Sl.: 02DLSK_ME_IJKLMNO_200826

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INDUSTRIAL ENGINEERING

MECHANICAL ENGINEERING

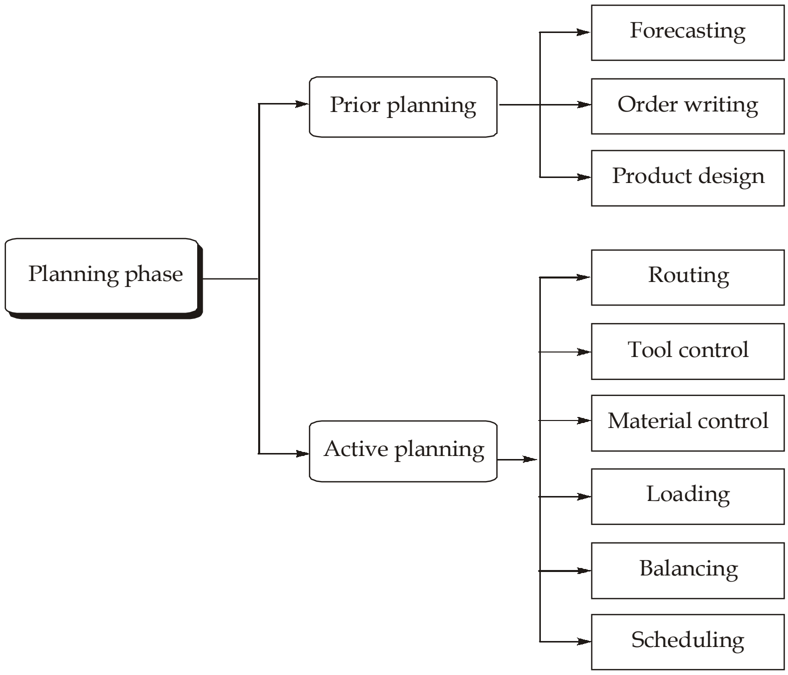
Date of Test : 20/08/2026

ANSWER KEY

1.	(d)	7.	(a)	13.	(c)	19.	(c)	25.	(c)
2.	(d)	8.	(c)	14.	(c)	20.	(b)	26.	(b)
3.	(b)	9.	(d)	15.	(b)	21.	(a)	27.	(c)
4.	(b)	10.	(d)	16.	(c)	22.	(d)	28.	(b)
5.	(b)	11.	(b)	17.	(b)	23.	(b)	29.	(c)
6.	(c)	12.	(b)	18.	(c)	24.	(b)	30.	(c)

DETAILED EXPLANATIONS

1. (d)



2. (d)

Objectives of loading and scheduling:

1. Scheduling aims to achieve the required rate of output with a minimum of delay, and disruption in processing.
2. To provide quantities of goods necessary to maintain finished inventories at levels predetermined to meet delivery commitments.
3. The aim of loading and scheduling is to have maximum utilization of men, machines and materials by maintaining a free flow of materials along the production line.
4. To prevent unbalanced allocation of time among production departments or work centres with a view to eliminate idle capacity.
5. To keep the production cost minimum.

3. (b)

As per SPT rule:

Jobs	Processing time	Due date	Job flow time
A	5	11	5
C	9	13	14
E	11	26	25
B	13	19	38
D	16	31	54

$$\text{Average job flow time using SPT rule} = \frac{5+14+25+38+54}{5} = 27.2$$

As per EDD rule:

Jobs	Processing time	Due date	Job flow time
A	5	11	5
C	9	13	14
B	13	19	27
E	11	26	38
D	16	31	54

Average job flow time using EDD rule = $\frac{5+14+27+38+54}{5}$ = 27.6

Now, $\frac{\text{Avg. job flow time using SPT}}{\text{Avg. job flow time using EDD}} = \frac{27.2}{27.6}$ = 0.9855 = 98.55%

4. **(b)**

Using S.M.A. for 3 period:

$$F_6 = \frac{D_5 + D_4 + D_3}{3} = \frac{434+399+390}{3} = 407.667 \text{ units}$$

Using S.M.A for 4 period:

$$F_6 = \frac{D_5 + D_4 + D_3 + D_2}{4} = \frac{434+399+390+350}{4} = 393.25 \text{ units}$$

Now, $(F_6)_{SMA3} - (F_6)_{SMA4}$ = 407.667 – 393.25 = 14.42 units

5. **(b)**

Activity on node diagram does not need any dummy activity and these are considered as simple and easy. These are preferred for line balancing. Event on node or activity on arrow diagram is preferred for PERT and CPM.

6. **(c)**

In SDE inventory control system, inventory are classified on the basis of availability for the production system.

S = Scarce
D = Difficult
E = Easy

7. **(a)**

Given: Arrival rate, $\lambda = \frac{7}{5}$ = 1.4 customer/minute

Service rate, $\mu = \frac{10}{5}$ = 2 customer/minute

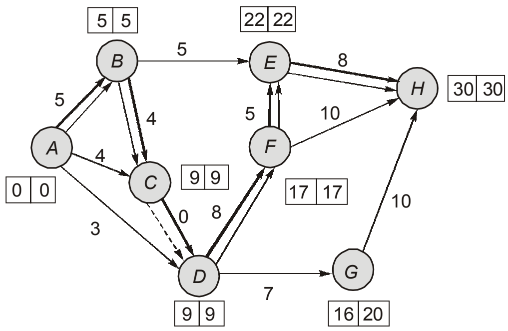
$$\rho = \frac{\lambda}{\mu} = \frac{1.4}{2} = 0.7$$

The average time a customer waits before being served is waiting time in queue for customer.

Waiting time in queue, $W_q = \frac{\rho^2}{(1-\rho)\times\lambda} = \frac{(0.7)^2}{(1-0.7)\times 1.4}$

W_q = 1.1667 minutes ≈ 1.2 minutes

8. (c)



Earliest expected time of the project completion is critical path duration.

∴ Project duration is 30 days

9. (d)

$$\text{Cycle time} = 6 \text{ (Maximum work station time)}$$

$$\text{Balance delay} = 1 - \left(\frac{\text{Total work}}{n \times \text{cycle time}}\right)$$

$$\text{BD} = 1 - \left(\frac{3+4+6+5+6+6}{6 \times 6}\right) = 1 - \frac{5}{6} = \frac{1}{6} \times 100$$

$$= 16.667\% \approx 16.7\%$$

10. (d)

11. (b)

Let the straight line trend equation is,

$$y = a + bx$$

where a and b are constants.

Year	Time(x)	$x_1 = (x-4)$	y	$x_1 y$	x_1^2
2004	1	–3	77	–231	9
2005	2	–2	88	–176	4
2006	3	–1	94	–94	1
2007	4	0	85	0	0
2008	5	1	91	91	1
2009	6	2	98	196	4
2010	7	3	90	270	9
		$\Sigma x_1 = 0$	$\Sigma y = 623$	$\Sigma x_1 y = 56$	$\Sigma x_1^2 = 28$

Let,

$$y = a + bx_1$$

$$\Sigma y = \Sigma a + b\Sigma x_1$$

$$623 = n \times a + b \times 0$$

$$a = \frac{623}{7} = 89$$

$$\Sigma x_1 y = a\Sigma x_1 + b\Sigma x_1^2$$

$$56 = a \times 0 + b \times 28$$

$$b = 2$$

Now, linear regression best line of fit, $y = 89 + 2x_1$

$$y = 89 + 2(x - 4)$$

$$y = 81 + 2x$$

For year 2012, $x = 9$

$$y = 81 + 2 \times 9 = 99 \text{ units}$$

12. **(b)**

For 700 units of A, units of B required = 3 × 700 = 2100 unit

Net requirement of B = 2100 – (200 + 120) = 1780 units

For 1780 units of B, units of E required = 1780 × 4 = 7120 units

Net requirement of C = 2 × 700 – (220 + 50) = 1130 units

For 1130 units of C, units of E required = 1130 × 3 = 3390 units

Net requirement of E = 7120 + 3390 – (310 + 250) = 9950 units

13. **(c)**

Using Johnson's algorithm. Find out the minimum time of printing and binding. If the minimum is for printing then perform job at the start or if the minimum is for binding then perform job in the last. Repeat the above process.

4	1	3	2	5	6

Book	Printing machine		Binding machine	
	In time	Out time	In time	Out time
4	0	20	20	80
1	20	50	80	160
3	50	100	160	250
2	100	220	250	350
5	220	310	350	380
6	310	410	410	420

Hence make span time is 420 hours.

14. **(c)**

Given: Demand, D = 4000 units per year

Total ordering cost, C_o = (13 + 12) = ₹ 25 per order

Total carrying cost based on average inventory, $(C_h)_1$ = 0.056 + 0.004 = ₹ 0.06 per unit per year

Inventory carrying cost based on maximum inventory, $(C_h)_2$ = ₹ 0.02 /unit/year

$$\text{Total variable cost} = (C_h)_1 \times \frac{Q}{2} + (C_h)_2 \times Q + C_o \times \frac{D}{Q}$$

$$= 0.06 \times \frac{Q}{2} + (0.02) \times Q + 25 \times \frac{4000}{Q}$$

$$TVC = \left(0.05Q + \frac{100000}{Q}\right)$$

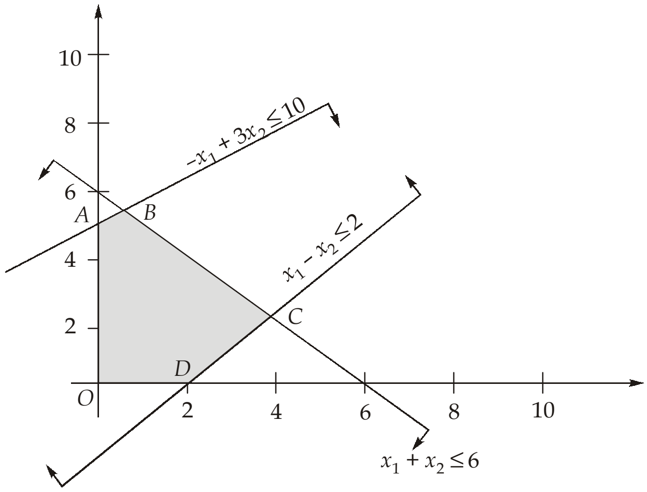
$$\text{At } EOQ, \quad \frac{d(TVC)}{dQ} = 0$$

$$0.05 - \frac{100000}{Q^2} = 0$$

$$Q = \sqrt{\frac{100000}{0.05}}$$

Economic order quantity, Q = 1414.213 units

15. (b)



Feasible region for the given constraint is $OABCD$.

Coordinates of the vertices of polygon $OABCD$ are,

For point B, $-x_1 + 3x_2 = 10$ ...(1)

$x_1 + x_2 = 6$ ...(2)

On adding 1 and 2, $4x_2 = 16$

$x_2 = 4$

$x_1 = 6 - 4 = 2$

$B(2, 4)$

For point C, $x_1 - x_2 = 2$ ...(3)

$x_1 + x_2 = 6$ ...(4)

On adding 3 and 4, $2x_1 = 8$

$x_1 = 4$

$x_2 = 6 - 4 = 2$

$C(4, 2)$

Hence, $O(0, 0)$, $A(0, 10/3)$, $B(2, 4)$, $C(4, 2)$, $D(2, 0)$

Value of objective functions at vertices,

$$Z(O) = 0 + 0 = 0$$

$$Z(A) = -0 + 2 \times \frac{10}{3} = \frac{20}{3}$$

$$Z(B) = -2 + 2 \times 4 = 6$$

$$Z(C) = -4 + 2 \times 2 = 0$$

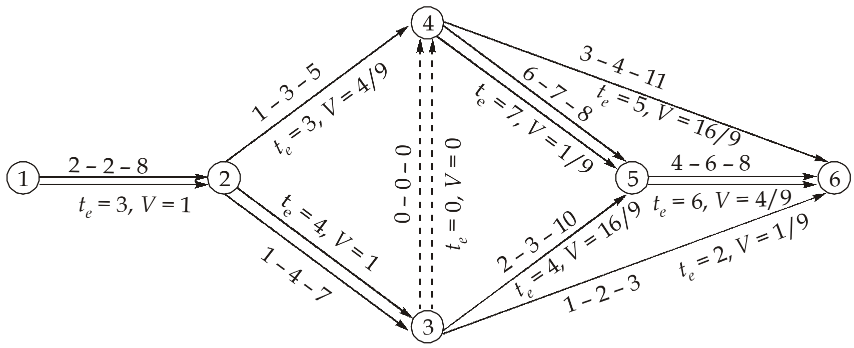
$$Z(D) = -2 + 0 \times 2 = -2$$

Hence, minimum value of objective function is – 2.

16. (c)

$$\text{Expected time, } = \frac{t_o + 4t_m + t_p}{6}$$

$$\text{Variance, } V = \left(\frac{t_p - t_o}{6}\right)^2 = \sigma^2$$



Different paths are:

$$
\begin{aligned}
1-2-3-4-5-6 &= 3+4+0+7+6 = 20 \text{ days}\\
1-2-3-5-6 &= 3+4+4+6 = 17 \text{ days}\\
1-2-3-4-6 &= 3+4+0+5 = 12 \text{ days}\\
1-2-3-6 &= 3+4+2 = 9 \text{ days}\\
1-2-4-5-6 &= 3+3+7+6 = 19 \text{ days}\\
1-2-4-6 &= 3+3+5 = 11 \text{ days}
\end{aligned}
$$

Hence, critical path is 1 – 2 – 3 – 4 – 5 – 6. Critical path duration is 20 days.

Variance at critical path, $V = (V)_{1-2} + (V)_{2-3} + (V)_{3-4} + (V)_{4-5} + (V)_{5-6}$

$$= 1 + 1 + 0 + \frac{1}{9} + \frac{4}{9}$$

$$V = \frac{23}{9}$$

Standard deviation of critical path, $\sigma = \sqrt{V} = \sqrt{\frac{23}{9}} = 1.5986$

Probability of completion in 21 days.

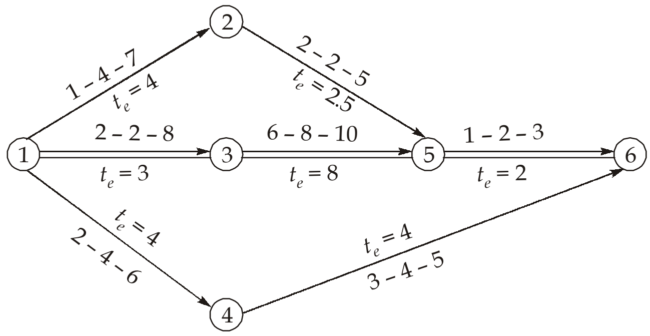
$$Z = \frac{x - \mu}{\sigma} = \frac{21 - 20}{1.5986} = 0.6255$$

Probability of project completion % from given table corresponding to $Z = 0.6255$ is 73.50%

17. (b)

Activity time on arrow is written in $t_o - t_m - t_p$ form.

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$



Different paths are:

$$1-2-5-6 = 4 + 2.5 + 2 = 8.5 \text{ weeks}$$
$$1-3-5-6 = 3 + 8 + 2 = 13 \text{ weeks}$$
$$1-4-6 = 4 + 4 = 8 \text{ weeks}$$

Hence, critical path is 1 – 3 – 5 – 6 and critical path duration is 13 weeks.

$$\text{Variance of critical path} = (V)_{1-3} + V_{3-5} + V_{5-6}$$
$$= \left(\frac{8-2}{6}\right)^2 + \left(\frac{10-6}{6}\right)^2 + \left(\frac{3-1}{6}\right)^2$$
$$V = 1+\frac{4}{9}+\frac{1}{9}=\frac{14}{9}$$

Standard deviation along critical path, $\sigma = \sqrt{V} = \sqrt{\frac{14}{9}}$

Standard deviation along critical path, $\sigma = 1.247 \approx 1.25$

18. (c)

The given problem is maximization type converting it into minimization type. Subtracting all the values from maximum value.

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

Using Hungarian method. Subtracting minimum value of row from all values of corresponding row.

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

Subtracting minimum value of column from all values of corresponding column.

	I	II	III	IV
A	20	65	40	$\boxed{0}$
B	$\boxed{0}$	35	$\cancel{0}$	20
C	10	$\boxed{0}$	$\cancel{0}$	$\cancel{0}$
D	10	10	20	$\cancel{0}$

Number of allocations are less than order of matrix.
So, adding minimum value at intersection of two lines and subtracting from uncovered values.

	I	II	III	IV
A	10	55	30	$\boxed{0}$
B	$\boxed{0}$	35	0	30
C	10	0	$\boxed{0}$	10
D	0	$\boxed{0}$	10	0

Sales men	Territory	Sales
A	IV	220
B	I	160
C	III	190
D	II	175
		745

This is a case of multiple optimal solution. Alternate optimal solution is

Sales men	Territory	Sales
A	IV	220
B	III	150
C	II	195
D	I	180
		745

19. (c)

Given: Annual demand, $D = 1500$

Ordering cost, $C_0 = ₹400$

Carrying cost, C_h = 40% of unit cost

Supplier	Lot size	Price per barrel
1	Any quantity	₹150
2	150 or more	₹140
3	250 or more	₹135

Supplier 1: $\text{EOQ} = \sqrt{\dfrac{2 \times 1500 \times 400}{0.40 \times 150}} = 141.42$

Supplier 2: $\text{EOQ} = \sqrt{\dfrac{2 \times 1500 \times 400}{0.40 \times 140}} = 146.38 \approx 146$

Supplier 3: EOQ $= \sqrt{\dfrac{2 \times 1500 \times 400}{0.40 \times 135}} = 149.07 \approx 149$ barrels

EOQ is below minimum limit for supplier 2 and 3.

For supplier 1: $(TC)_1 = 1500 \times 150 + \sqrt{2 \times 1500 \times 400 \times 0.4 \times 150}$

$= ₹233485.28$

For supplier 2: $(TC)_2 = 1500 \times 140 + \dfrac{1500}{150} \times 400 + \dfrac{150}{2} \times 0.4 \times 140$

$= ₹218200$

For supplier 3: $(TC)_3 = 1500 \times 135 + \dfrac{1500}{250} \times 400 + \dfrac{250}{2} \times 0.4 \times 135$

$= ₹211650$

The total cost is minimum for supplier 3. So order to be placed with supplier 3.

20. (b)

Using NW corner rule,

	I	II	III	IV	
A	2 (20)	1	6	5	40/20
B	7	10	2	5	100
C	4	6	3	8	20
	20/0	40	50	50	

	II	III	IV	
A	~~1(20)~~	~~6~~	~~4~~	20/0
B	10	2	5	100
C	6	3	8	20
	40/20	50	50	

	II	III	IV	
B	10(20)	2	5	100/80
C	6	3	8	20
	20/0	50	50	

	III	IV	
B	2(50)	5	80/30
C	3	8	20
	50/0	50	

	IV	
B	5(30)	30/0
C	8(20)	20/0
	50/20/0	

NW- method

	I	II	III	IV	
A	2(20)	1(20)	6	4	40/20/0
B	7	10(20)	2(50)	5(30)	100/80/30/0
C	4	6	3	8(20)	20/0
	20/0	40/20/0	50/0	50/20/0	

Initial solution using North west corner is

$2 \times 20 + 1 \times 20 + 10 \times 20 + 2 \times 50 + 5 \times 30 + 8 \times 20$

$= 40 + 20 + 200 + 100 + 150 + 160 = ₹670$

Using least cost method:

	I	~~II~~	III	IV	Supply
~~A~~	~~2~~	~~1(40)~~	~~6~~	~~5~~	~~40/0~~
B	7	~~10~~	2	5	100
C	4	~~6~~	3	8	20
Demand	20	40/0	50	50	

	II	~~III~~	IV	
B	7	~~2(50)~~	5	100/50
C	4	~~3~~	8	20
	20	50/0	50	

	~~I~~	IV	
B	~~7~~	5(50)	50/0
~~C~~	~~4(20)~~	~~8~~	~~20/0~~
	20/0	50/0	

	I	II	III	IV	
A	2	1(40)	6	5	40/0
B	7	10	2(50)	5(50)	100/50/0
C	4(20)	6	3	8	20/0
	20/0	40/0	50/0	50/0	

Initial solution using least cost method is

$1 \times 40 + 2 \times 50 + 5 \times 50 + 4 \times 20$

$= 40 + 100 + 250 + 80 = ₹470$

$$\frac{\text{NW corner}}{\text{Least cost}} = \frac{670}{470} = 1.42553$$

21. (a)

$$\text{Cycle time} = T = 1.5 \text{ month} = 0.125 \text{ year}$$

$$N = \frac{1}{T} = 8\,;\ Q = 2250$$

$$\text{Annual demand, } D = N \times Q = 18{,}000 \text{ units}$$

$$\text{TIC}(Q) = \text{O.C} + \text{H.C} = NC_O + \frac{Q}{2}C_h = ₹\ 6025$$

$$\text{TIC}(Q^*) = \sqrt{2DC_oC_h\left(\frac{C_b}{C_h + C_b}\right)} = ₹5452.04$$

$$\%\text{saving} = \frac{TIC(\text{Q}) - TIC(\text{Q}^*)}{TIC(Q^*)} = 10.51\%$$

22. (d)

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

Jobs	C.R.
I	$\frac{32}{8} = 4$
II	$\frac{41}{6} = 6.83$
III	$\frac{28}{9} = 3.11$
IV	$\frac{35}{11} = 3.18$
V	$\frac{46}{10} = 4.6$

Arrange all jobs in increasing order of CR.

Jobs	Processing time	Due date	In	Out
III	9	28	0	9
IV	11	35	9	20
I	8	32	20	28
V	10	46	28	38
II	6	41	38	44

$$\text{Average job flow time} = \frac{9+20+28+38+44}{5} = 27.8$$

23. (b)

We know,
$$Q^* = \sqrt{\frac{2DC_o}{C_h}\left(\frac{C_b+C_h}{C_b}\right)}$$

$C_b = 0.25 \times 20 =$ Rs. 5/unit/year

$C_h = 0.2 \times 20 =$ Rs. 4/unit/year

$$Q^* = \sqrt{\frac{2\times 10000\times 10}{4}\left(\frac{5+4}{5}\right)} = 300 \text{ units}$$

But we know for optimum backorder (S^*) :

$$(Q^* - S^*)C_h = S^* C_b$$
$$(300 - S^*)4 = S^* \times 5$$
$$S^* = \frac{400}{3}$$

24. (b)

To minimize time first apply row transaction (Subtract minimum time of row by other) we get

	M_1	M_2	M_3	M_4
J_1	2	0	1	4
J_2	0	1	4	2
J_3	3	2	$\cancel{8}$	1
J_4	1	3	0	2

Then apply column transaction (Subtract column minimum by others)

	M_1	M_2	M_3	M_4
J_1	2	$\boxed{0}$	1	3
J_2	$\boxed{0}$	1	4	1
J_3	3	2	0	$\boxed{0}$
J_4	1	3	$\boxed{0}$	1

So, $J_1 = M_2$, $J_2 = M_1$, $J_3 = M_4$, $J_4 = M_3$

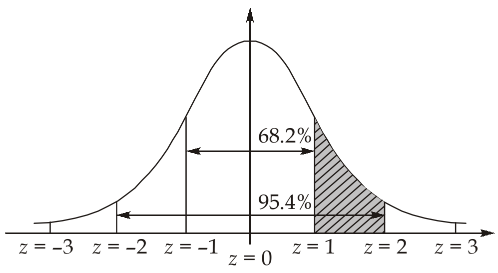
25. (c)

$$T_e = \frac{t_o + 4\times t_m + t_p}{6}$$

$$\bar{x} = T_e = \frac{9 + 15 \times 4 + 21}{6} = 15 \text{ days}$$

$$z = \frac{x - \bar{x}}{\sigma}$$

$$\sigma = \frac{t_p - t_o}{6} = \frac{21 - 9}{6} = 2 \text{ days}$$



$$Z_{x=17} = \frac{17 - 15}{2} = 1$$

$$Z_{x=19} = \frac{19 - 15}{2} = 2$$

We know when, $z = 0$

Probability = 50%

So, when $z = 1$

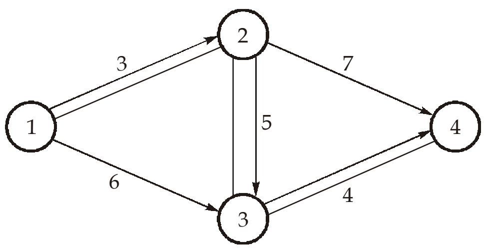
$$P(x) = 50 + \frac{68.2}{2} = 84.1\%$$

when $z = 2$

$$P(x) = 50 + \frac{95.4}{2} = 97.7\%$$

Between $P(19)$ and $P(17)$ = 97.7 – 84.1 = 13.6%

26. **(b)**



Critical path 1 - 2 - 3 - 4

Total time, t_E = 12 days

Total cost = Direct cost (DC) + Indirect cost (IDC)

DC = 500 + 1400 + 1000 + 1150 + 1000

= Rs. 5050

IDC = 12 × 900 = Rs 10800

So, we have to crash total time to 10 days, we have to find cost time slope of all the activity

$$\frac{\Delta C}{\Delta t} = \frac{C_C - C_N}{T_N - T_C}$$

Activity	$\Delta C/\Delta T$
1 - 2	500
1 - 3	600
2 - 3	400
2 - 4	300
3 - 4	700

So we will take activity for crash which have minimum cost time slope along a critical path. So in activity

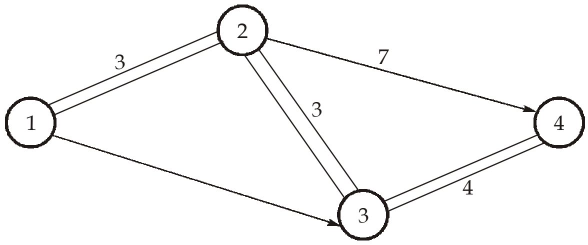
(1-2) → 500 (Maximum 1 day crash)

(2-3) → 400 (Maximum 2 day crash)

(3-4) → 700 (Maximum 2 day crash)

So, we choose (2-3) activity for crashing 2 days.

So, new network diagram after crashing,



So,

$$T_E = 10 \text{ days}$$
$$DC = 5050 + 400 \times 2 = \text{Rs } 5850$$
$$ICC = 10 \times 900 = 9000$$
$$TC = 9000 + 5850$$
$$= \text{Rs. } 14850$$

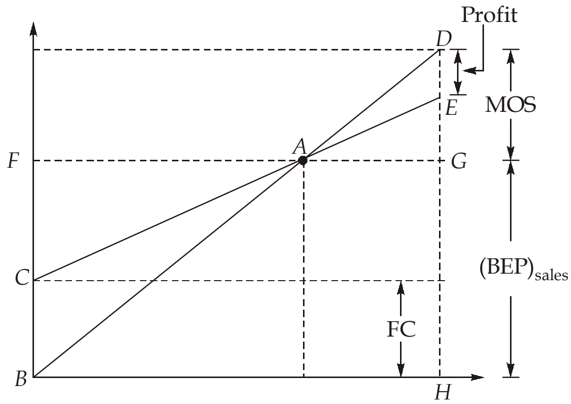
27. (c)

When in the final solution artificial variable remain in the basis then there is no solution to such problem.

28. (b)

$$\text{Fixed cost} = \text{Rs. } 10 \text{ lakhs}$$
$$(BEP)_{sales} = \text{Rs. } 20 \text{ lakhs}$$
$$\text{Actual sales} = \text{Rs. } 50 \text{ lakhs}$$

From break even analysis we have,



From figure, $BF = GH = (BEP)_{sales}$ and $\Delta ABC \sim \Delta ADE$

$$\frac{AB}{BC} = \frac{AD}{DE} \quad \text{... (i)}$$

Similarly, $\Delta BFA \sim \Delta DGA$

$$\frac{AB}{BF} = \frac{AD}{DG} \quad \text{... (ii)}$$

From equation (i) and (ii), we get,

$$\frac{DE}{BC} = \frac{DG}{BF}$$

$$\therefore \qquad \frac{\text{Profit}}{\text{Fixed cost}} = \frac{\text{MOS}}{(\text{BEP})_{\text{sales}}}$$

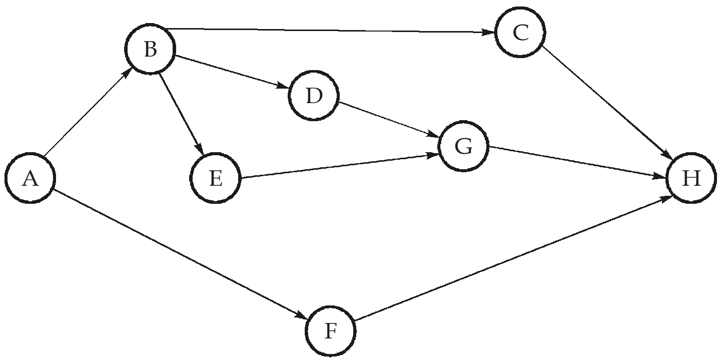
$$\text{Profit} = \frac{\left[\text{Actual sales} - (\text{BEP})_{\text{sales}}\right]}{(\text{BEP})_{\text{sales}}} \times \text{Fixed cost}$$

$$= \left(\frac{50-20}{20}\right) \times 10 = \text{Rs. 15 lakhs}$$

29. (c)

Given: Cycle time (T_C) = 60 seconds.

Network diagram for given work element would be,



According to largest candidate rule (highest task time first) rearranging the table we get,

Work element	Time (s)	Immediate predecessor(s)
B	40	A
D	35	B
H	30	C, F, G
F	25	A
C	20	B
A	15	-
G	10	D, E
E	5	B

Now,

Work station	Element	T_i	T_{si}	Idle time
I	A B E	15 40 5	60	0
II	D F	35 25	60	0
III	G C H	10 20 30	60	0

Total number of work stations are 3.

30. **(c)**

Given:

9	15	6	14	18
7	5	10	4	13
11	14	13	10	14
19	22	15	26	24
12	8	10	9	13

We need to perform optimization (or) find total minimum cost, then

STEP-I: Make atleast one zero in each column and row by subtracting least value cell from each cell of respective row (or) column.

We get,

2	9	$\boxed{0}$	8	8
2	1	6	$\boxed{0}$	5
$\boxed{0}$	4	3	$\cancel{0}$	$\cancel{0}$
3	7	$\cancel{0}$	11	5
3	$\boxed{0}$	2	1	1

$\because$ Number of allocation = 4 < Size of matrix = 5

We need to perform optimality test,

STEP-II:

2	9	$\boxed{0}$	8	8
2	1	6	$\boxed{0}$	5
$\boxed{0}$	4	3	$\cancel{0}$	$\cancel{0}$
3	7	$\cancel{0}$	11	5
3	$\boxed{0}$	2	1	1

Now, we need to subtract smallest element cell from each cell except cells having line passing through them and add smallest elements at intersection of lines.

STEP-III:

$\boxed{0}$	7	$\cancel{0}$	6	6
2	1	8	$\boxed{0}$	5
$\cancel{0}$	4	5	$\cancel{0}$	$\boxed{0}$
1	5	$\boxed{0}$	9	3
3	$\boxed{0}$	4	1	1

Now, number of allocations are equal to size of matrix, then the obtained solution is optimized.

$\therefore$ Total minimum cost = 9 + 4 + 14 + 15 + 8 = 50

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