15, 0.10 for the past five weeks.

MON	= 2460
TUE	= 2240
WED	= 2600
THU	= 2325
FRI	= 2285
SAT	–
SUN	= 2965

Solution : 29

Advantages of exponential smoothing method of forecasting are:–

1. It gives more significance to recent observations.
2. It can produce accurate forecasts.
3. It can produce forecasts quickly.
4. It requires a significantly smaller amount of data to be stored compared to the methods of moving averages.
5. It is easy to learn and apply.
6. It has a relatively low computational cost.

Exponentially smoothed forecast for the periods using.

when $\alpha = 0.1$

Month 1	F_1 = 10 (Assumed)
Month 2	F_2 = 10
Month 3	F_3 = 10.8
Month 4	F_4 = 12.62
Month 5	F_5 = 12.858
Month 6	F_6 = 14.5722
Month 7	F_7 = 14.314
Month 8	F_8 = 14.482
Month 9	F_9 = 13.835

when $\alpha = 0.3$

Month 1	F_1 = 10
Month 2	$F_2 = F_1$ = 10
Month 3	F_3 = 12.4
Months 4	F_4 = 17.38
Month 5	F_5 = 16.66
Month 6	F_6 = 20.66
Month 7	F_7 = 18.06
Month 8	F_8 = 17.44
Month 9	F_9 = 14.6

Solution : 30

$$\text{Tracking signal} = 4.29$$

If the value of TS goes beyond $3\sqrt{MSE}$ then it indicates that model needs to be revised.

As we want our forecast to be as close as possible to the actual demand. Here, in this case $\alpha = 0.2$ (small value of α) is not justified as forecast value is close to the last forecasted value and is not close to the actual demand.

Solution : 31

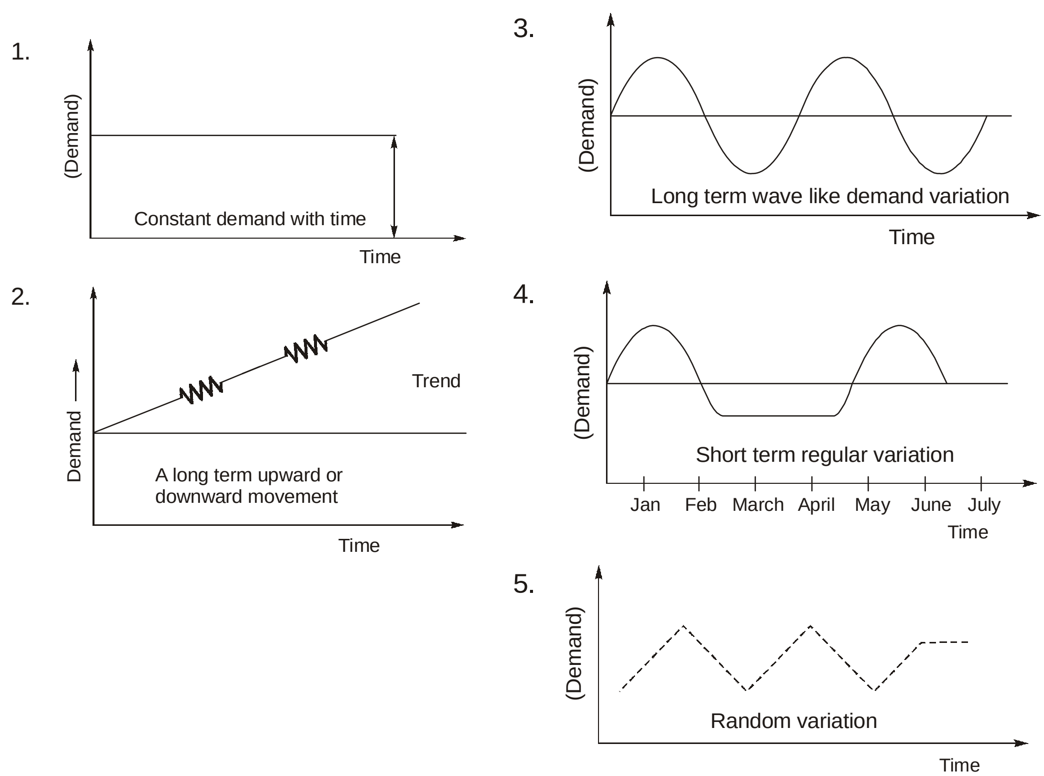
$$y = 10.588 + 0.06436x$$

$$r = 0.987$$
Demand for tyres, y = 217 tyres

Solution : 32

(i) Time series forecasting model:

1. Permanent (Example pen)
2. Trend
3. Cyclic (Example sugarcane)
4. Seasonal (Example woollen cloth)
5. Random variation



Simple Exponential Smoothing Method:

These are used to overcome the limitation of simple moving average method i.e. when the value of n is large one has to manage large size of data and the moving average method use only limited number of values to forecast not all of data

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

$$F_{t+1} = F_t + \alpha(D_t - F_t) \quad \text{...(i)}$$

D_t = Demand of last month

F_t = Forecast of last month

α = Exponential smoothening exponent ($0 \le \alpha \le 1$)

$\left(\alpha = \dfrac{2}{N+1}\right)$ when value of α is not given.

N = Number of value taken

Limitation:

As it can be seen from equation (i) that as the data get older, its weights in the forecasted value decreases smaller the value of α, more will be the smoothening effect i.e. almost similar value to last year forecast value if value of α is large than it seem to be more responsive and value of forecast will be equal to the actual demand of last year

when $\alpha = 0 \longrightarrow F_{t+1} = F_t$ (more stable)

$\alpha = 1 \longrightarrow F_{t+1} = D_t$ (responsive)

$\alpha = 1 \longrightarrow$ Require for new product

$\alpha = 0 \longrightarrow$ Require for old and stable product

(ii)

Months	Jan	Feb	Mar	Apr	May	June	July	August	Sep.	Oct.	Nov.	Dec.
$T.S. = \frac{\Sigma(D_t - F_t)}{MAD}$	–1	–2	0	–0.36	2.6	4.18	5.35	6.55	7.63	8.588	9.65	10.5882

Comment: Tracking signal – monitors the performance of the forecasting model and automatically indicates whether the model needs to be revised. Upper limit of tracking signal is taken as $3\sqrt{MSE}$. If value of Tracking signal goes beyond this limit than model need to be revised.

Solution : 33

Trend line $y = 5.342 + 0.66129x$

For 2016 for demand index sale's must be 1924 units.

■■■■

2 Inventory Cantrol and Break Even analysis

LEVEL 1 Objective Questions

1. (b)
2. (b)
3. (c)
4. (10)
5. (30)
6. (141
7. (b)
8. (4669)
9. (b)
10. (d)
11. (600)
12. (d)
13. (c)
14. (b)
15. (80.55) (80 to 81)
16. (258) (256 to 260)
17. (d)
18. (d)
19. (a)
20. (b)

LEVEL 2 Objective Questions

21. (3)(2.99 to 3.01)
22. (75000)
23. (9.54) (8 to 11)
24. (a)
25. (b)
26. (4.133) (4 to 4.3)
27. (25.2)
28. (894.78)
29. (73.25)
30. (b)
31. (1)
32. (1000)
33. (c)
34. (17.91)
35. (100)
36. (10000)
37. (a)
38. (a)

LEVEL 3 Conventional Questions

Solution : 39

Inventory may be defined as the stock of goods, commodities and other economic resources that are stored or reserved in order to ensure smooth and efficient running of business affairs. Inventory is "usable but idle resource".

Deterministic Inventory Models: In this model, we deal with situations in which demand is assumed to be fixed and completely known. Models for such situations are called Economic Lot Size Models or Economic Order Quantity Models.

Probabilistic Inventory Models: In this model, one or more of the inputs is not known with certainty and will be represented by a random variable with a probability distribution, for example, demand might be variable and will follow some probability distribution with known parameters.

EOQ_1 = 600 units

% increase in EOQ = 10.55%

As minimum inventory cost decreases with 10% decrease in carrying cost and with 10% increase in ordering cost, it is beneficial to accept new *EOQ* for the present sensitivity analysis.

Solution : 40

EOQ = 895 units

Time between two consecutive order
= 81 days

Number of order per year = 4.47

Optimal cost = ` 25342

Solution : 41

Q^* = 190

Inventory Cost = ` 3794.7

The inventory cost with 300 lot is high so it is not economical.

Solution : 42

As $(TC)_{2000}$ is minimum hence 2000 is the most economic order size

Solution : 43

q = 4582.57 or 4583 switches

Optimum level of inventory at the beginning of any period = 2292 switches

Re-order cycle time = 55 days

Number of runs = 7

Let cost of each switch be = ` 10

Minimum Annual inventory cost = $\sqrt{2DC_0C_h}$ = ` 45825.75

Solution : 44

(i) : ABC Analysis – An *ABC* analysis consists of separating the inventory items into three groups *A*, *B*, *C* according to their annual cost volume consumption, i.e. unit cost × annual consumption.

A – items – High value : These are relatively few items whose value accounts for 60-70% of the total value of the inventory. These will usually be 10-15% of the total items.

B – items – Medium value : A large number of items in the middle of the list, usually about 20-25% of the items whose total value accounts for about 20-25% of the total value.

C – items – Low value : The bulk of items usually about 60-70% whose total inventory values are almost negligible. They account for 10-15% of the total value.

Other similar approaches are:

1. HML: (High, Medium, Low) – Materials are classified according to their unit price in 3 categories.
2. VED : (Vital, Essential, Desirable) – Materials are classified according to their operational characteristics.
3. SDE : (Scarce, Difficult, Easy) – Materials are classified on the basis of availability of inventory items for the production system.

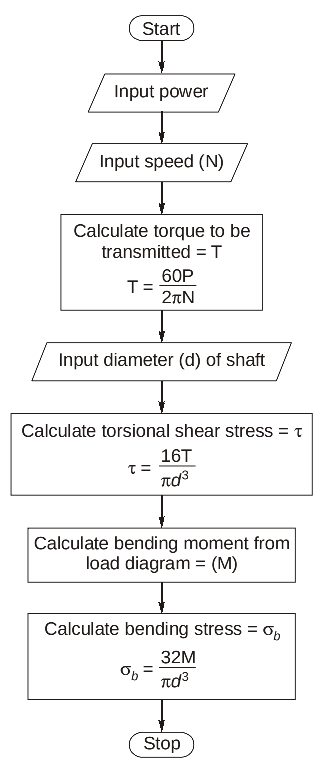
Advantages of such approaches are:–

1. Better control of High-priority inventory.
2. It reduces the cost of inventory items in storage.
3. It ensures control over the costly items in which a large amount of capital is invested.
4. It helps in regular monitoring of critical items and prevents stock out to avoid loss in production.

(ii) : Flow chart is a diagrammatic representation of an algorithm. Flow charts are very helpful in writing program and explaining program to others. A programmer draws a flow chart before writing a computer program. This helps to understand a process and find any flaws and bottlenecks in it. It enables communication between programmers and clients. Once a flow chart is drawn, it becomes comparatively easy to write the program in any high level language. Thus it is good for documentation of a complex program.

Flow Chart:

To calculate the torsional and bending stresses in a shaft transmitting power.



Solution : 45

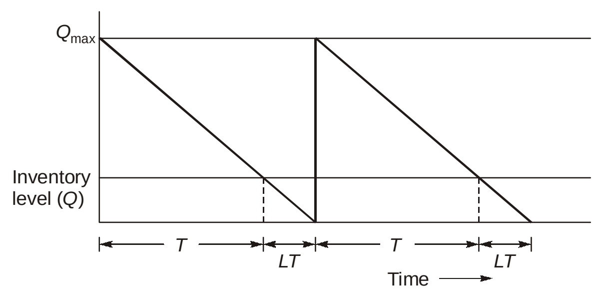
$$q_1 = 2500$$
$$q_2 = 1667$$

Solution : 46

For a deterministic model. The assumptions made are:

1. Demand is fixed and known.
2. Lead time is known and constant
3. No shortage or stockout is allowed
4. No safety stock is considered
5. Instantaneous replemishment

Model graphical representation:



Let

$$C = \text{Unit cost}$$
$$D = \text{Annual demand}$$
$$C_o = \text{Ordering cost/year}$$
$$C_h = \text{Holding cost/unit/year}$$
$$Q = \text{Order quantity}$$

Total inventory cost = Ordering cost + Holding cost

$$\text{TIC} = \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_h$$

for optimum order size (Q^*)

$$\frac{d(\text{TIC})}{dQ} = 0$$

$$\frac{-D}{Q^2} \times C_o + \frac{C_h}{2} = 0$$

$$Q^* = \sqrt{\frac{2DC_o}{C_h}}$$

Number of orders, $n = \dfrac{D}{Q^*}$

Optimum time for ordering, $T^* = \dfrac{Q^*}{D}$

Total inventory cost, $$\text{TIC} = \frac{D}{Q^*}C_o + \frac{Q^*}{2}\times C_h = \frac{D}{\sqrt{\frac{2DC_o}{C_h}}}\times C_o + \frac{1}{2}\sqrt{\frac{2DC_o}{C_h}}\times C_h$$

$$= \frac{\sqrt{DC_oC_h}}{\sqrt{2}} + \frac{\sqrt{DC_oC_h}}{\sqrt{2}} \quad \text{TIC}(Q^*) = \sqrt{2DC_oC_h}$$

Solution : 47

The analysis which provides a relationship between revenues and costs with respect to volume (quantity) of sales and represents the level of sales at which costs and revenues are in equilibrium, is called break-even analysis. It is useful to the manager in the following ways :

What volume of sales will be necessary to cover.

(i) A reasonable return on capital employed.

(ii) Preference and ordinary dividends.

(iii) Reserves.

- Computing costs and revenues for all possible volumes of output to fix budgeted sales.
- To find the price of an article to give the desired profit.
- To determine variable cost per unit
- To compare a number of business enterprises by arranging their earnings in order of magnitude.

percentage increase in sales price = 8%.

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3 PERT and CPM

LEVEL 1 Objective Questions

1.	(d)
2.	4(no range)
3.	(c)
4.	(b)
5.	(d)
6.	(b)
7..	(d)
8.	(b)
9.	(c)
10.	(d)
11.	(c)
12.	(b)
13.	(c)
14.	(c)
15.	(a)
16.	(d)
17.	(d)

LEVEL 2 Objective Questions

18.	(c)
19.	(c)
20.	(15.87) (15.50 to 16.00)
21.	(c)
22.	(d)
23.	(b)
24.	(1)
25.	(d)
26.	(b)
27.	(13.25) (13 to 14)
28.	(b)
29.	(a)
30.	(18) (No range)
31.	(b)
32.	(c)
33.	(d)
34.	(c)
35.	50(49.5 to 50.5)

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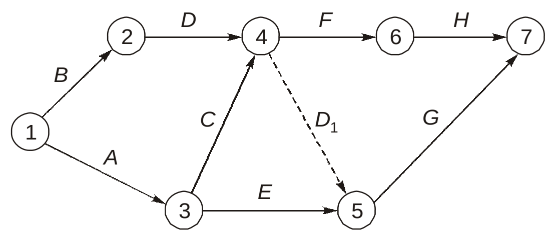
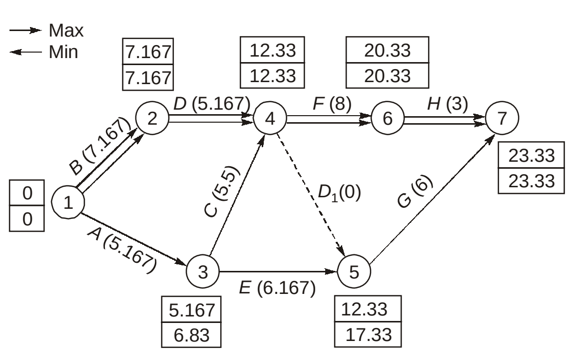
LEVEL 3 Conventional Questions

Solution : 36



Project Network

Activity	a	m	b	t_E (Week)	σ^2
A	3	5	8	$\frac{3+20+8}{6}=5.167$	$\left(\frac{8-3}{6}\right)^2=0.694$
B	6	7	9	$\frac{6+28+9}{6}=7.167$	$\left(\frac{9-6}{6}\right)^2=0.25$
C	4	5	9	$\frac{4+20+9}{6}=5.5$	$\left(\frac{9-4}{6}\right)^2=0.694$
D	3	5	8	$\frac{3+20+8}{6}=5.167$	$\left(\frac{8-3}{6}\right)^2=0.694$
E	4	6	9	$\frac{4+24+9}{6}=6.167$	$\left(\frac{9-4}{6}\right)^2=0.694$
F	5	8	11	$\frac{5+32+11}{6}=8$	$\left(\frac{11-5}{6}\right)^2=1$
G	3	6	9	$\frac{3+24+9}{6}=6$	$\left(\frac{9-3}{6}\right)^2=1$
H	1	2	9	$\frac{1+8+9}{6}=3$	$\left(\frac{9-1}{6}\right)^2=1.78$



The critical path is BDFH (1-2-4-6-7)

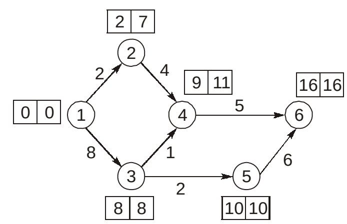
Expected project completion,

$$T_E = 23.33 \text{ weeks}$$

$$P(z) = 0.9997 \text{ or } 99.97\%$$

Solution : 37

CPM network diagram is



Total float for activity 2 – 4 = 5

Safety float for activity 1 – 2 = 5

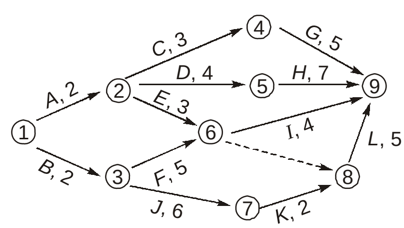
So critical path is 1-3-5-6. So total project duration is = 8 + 2 + 6 = 16

Solution : 38

Therefore project cost = 3760

Thus the precedence diagram becomes

Solution : 39



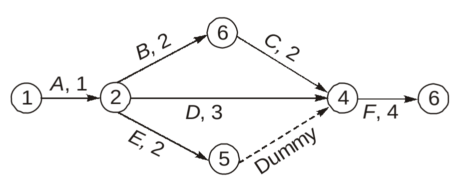
Thus the critical path is ① → ③ → ⑦ → ⑧ → ⑨ (*B* – *J* – *K* – *L*)

(T_E = 15 days)

From the probability table, Probability = 99.77%

Solution : 40

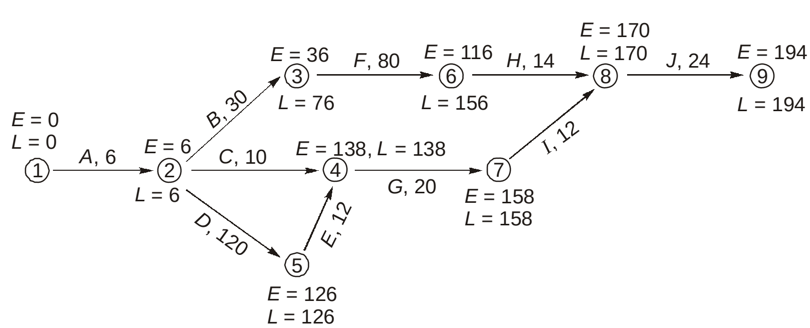
Arrow diagram:



Among the six activities, activity '*F*' is most uncertain.

From SND chart, Probability = 0.9474 or 94.74%

Solution : 41



Therefore critical path is : 1 — 2 — 5 — 4 — 7 — 8 — 9
Duration = 194 days.

Solution : 42

(i) Statistical assumptions made in PERT are:

(a) The activity durations are independent random variables.

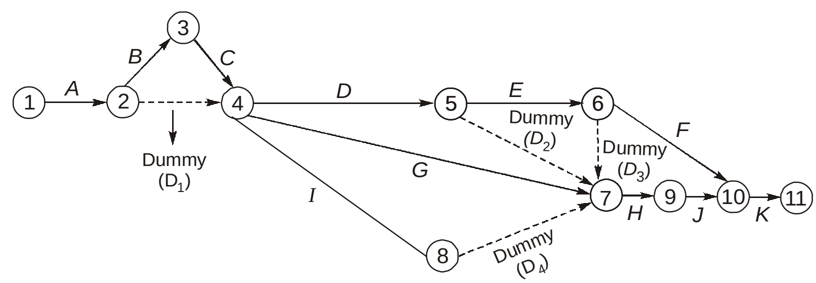
(b) The critical paths are independent

(c) The project duration is assumed to follow a normal distribution, independent of the distribution of the activity duration.

(d) The activity time follows: β – distribution

(e) The estimated time of completion is based on three time estimates (t_0, t_m and t_p).
If a particular activity has high variance then it will increase overall variance of project completion time if it falls on critical path.

Network diagram :



Critical path → ($A \to B \to C \to D \to E \to D_3 \to H \to J \to K$) ($T_E$ = 44.82)

Probability of completion of project in 45 days is 0.0398 + 0.5 = 0.5398

Probability of completion in 50 days is 0.4987 + 0.5 = 0.9987

Solution : 43

CPM	PERT
(i) CPM uses activity network	(i) PERT uses event oriented network
(ii) It is used extensitely in construction projects	(ii) Mostly used in *R&D* projects
(iii) Deterministic concept is used	(iii) Probabilistic model is used
(iv) CPM can control both time and cost when planning	(iv) PERT is basically a tool for planning
(v) Duration of activity may be estimated with a fair degree of accuracy	(v) Estimate of time for activities are not so accurate and definite

Critical path : $A \to C \to F \to H \to J$
Project Duration : 44 days

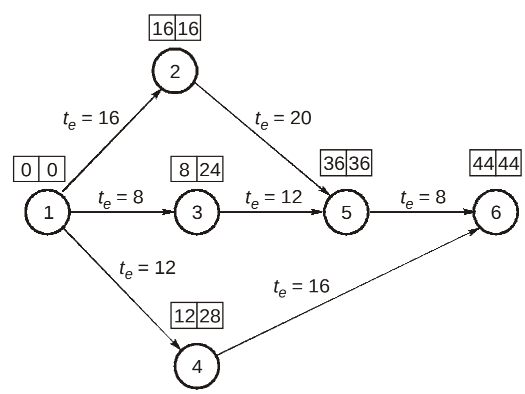
Solution : 44

(i) • Earliest start time (EST): It is the earliest time at which an activity can start. EST = E_j.

• Earliest finish time (EFT): It is the earliest possible time at which an activity can finish. EFT = EST + t_{ij}

- Latest start time (LST): It is the latest time by which the activity must be completed so that the scheduled date for the completion of the project may not be delayed.
  LFT = L_j.
- Total float (TF) (or) Total slack (TS): Total float is the extra time which is available with any parallel activity without affecting the project completion time. The calculation of slacks or floats is used to determine the critical activities in a project network.
- Safety float: It is extra time available for starting any activity (t_{ij}) beyond LST of i^{th} node without affecting the LST of j^{th} node. SF = $L_j - L_i - t_{ij}$
- Independent float (IF): It is surplus time available with any activity without affecting any of earliest and latest time of any successor activity. Independent floats take a pessimistic view of the situation of an activity.
  Note: TF + IF = FF + SF
- Critical activities and critical path: The activities for which total float (TF) is zero are "Critical activities", any delay on the critical activities will affect the project completion. Combination of critical activities is called critical path and it tells us that 'in how much time project can be completed". It is the longest path.
  The critical path is represented by double thick arrow line to distinguish it clearly.

  Critical path 1 - 2 - 5 - 6



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4 Queuing Theory

LEVEL 1 Objective Questions

1. (0.593) (0.58 to 0.60)
2. (a)
3. 3.2(3 to 3.5)
4. (b)
5. 0.297 (0.277 to 0.312)
6. (b)
7. (b)
8. (b)
9. (c)
10. (d)
11. (b)
12. (0.25)
13. (c)
14. (c)

LEVEL 2 Objective Questions

15. (b)
16. (c)
17. (0.343)(0.31 to 0.37)
18. (15)
19. 62.5(62.3 to 62.8)
20. 0.5 (0.4 to 0.6)
21. (d)
22. (0.6) (No range)
23. (b)

■■■■

LEVEL 3 Conventional Questions

Solution : 24

Probability that a person will have to wait

$$\rho = 0.33$$

$$\text{Average queue length} = \frac{1}{6}\text{ person}$$

$$\text{Increase in the flow of arrivals} = \frac{4}{21} - \frac{1}{9} = \frac{5}{63}\text{ per minute}$$

$$\text{Probability (waiting time} \geq 10\text{ min)} = 3.61\%$$

$$\text{Probability [time in the system} \geq 10] = 10.83\%$$

Solutin : 25

$$\text{Mean queue size, } l_q = 2.25\text{ trains}$$

$$\text{Probability } (n > 10) = 0.042$$

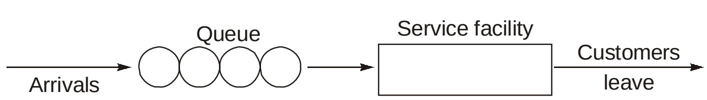
Solution : 26

$$L_s = 9$$
$$L_q = 8.1$$
$$W_s = 5\text{ minutes}$$
$$W_q = 4.5\text{ minutes}$$

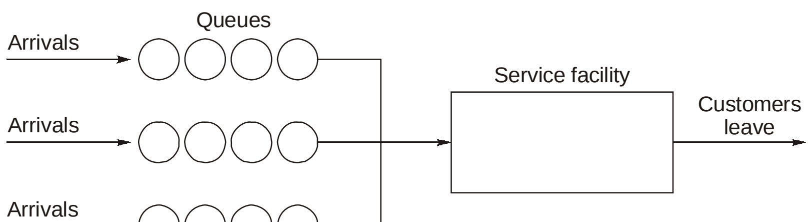
Solution : 27

(i) Different waiting line structures are:

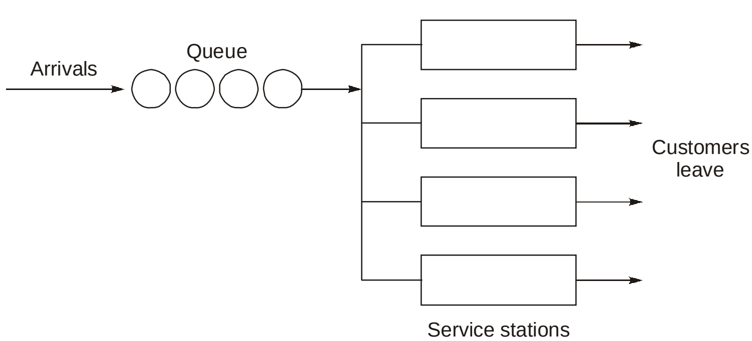
(a) Single server – Single Queue



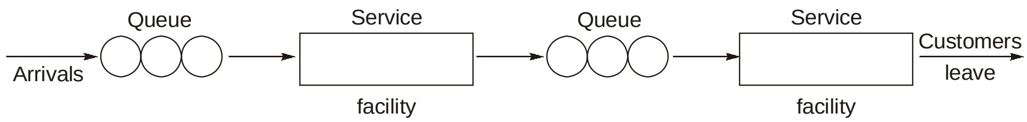
(b) Single Server – Several Queues



(c) Several (Parallel) Servers – Single Queue



(d) Service facilities in series:



(ii) Types of distributions assumed for arrivals and services are:

1. Random arrivals generally follow a Poisson distribution.
2. Service pattern are randomly distributed according to exponential probability distribution.

(iii) Given ($\lambda = \mu$)

$$\text{Utilization factor} = \frac{\lambda}{\mu}$$

$$\rho = 1 \quad (\text{when } \lambda = \mu)$$

and mean waiting time for a customer before being served (W_S) = $\frac{L_S}{\lambda}$

and $$L_S = \left(\frac{\lambda}{\mu - \lambda}\right)$$

$$W_S = \frac{1}{\mu - \lambda} = \underset{(\text{infinite})}{\infty} \quad [\text{when } \lambda = \mu]$$

Solution : 28

Utility of teller, $P = 0.75$

Average number in waiting line, $L_q = 2.25$ person

Average number in the system, $L_s = 3$ person

Average waiting time in line, $W_q = 9$ min.

Average waiting time in system, $W_s = 12$ min.

Present level of service for 3 or fewer persons = 68.4%

$$\text{Utilization, } \rho = 0.47$$

Solution : 29

The service of repairman *B* should be used.

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5 Scheduling, Line Balacning

LEVEL 1 Objective Questions

1.	(a)
2.	(c)
3.	(c)
4.	(d)
5.	(b)
6.	(c)
7.	(d)
8.	(d)
9.	(c)
10.	(c)
11.	(d)
12.	(c)
13.	(c)
15.	3(2.5 to 3.2)
16.	35.71(34.02 to 36.45)
17.	(c)
18.	(a)

LEVEL 2 Objective Questions

19.	(b)
20.	(a)
21.	(d)
22.	(37) (No range)
23.	(22.22)(21 to 23)
24.	23.33(22.9 to 23.58)
25.	14.4(14.1 to 14.8)
26.	87.14(86.84 to 87.84)
27.	6 (no range)
28.	14%
29.	(a)
30.	80(79 to 81)
31.	(a)
32.	(43)
33.	71.88(70.26 to 72.36)
34.	6(4.0 to 6.0)
35.	(b)
36.	(14)
37.	20.83(20 to 21)

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LEVEL 3 Conventional Questions

Solution : 38

4-1-5-2-3 (or) 4-5-1-2-3

Solution : 39

1	4	5	3	2	7	6

First Schedule

or

1	5	3	2	4	7	6

Second Sechedule

∴ minimum elapsed time T = 67 hours, Idle time for m/c A = 1 hour

Idle time for m/c B = 17 hours

Solution : 40

The order comes to be

A - C - I - B - H - F - D - G - E

(or)

A - C - I - H - B - F - D - G - E

Optimum cycle times = 61

Idleness of M/c I = 18%

Utilization of M/c II = 81.96%

Idleness of M/c II = 3.3%

Utilization of M/c II = 96.72%

Solution : 41

Work Station	Activity	T_{si} (Station time)
I	1 3 2	216
II	5 4 6	222
III	7 8 9 10	228

Actual production rate = 10216 units

Solution : 42

Work Station	Element	T_{Si}	Idle time
I	1 2	5 + 3 = 8	2
II	5, 3	6 + 4 = 10	0
III	6, 10, 9	5 + 4 + 1 = 10	0
IV	4, 7, 11	3 + 2 + 4 = 9	1
V	12	7	3
VI	8	6	4

Balance delay = 16.67%

Line efficiency n_L = 83.33%

Smoothness Index (SI) = 5.477

Solution : 43

- Shortest Processing Time (SPT)
- Earliest Due Date (EDD)
- Minimum Slack Time (MST)

Slack time Remaining = Due time – processing time

- Critical Ratio Rule

$$\text{Critical ratio} = \frac{\text{Due time}}{\text{Processing time}}$$

Optimum sequence, E - D - C - A - B - F

Job	Preparation time		Point shop time	
	In	Out	In	Out
E	0	2	2	8
D	2	5	8	16
C	5	10	16	23
A	10	20	23	28
B	20	27	28	32
F	27	31	32	35

∴ Make span time = 35 Hours.

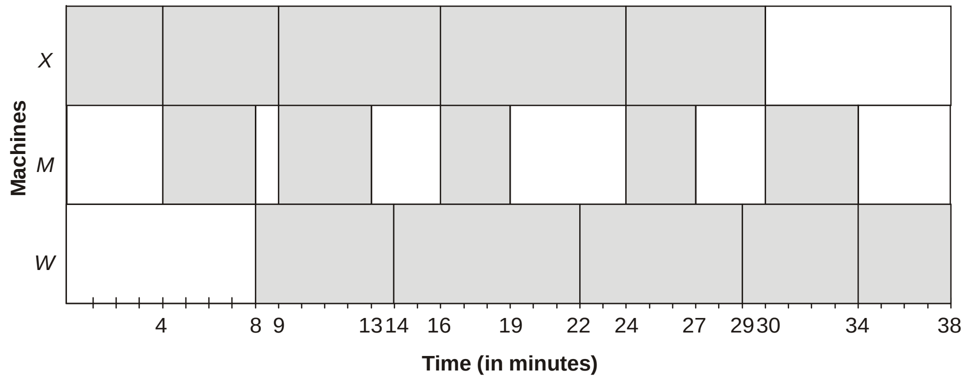
Solution : 44

Optimal sequence, $A \rightarrow L \rightarrow O \rightarrow N \rightarrow E$

There is no alternative sequences possible.

	X		M		W	
Job	In	Out	In	Out	In	Out
A	0	4	4	8	8	14
L	4	9	9	13	14	22
O	9	16	16	19	22	29
N	16	24	24	27	29	34
E	24	30	30	34	34	38
Process time (PT):	30		18		30	

Make span time = 35 minutes.



Utilization % of machine, X = 78.95%

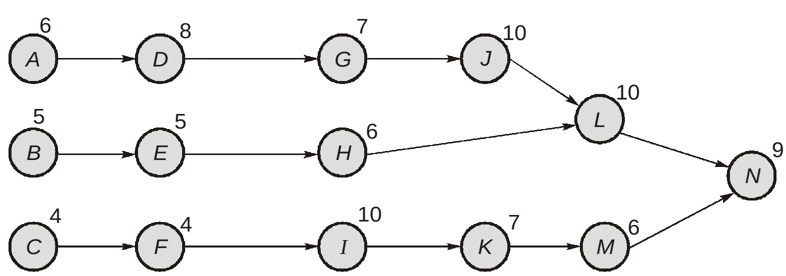
Idle time for machine, M = 20 min

Utilization % of machine, M = 47.37%

Idle time for machine, W = 8 minutes

Utilization % of machine, M = 78.95%

Solution : 45



Work Station	Element	Station Time (T_{si})	Idle Time ($T_c - T_{si}$)
I	*A*-6 *B*-5 *E*-5 *C*-4	20	0
II	*D*-8 *G*-7 *F*-4	19	1
III	*I*-10 *J*-10	20	0
IV	*K*-7 *H*-6 *M*-6	19	1
V	*L*-10 *N*-9	19	1

Total work duration of all the tasks = 97 min

Cycle time (T_c) = 20 min

The optimal number of work stations = 5

Balnce delay = 3%

Line efficiency = 97%

■■■■

6 PPC and MRP

LEVEL 1 Objective Questions

1.	(b)
2.	(d)
3.	(c)
4.	(b)
5.	(a)
6.	(d)
7.	(b)
8.	(d)
9.	(a)
10.	(a)
11.	(c)
12.	(b)
13.	(d)
14.	(c)
15.	(c)
16.	(c)
17.	(a)
18.	(a)

LEVEL 2 Objective Questions

19.	(a)
20.	(d)
21.	(405)
22.	(c)
23.	(d)
24.	(b)
25.	(a)
26.	(d)
27.	(b)
28.	(c)
29.	(b)
30.	(b)
31.	(d)
32.	(c)
33.	(d)
34.	7(6.2 to 7.4)

■■■■

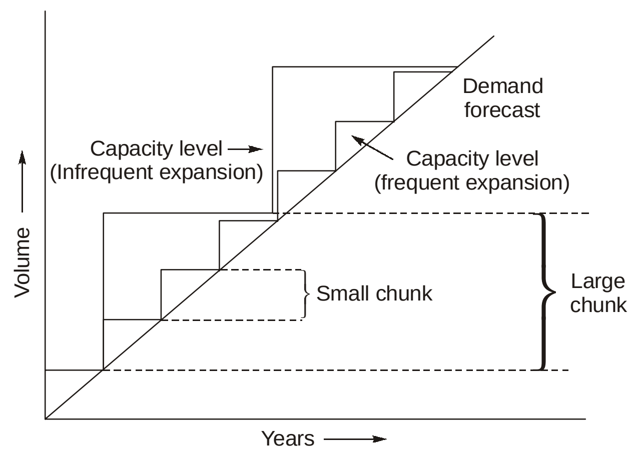
LEVEL 3 Conventional Questions

Solution : 35

Capacity Expansion: There are two types of costs to consider when adding or expanding capacity ®the cost of upgrading too frequently and that of upgrading too infrequently. Upgrading capacity too frequently is expensive. Direct costs including removing and replacing old requirements and training employees on the new equipment. In addition, the new equipment must be purchased, often for considerably more than the selling price of the old. Finally, there is the opportunity cost of idling the plant or service site during the changeover period.

Conversely, upgrading the capacity too infrequently is also expensive. Infrequent expansion means that capacity is purchased into the large chunks. Any excess capacity that is purchased must be carried as overhead until it is utilized.

Frequent versus Infrequent Capacity Expansion.



Solution : 36

Material Requirements Planning (MRP) is a production planning, scheduling, and inventory control system used to manage manufacturing processes. MRP works backward from a production plan for finished goods to develop requirements for components and raw materials.

Objectives:

1. To ensure that material and components are available for production, and final products are ready for dispatch.
2. To ensure minimum-inventory level and right quantity of material is available at the right time to produce right quantity of final products.
3. To ensure planning of all manufacturing processes, this involves scheduling of different job works as to minimize or remove any kind of idle time for machines and workers.

Dependent Demand : It is demand for component parts or subassemblies. Dependent demand depends upon the number of finished goods required or on number of other items.

Lot size : The part quantities issued in the planned order receipt and planned order release sections of an MRP schedule.

Gross Requirements : These are the total requirements for each item and calculated from the planned order release schedule of each final item.

Time phasing : Materials that are planned with the time phased planning technique are provided with the MRP date in the file. It represents the date on which the material is to be planned again and is calculated on the basis of the planning cycle.

Net requirement : The requirements of an item based on its gross requirements, minus stock already on-hand and scheduled receipts is defined as net requirement.

Solution : 37

$$N = 25 \text{ machine}$$

Solution : 38

Rounding off to higher integer $k_c = 5,\ k_p = 9$

Actual safety

$$\alpha_c = 25\%$$
$$\alpha_p = 12.5\%$$

Rounding off to lower integer $k_c = 4,\ k_p = 8$

$$\alpha_c = 0$$
$$\alpha_p = 0$$

Reduces safety factor to zero.

■■■■

7 Linear Programming

LEVEL 1 Objective Questions

1.	(b)
2.	(b)
3.	(c)
4.	(a)
5.	(b)
6.	(a)
7.	(6) (No range)
8.	(d)
9.	(c)
10.	(c)
11.	(d)
12.	(d)
13.	(c)
14.	(c)
15.	(b)
16.	(c)
17.	(c)
18.	(b)
19.	(d)

LEVEL 2 Objective Questions

20.	(28000)
21.	(a)
22.	(b)
23.	(3) (No range)
24.	(d)
25.	(– 2)
26.	(d)
27.	(a)
28.	(c)
29.	(c)
30.	(b)

■■■■

LEVEL 3 Conventional Questions

Solution : 31

Thus x_1 and x_2 are the decision variables for the said LPP.
The objective is to choose the values of x_1 and x_2 so as to maximize

$$Z = 3x_1 + 5x_2$$

Subject to restriction $x_1 \leq 4$

$$2x_2 \leq 12$$

$$3x_1 + 2x_2 \leq 18$$

and $x_1 \geq 0$ and $x_2 \geq 0$

Maximum profit, Z_{max} = ` 36000 per week

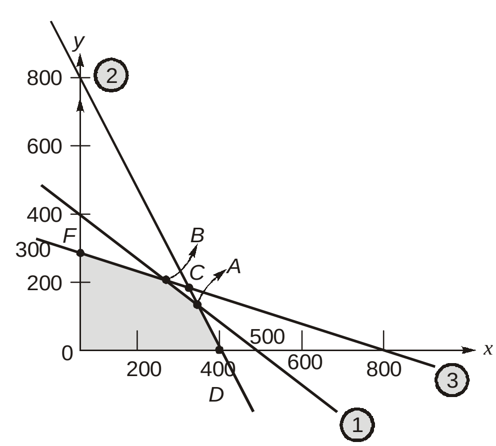
Solution : 32

(i) **Degeneracy :** An LP is degenerate if in a basic feasible solution, one of the basic variables takes on a zero value. Degeneracy is caused by a redundant constraints and could cost simplex method extra iterations.

(ii) **Alternative Optima :** An alternative optimal solution also called as an alternate optima, which is when a linear/integer programming problem has more than one optimal solution. Typically, an optimal solution is a solution to a problem which satisfies the set of constraints of the problem and the objective function which is to maximize or minimize. Alternate optima are said to exist when in the final objective function row, there exists $Z_j - C_j$ values (reduced objective function coefficients) which are zero for non basic variables. These non basic variables may then enter the basis (without altering the value of the objective function) and an alternative optimal solution is obtained.

(iii) **Unbounded solution :** In some linear programming models, the value of the variables may be increased indefinitely without violating any of the constraints, meaning that the solution space is unbounded in atleast one direction. As a result, the objective function may increase (maximization case) or decrease (minimization case) indefinitely. In this case both the solution space and the optimum objective value are unbounded. The rule for recognizing unboundedness is that if at any iteration all the constraint coefficients of any non basic variables are zero or negative, then the solution space is unbounded in that direction. If, in addition, the objective coefficient of that variable is negative in the case of maximization or positive in the case of minimization, then the objective function is unbounded as well.

Solution : 33



$$\text{Product } 'B' = y$$
$$\text{Profit, } z = 120x + 100y$$

Constraints,
$$2x + 2.5y \leq 1000 \quad \text{... (i)}$$
$$3x + 1.5y \leq 1200 \quad \text{... (ii)}$$
$$1.5x + 4.0y \leq 1200 \quad \text{... (iii)}$$
$$x, y \geq 0$$

or A = In integer form (333, 133)

$$Z_A = (120 \times 333 + 100 \times 133) = 53260 \text{ - Optimum profit.}$$

Solution : 34

$$Z = 3x_1 + 2x_2 + 5x_3 = 2 \times 100 + 5 \times 230 = 1350$$

Solution : 35

Taking whole numbers, $\begin{pmatrix} x = 11 \\ y = 11 \end{pmatrix}$

$$\text{Profit } (z) = 10 \times 11 + 10 \times 11 = 220$$

Solution : 36

Since the maximum profit is Rs. 500 at point $C(6, 2)$, therefore the optimum point is C.

Number of products of type A to be produced are 6 and

Number of products of type B to be produced are 2.

Solution : 37

The company should produce 7.5 pages in magazine I and 5 pages in magazine II to maximize its reach i.e. to 27500 people.

■■■■

8 Transportation & Assignment

LEVEL 1 Objective Questions

2. (a)
3. (b)
4. (c)
5. (c)
6. (a)
7. (a)
8. (b)
9. (d)
10. (b)

LEVEL 2 Objective Questions

11. (1156)
12. (13)
13. (b)
14. (4550) (No range)
15. 128(127.5 to 128.5)
16. (20)
17. (c)
18. (b)
19. (c)
20. (a)

■■■■

LEVEL 3 Conventional Questions

Solution : 21

Optimal assignment is

$1 \to B$

$2 \to A$

$3 \to E$

$4 \to C$

$5 \to D$

	A	B	C	D	E
1	12	[0]	~~0~~	7	~~0~~
2	[0]	10	8	10	~~0~~
3	~~0~~	8	4	2	[0]
4	23	1	[0]	~~0~~	5
5	15	5	~~0~~	[0]	1

Maximum profit = ₹ 196000

Solution : 22

$B \to a$; $E \to b$; $D \to c$; $A \to d$; $F \to e$; $C \to f$

Solution : 23

Maximum profit = 77000

North west corner rule is used to get initial basic feasible solution in transportation problem. This method starts in the cell (route) corresponding to the north west corner or the upper left of the table with maximum amount allocated to the selected cell and adjust the associated supply and demand quantities by subtracted the allocated quantity. This method is repeated until all the allocations are made.

Solution : 24

(i) The North-West Corner Rule is a method adopted to compute the initial feasible solution of the transportation problem. The name North-West Corner is given to this method because the basic variables are selected from extreme left corner.

(ii) If the basic feasible solution of a transportation problem with 'm' origins and 'n' destinations has fewer than $(m + n - 1)$ positive x_{ij} (occupied cells), the problem is said to be a degenerate transportation problem. Degeneracy can occur at two stages.

- At the initial solution
- During the testing of the optimal solution.

To resolve degeneracy, we make use of an artificial quantity ($\in$). The quantity '$\in$' is assigned to that unoccupied independent cell (i.e. it should not make close loop), which has the minima transportation cost.

The quantity '$\in$' is so small that it does not affect the supply and demand constraints.

Transportation cost = 475

Optimality check is done with,

- Stepping stone method
- MODI or UV method.

Solution : 25

As there are more than one zero in each row and column, multiple assignments are possible.

$$\begin{bmatrix} C_1 \rightarrow M_1 \\ C_2 \rightarrow M_2 \\ C_3 \rightarrow M_3 \\ C_4 \rightarrow M_4 \end{bmatrix}$$

Solution (cost) = 10 + 10 + 20 + 6 = 46

$$\begin{bmatrix} C_1 \rightarrow M_3 \\ C_2 \rightarrow M_2 \\ C_3 \rightarrow M_1 \\ C_4 \rightarrow M_4 \end{bmatrix}$$

Cost = 8 + 10 + 22 + 6 = 46

Solution : 26

Feasible solution (optimum) :

44	50	40 ($\in$)	39 (180)	0
42 (90)	51 (20)	54	53	0 (60)
41	40 (80)	42 (120)	45	0

Transportation cost = Rs 20060.

Solution : 27

Jobs		**Machines**
A	$\rightarrow$	W
B	$\rightarrow$	X
C	$\rightarrow$	Y

Solution : 28

Optimum assignment is

$A \rightarrow 1$, $B \rightarrow 2$, $C \rightarrow 4$, $D \rightarrow 3$

Total work time = 20 + 34 + 18 + 35 = 107 hours.

■■■■

9 Element of Computation and Maintenance

LEVEL 1 Objective Questions

1.	(a)
2.	(c)
3.	(a)
4.	(b)
5.	(b)
6.	(d)
7.	(d)
8.	(d)
9.	(a)
10.	(c)
11.	(d)
12.	(d)

LEVEL 2 Objective Questions

13.	(a)
14.	(c)
15.	(c)
16.	(a)
17.	(0.025) (0.020 to 0.030)
18.	(2) (3.5 to 4.5)
19.	9.48(8 to 11)
20.	(d)
21.	(c)

■■■■