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CLASS TEST

MECHANICAL ENGINEERING

Date of Test : 07/10/2021

ANSWER KEY ➤ Industrial Engineering

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

DETAILED EXPLANATIONS

1. (d)

In VED method inventories are classified on the basis of importance for the production system.

$V \rightarrow$ Vital

$E \rightarrow$ Essential

$D \rightarrow$ Desirable

2. (b)

$D = 50000\ C_0 = ₹25,\ C_u = ₹40,\ C_h = 0.1$ of $C_u = 0.1 \times 40 = ₹4$

$$EOQ = \sqrt{\frac{2DC_0}{C_h}} = \sqrt{\frac{2 \times 50000 \times 25}{4}} = 790.569 \text{ units}$$

$\because$ EOQ > Maximum quantity that can be ordered at ones.

So, $$(TIC)_{Q\,=\,600} = \frac{D}{Q} \times C_0 + \frac{Q}{2} \times C_h = \frac{50000}{600} \times 25 + \frac{600}{2} \times (40 \times 0.1) = ₹3283.33$$

Alternate:

$$TIC = \frac{\sqrt{2DC_0C_h}}{2}\left[k + \frac{1}{k}\right] \qquad \left\{k = \frac{Q^*}{Q}\right\}$$

$$= \frac{\sqrt{2 \times 50000 \times 25 \times 4}}{2}[1.317615 + 0.758947]$$

$$TIC = ₹3283.33$$

3. (c)

Where,
D = Total demand
C = Cost per unit
C_h = Holding cost
C_0 = Ordering cost
Q^* = Quantity ordered at EOQ.

Given, Total worth = ₹100000

$D \times C = 100000$

$C_0 = 1.5\%$ of $(Q^* \times C)$

$C_h = 8\%$ of C

$$Q^* = \sqrt{\frac{2DC_0}{C_h}} = \sqrt{\frac{2 \times \left(\frac{100000}{C}\right) \times 1.5 \times Q^* \times C \times 100}{100 \times 8 \times C}} = \sqrt{\frac{150000 \times Q^*}{4 \times C}}$$

$$(Q^*)^2 = 37500 \times \frac{Q^*}{C}$$

$$(Q^* \times C) = ₹37500$$

4. (d)

If all the values in the replacement ratio column are either negative or infinite then the solution terminates and it is the case of unbounded solution.

7. (b)

By Hungarian's Method:

Step: 1

Subtracting the smallest element in each row from every element of corresponding row.

16	8	12	0
0	8	5	13
16	2	18	0
0	16	8	4

Step: 2

Subtracting the smallest element of each column from every element of corresponding column.

16	6	7	0
0	6	0	13
16	0	13	0
0	14	3	4

→ Opportunity cost matrix

Step: 3

Making allocation in opportunity cost matrix:

16	6	7	$\boxed{0}$
$\cancel{0}$	6	$\boxed{0}$	13
16	$\boxed{0}$	13	$\cancel{0}$
$\boxed{0}$	14	3	4

Allocation are, $A \to S$, $B \to R$, $C \to Q$, $D \to P$

$$\text{Minimum time} = 20 + 26 + 22 + 33 = 101 \text{ hours}$$

9. (d)

$$\text{Total float} = L_j - (E_i + t_{Eij}) = 19 - (5 + 10) = 4$$

$$\text{Independent float} = E_j - (L_i + t_{Eij}) = 17 - (6 + 10) = 1$$

$$\text{T.F.} - \text{I.F.} = 4 - 1$$

$$\text{T.F} - \text{I.F.} = 3$$

10. (d)

We know that,

$$\left(\frac{P}{V}\right)_{\text{ratio}} = \frac{(S-V)}{S} \times 100\% = \frac{(1000000 - 650000)}{1000000} \times 100\%$$

$$= 35\%$$

$$\text{BEP} = \frac{\text{Fixed cost}}{\left(\frac{P}{V}\right)_{\text{ratio}}} = \frac{90000}{0.35} = ₹257142.86$$

$$(\text{BEP})_{\text{sales}} \approx ₹257143$$

11. (a)

Minimum processing time on M_1 is = 7
Maximum processing time on M_2 is = 5
Maximum processing time on M_3 is = 6
Minimum processing time on M_4 is = 6
Minimum $M_{1j} \geq$ Maximum M_{2j}, Maximum M_{3j}
Minimum $M_{4j} \geq$ Maximum M_{2j}, Maximum M_{3j}
We can reduce this problem to n jobs on 2 machines. Processing times $M_{1j} + M_{2j} + M_{3j}$ and $M_{4j} + M_{2j} + M_{3j}$ for each job and solving the problem.

Combination of Machines \ Jobs	*P*	*Q*	*R*	*S*	*T*
$M_1 + M_2 + M_3$	18	20	12	15	19
$M_2 + M_3 + M_4$	20	21	14	9	15

R – P – Q – T – S
Hence the required optimum sequence is R – P – Q – T – S.

12. (a)

$$\text{MAD} = \frac{\sum_{i=1}^{n} |D_i - F_i|}{n}$$

$$= \frac{\{|110-96| + |124-127| + |119-134| + |134-112|\}}{4}$$

$$= \frac{14+3+15+22}{4} = \frac{54}{4}$$

$$\text{RSFE} = \sum_{i=1}^{n} (D_i - F_i)$$

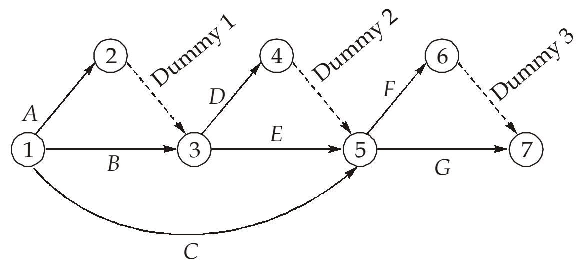
$$= (110 - 96) + (124 - 127) + (119 - 134) + (134 - 112)$$

$$= 14 - 3 - 15 + 22 = 18$$

$$\frac{\text{RSFE}}{\text{MAD}} = \frac{18}{(54/4)} = \frac{18 \times 4}{54} = 1.333$$

13. (c)

Network diagram:



14. (a)

Not more than three customers waiting in the queue means there should be at least four customers in the system.

$$P_0 + P_1 + P_2 + P_3 + P_4 + \ldots\ldots = 1$$

$$P(4 \geq \text{customer} \geq 0) = P_0 + P_1 + P_2 + P_3 + P_4$$

$$= P_0 + \rho P_0 + \rho^2 P_0 + \rho^3 P_0 + \rho^4 P_0$$

$$P_0 = 1 - \rho = 1 - \left(\frac{\lambda}{\mu}\right) = 1 - \frac{100}{120} = \frac{1}{6}$$

$$\rho = \frac{\lambda}{\mu} = \frac{100}{120} = \frac{5}{6}$$

$$P(4 \geq n \geq 0) = \frac{1}{6} + \left(\frac{5}{6}\right) \times \left(\frac{1}{6}\right) + \left(\frac{5}{6}\right)^2 \times \left(\frac{1}{6}\right) + \left(\frac{5}{6}\right)^3 \times \left(\frac{1}{6}\right) + \left(\frac{5}{6}\right)^4 \times \left(\frac{1}{6}\right)$$

$$= \frac{1}{6}\left[1 + \left(\frac{5}{6}\right) + \left(\frac{5}{6}\right)^2 + \left(\frac{5}{6}\right)^3 + \left(\frac{5}{6}\right)^4\right]$$

$$= \frac{1}{6}\left[\frac{1\left(1 - \left(\frac{5}{6}\right)^5\right)}{\left(1 - \frac{5}{6}\right)}\right] = 1 - \left(\frac{5}{6}\right)^5 = 0.598$$

$$P(4 \geq n \geq 0) = 59.8\%$$

15. (d)

In given matrix job 1 cannot be assigned to technician A.

M	6	4	3
4	2	7	0
5	3	6	4
7	4	5	4

Step: 1

Subtracting the smallest element in each row from every element of corresponding row.

M	3	1	0
4	2	7	0
2	0	3	1
3	0	1	0

Step: 2

Subtracting the smallest element of every column from corresponding element of each column.

M	3	0	0
2	2	6	0
0	0	2	1
1	0	0	0

Step: 3

Making allocation in opportunity cost matrix:

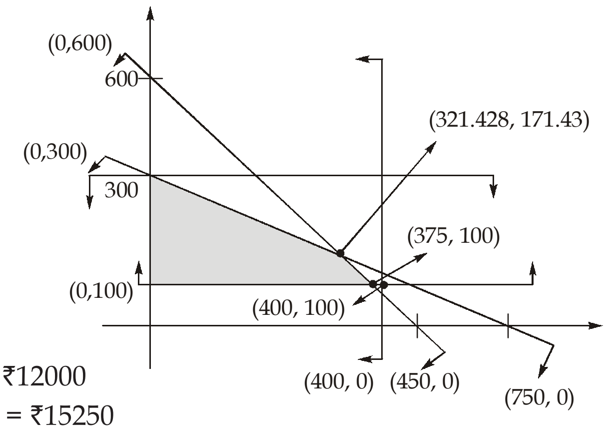
M	3	$\boxed{0}$	$\cancel{0}$
2	2	6	$\boxed{0}$
$\boxed{0}$	$\cancel{0}$	2	1
1	$\boxed{0}$	$\cancel{0}$	$\cancel{0}$

Allocation are, $A \to 3, \quad B \to 4, \quad C \to 1, \quad D \to 2$

Minimum total cost = (4 + 0 + 5 + 4) × 100 = ₹ 1300

16. (a)

$$\text{Profit,} \quad Z = 30x + 40y$$
$$1.6x + 1.2y \leq 720$$
$$1.2x + 3y \leq 900$$
$$x \leq 400$$
$$100 \leq y \leq 300$$
$$1.6x + 1.2y \leq 720$$
$$1.2x + 3y \leq 900$$
$$x = 321.428$$
$$y = 171.488$$
$$P_{(0,\,300)} = 30 \times 0 + 300 \times 40 = ₹12000$$
$$P_{(375,\,100)} = 375 \times 30 + 100 \times 40 = ₹15250$$
$$P_{(321.428,\,171.428)} = 321.428 \times 30 + 171.428 \times 40$$
$$= 16499.96 \simeq ₹16500$$



Point (400, 100) is outside of feasible region.

$$P_{(0,\,100)} = 30 \times 0 + 100 \times 40 = ₹4000$$

So, maximum profit is ₹ 16500.

17. (c)

Destination / Origin	A	B	C	D	Capacity
P	30 $\boxed{2}$	20 $\boxed{0}$	40 $\boxed{4}$	17 $\boxed{9}$	15/6/4/0
Q	60	28 $\boxed{0}$	35 $\boxed{19}$	52	19/0
R	26 $\boxed{9}$	13 $\boxed{17}$	50	22 $\boxed{0}$	26/09/0
Demand	11/2/0	17/0	23/4/0	09/0	

It is a balanced transportation problem.

Initial solution, Z = 30 × 2 + 40 × 4 + 17 × 9 + 35 × 19 + 26 × 9 + 13 × 17

Initial solution, Z = ₹1493

18. (a)

Using SPT rule:

Jobs	Processing time	Job flow time
D	6	6
A	7	13
B	9	22
E	11	33
C	13	46

$$\text{Average job flow time} = \frac{46+33+22+13+6}{5} = \frac{120}{5} = 24$$

Using EDD Rule:

Jobs	Processing time	Job flow time
A	7	7
C	13	20
D	6	26
B	9	35
E	11	46

$$\text{Average job flow time} = \frac{7+20+26+35+46}{5} = 26.8$$

$$\frac{\text{Average job flow time using SPT rule}}{\text{Average job flow time using EDD rule}} = \frac{24}{26.8} = 0.895$$

19. (d)

Year(X)	Demand in 100 units(y)	Deviation of x from 2010(x)	x^2	xy
2007	85	–3	9	–255
2008	75	–2	4	–150
2009	80	–1	1	–80
2010	72	0	0	0
2011	65	1	1	65
2012	60	2	4	120
2013	55	3	9	165
$n = 7$	$\Sigma y = 492$	$\Sigma x = 0$	$\Sigma x^2 = 28$	$\Sigma xy = -135$

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

$$\Rightarrow \quad \Sigma y = na + b\Sigma x$$

$$\Rightarrow \quad 492 = 7 \times a + 0$$

$$\Rightarrow \quad a = 70.2857$$

$$\Sigma xy = a\Sigma x + b\Sigma x^2$$

$$\Rightarrow \quad -135 = 0 + b \times 28$$

$$\Rightarrow \quad b = -4.82143$$

Best line of fit, $y = a + bx = (70.2857 - 4.82143x)$

Demand in 2015 $= (70.2857 - 4.82143 \times 5) \times 100 = 4617.856$ units.

20. (b)

Assigning elements to various work stations, we have the four work stations in the order given below:

	Work element	Station time
Work station I	*A, C*	1.0 min
Work station II	*B, D*	1.0 min
Work station III	*E, F, G*	0.9 min
Work station IV	*H, I*	1.0 min

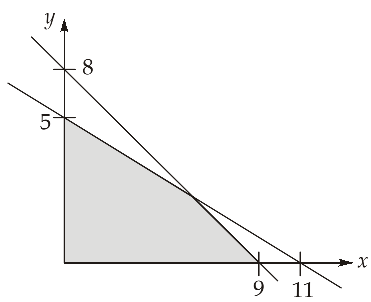
$$n = \text{No. of work station}$$

$$\text{Balance delay} = 1 - \frac{TWC}{n \times T_c}$$

$$= 1 - \frac{3.9}{4 \times 1} = \frac{4 - 3.9}{4} = \frac{0.1}{4} = \frac{0.1 \times 100\%}{4} = 2.5\%$$

21. (c)

Number of independent feasible solutions will be infinite. Because all the points within the feasible region will be a solution.



22. (d)

For minimum value of tardiness, jobs are scheduled as per EDD rule.

Job	*C*	*A*	*B*	*E*	*F*	*D*
Processing time	11	8	7	9	13	4
Due date	12	21	24	28	32	37
Job flow time	11	19	26	35	48	52
Tardiness	0	0	2	7	16	15

$$\text{Average tardiness} = \frac{0+0+2+7+16+15}{6} = \frac{40}{6} = 6.667 \text{ days}$$

23. (a)

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

$$\mu = \text{Critical path (mean)} = 22 \text{ (Critical path of project)}$$

$$z = \frac{24-22}{2} = 1$$

at $z = 1$, Probability $= 0.8413$

24. (c)

If $TIC(Q_1) = TIC(Q_2)$

Then, $EOQ,\ Q^* = \sqrt{Q_1 \times Q_2} = \sqrt{1000 \times 1600}$

$$Q^* = 1264.91$$

Alternate:

Where, C_h = Holding cost

C_0 = Ordering cost

Q = Quantity ordered

D = Total demand

$$TIC = \frac{D}{Q} \times C_0 + \frac{Q}{2} \times C_h$$

$$\frac{D}{1000} \times C_0 + \frac{1000}{2} \times C_h = \frac{D}{1600} \times C_0 + \frac{1600}{2} \times C_h$$

$$DC_0\left[\frac{600}{1000 \times 1600}\right] = 300\ C_h$$

$$\frac{2DC_0}{C_h} = 1000 \times 1600$$

$$Q^* = \sqrt{\frac{2DC_0}{C_h}} = \sqrt{1000 \times 1600} = 1264.91 \text{ units}$$

25. (b)

$$\text{EOQ} = \sqrt{\frac{2DC_0}{C_h} \times \left(\frac{C_b + C_h}{C_b}\right)} = \sqrt{\frac{2 \times 8000 \times 25}{0.2 \times 25} \times \left(\frac{2.5+5}{2.5}\right)}$$

$$\text{EOQ}(Q^*) = 489.898 \text{ units}$$

We know that, for optimum number of quantity backordered (S^*)

$$(Q^* - S^*) \times C_h = S^* \times C_b$$

$$(489.898 - S^*) \times (0.2 \times 25) = S^* \times (0.1 \times 25)$$

$$S^* = \frac{489.898 \times 2}{3}$$

$$S^* = 326.6 \text{ units}$$

26. (c)

$$\lambda = 3/\text{hr}, \qquad \mu = 4/\text{hr}$$

$$\rho = \frac{3}{4} = 0.75$$

$$L_s = \frac{\rho}{1-\rho} = \frac{0.75}{1-0.75} = 3$$

$$\text{Cost} = \text{Length of system} \times \text{idle cost/hr} \times \text{Time} + \text{Wage rate} \times \text{time}$$

$$\text{Cost} = 3 \times 6 \times 1 + 4 \times 1 = ₹22$$

27. (b)

$$\text{Arrival rate, } \lambda = \frac{12}{8\times 60} = \frac{1}{40} \text{ cycles/min}$$

$$\text{Service rate, } \mu = \frac{1}{25} \text{ cycles/min}$$

Now, number of cycles in system

$$L_s = \frac{\lambda}{\mu-\lambda} = \frac{1/40}{\left(\frac{1}{25}\right)-\left(\frac{1}{40}\right)}$$

$$L_S = \frac{25}{15} = \frac{5}{3}$$

28. (b)

Q = 10000 units, C = Rs. 10.00 unit, C_s = Rs. 25, C_h = 0.12 × 10 = Rs. 1.2 per unit/year

$$\text{Average lead time} = \frac{15+23+18+14+30}{5} = 20 \text{ days}$$

Optimum buffer stock = (Max. lead time – Average lead time) × Demand per day

$$= (30-20)\times\frac{10000}{365} = 273.973 \approx 274 \text{ units (approx.)}$$

$$EOQ,\ Q_0 = \sqrt{\frac{2\times C_s\times D}{C_h}} = \sqrt{\frac{2\times 25\times 10000}{1.2}}$$

$$Q_0(EOQ) = 645.497 \approx 646 \text{ units}$$

$$\text{Average inventory level} = \left(\frac{Q_0}{2}\right) + \text{Buffer stock}$$

$$= \left(\frac{646}{2}\right) + 274 = 597 \text{ units}$$

29. (d)

Forecast for the January is not given. Assuming forecast for January is equal to demand in January.

Months	D_i	F_i (Forecast)
January	1080	1080
February	950	1080
March	1050	1041
April	1120	1044

Assume,

$$F_1 = D_1$$

$$F_2 = F_1 + \alpha(D_2 - F_1)$$

$$= 1080 + \alpha(1080 - 1080)$$

$$= 1080$$

$$F_3 = F_2 + \alpha(D_2 - F_2)$$

$= 1080 + 0.3(950 - 1080)$
$= 1041$
$F_4 = F_3 + \alpha(D_3 - F_3)$
$= 1041 + 0.3(1050 - 1041)$
$= 1043.7$
$F_4 \simeq 1044$
$F_5 = F_4 + \alpha(D_4 - F_4)$
$= 1044 + 0.3(1120 - 1044) = 1066.8$
$F_4 \simeq 1067$ Water purifiers

Forecast using weighted moving average is given as

$= 1120 \times 0.4 + 1050 \times 0.3 + 950 \times 0.2 + 1080 \times 0.1 = 1061$

Therefore difference in forecast $= 1067 - 1061 = 6$

30. (d)

$$(\text{BEP})_1 = \frac{F_1}{(s-v)_1} = \frac{2700000}{(54-45)} = 300000$$

$$(\text{BEP})_2 = \frac{F_2}{(s-v)_2}$$

$\because$ (BEP) is same so, $(\text{BEP})_2 = 300000$

$$300000 = \frac{F_2}{(54 \times 1.12 - 45 \times 1.10)}$$

$F_2 =$ ₹3294000

Profit = Sale – (F.C. + V.C.)

$= 54 \times 1.12 \times 350000 - (3294000 + 1.1 \times 45 \times 350000)$

Profit = ₹ 549000 = ₹ 5.49 lakh

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