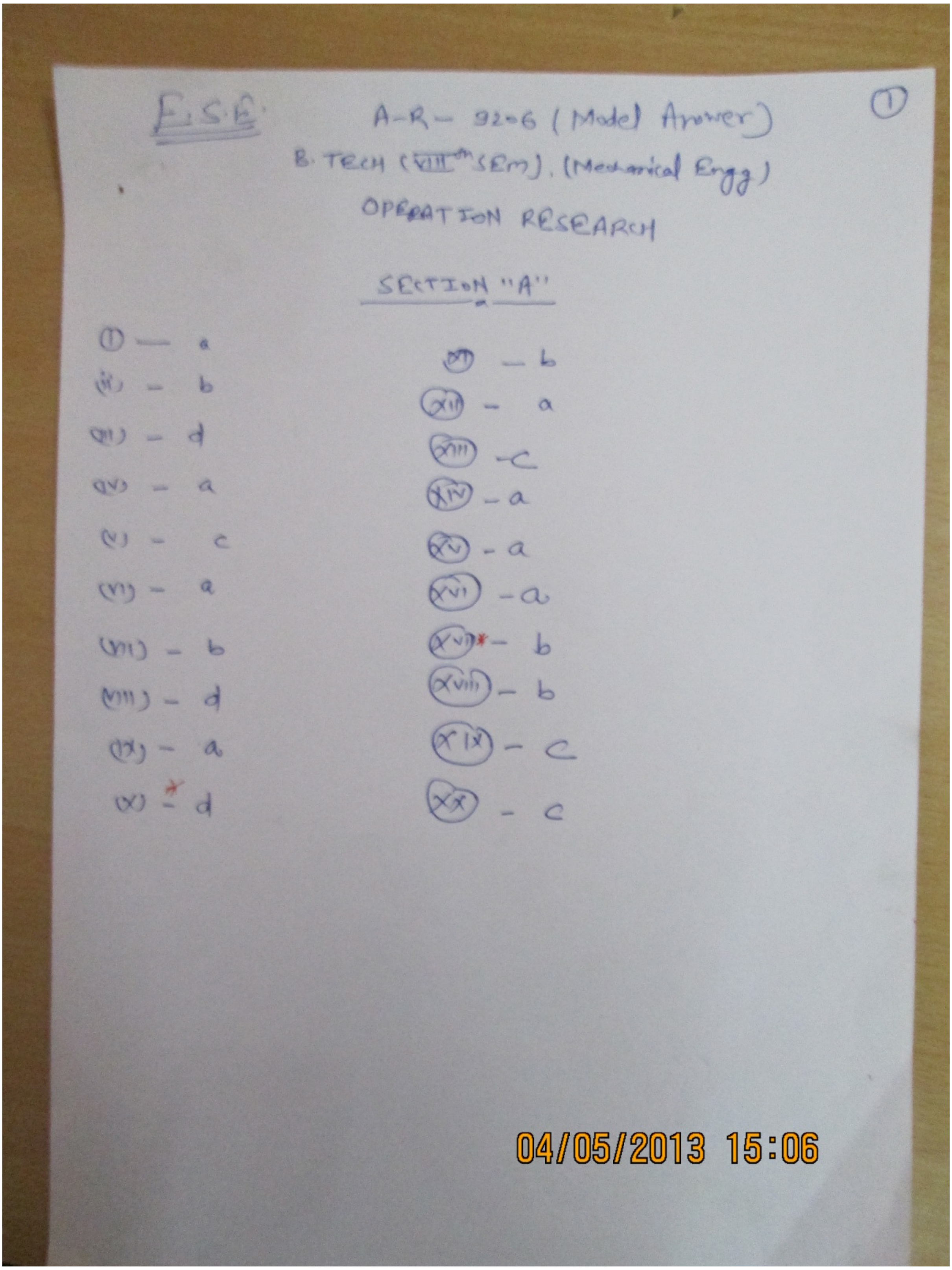

E.S.E.

A-R- 9206 (Model Answer)

B. TECH (VIIIth SEm). (Mechanical Engg)

OPERATION RESEARCH

①

SECTION "A"

① — a
(ii) — b
(iii) — d
(iv) — a
(v) — c
(vi) — a
(vii) — b
(viii) — d
(ix) — a
(x) — d

(xi) — b
(xii) — a
(xiii) — c
(xiv) — a
(xv) — a
(xvi) — a
(xvii) — b
(xviii) — b
(xix) — c
(xx) — c

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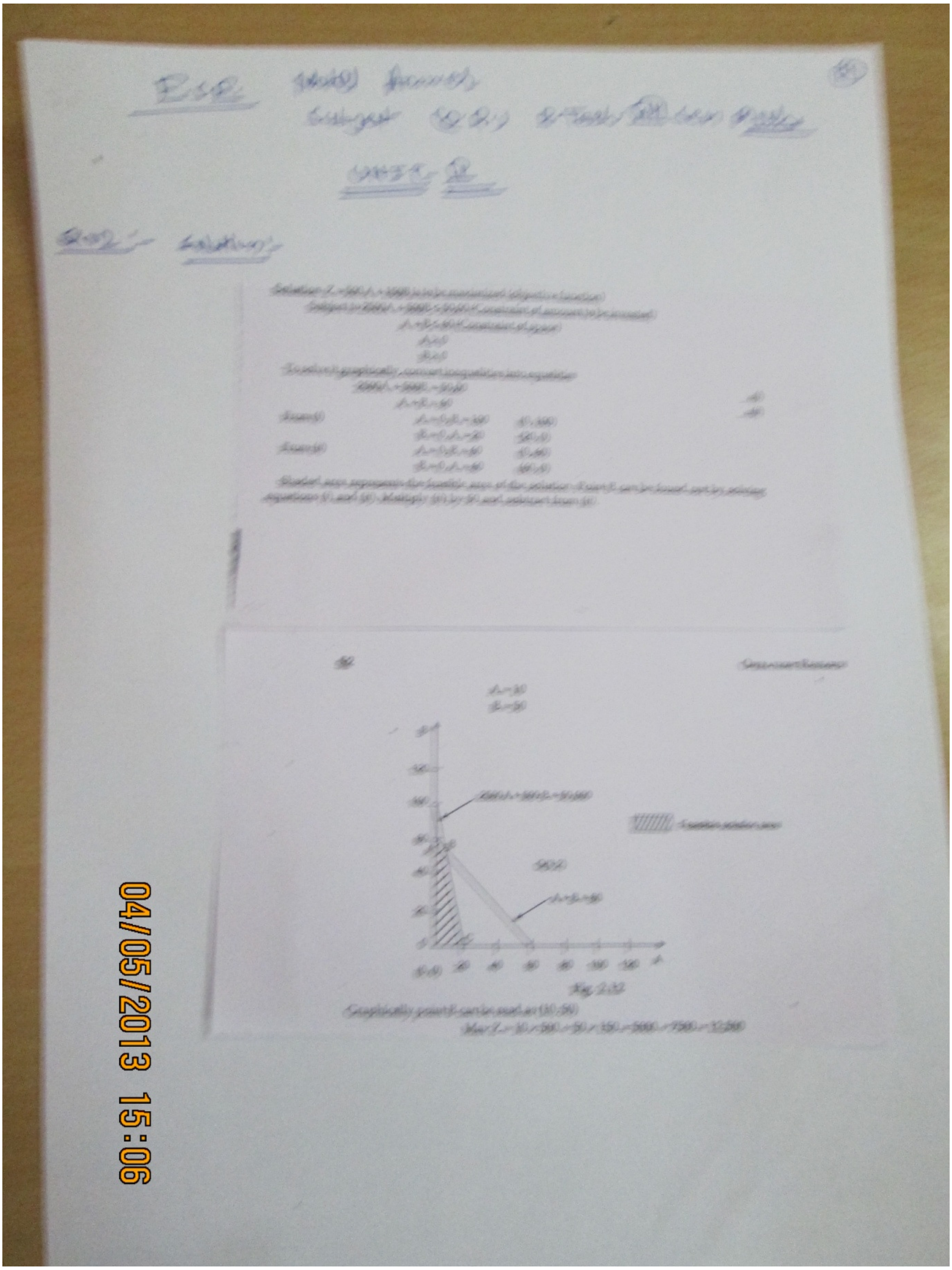

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Q.03:-

Solution:-

Solution. Let x_1 = Number of pages of magazine

x_2 = Number of spots on TV

Maximize $Z = 60000\,x_1 + 120000\,x_2$

Subject to

$$9000\,x_1 + 12000\,x_2 \le 720000$$
$$3x_1 + 4x_2 \le 240$$
$$x_1 \ge 2$$
$$x_2 \ge 3$$
$$x_1, x_2 \ge 0$$

Introducing slack and artificial variables, we have

Maximize $Z = 6000\,x_1 + 120000\,x_2 + 0S_1 + 0S_2 - MA_1 - MA_2$

Subject to

$$3x_1 + 4x_2 + S_1 = 240$$
$$x_1 - S_2 + A_1 = 2$$
$$x_2 - S_3 + A_2 = 3$$
$$x_1, x_2, S_1, S_2, A_1, A_2 \ge 0$$

Now, the first simplex table can be constructed as follows:

TABLE 3.40 First Simplex Table

$C_j \rightarrow$			60000	120000	0	0	0	$-M$	$-M$	
↓	Basic variables	Solution values	x_1	x_2	S_1	S_2	S_3	A_1	A_2	Minimum ratio
0	S_1	240	3	4	1	0	0	0	0	60
$-M$	A_1	2	1	0	0	-1	0	1	0	∞
$-M$	A_2	3	0	①	0	0	-1	0	1	3 → key row
	Z_j	$-5M$	$-M$	$-M$	0	M	M	$-M$	$-M$	
	$(C_j - Z_j)$		$60000 + M$	$120000 + M$	0	$-M$	$-M$	0	0	

↑ key column

Since x_2 column has the largest positive value and minimum ratio is that of A − 2 row and ① is the key element.

x_2 will replace row A_2.

New elements of row A_2 are obtained by dividing by the key element, *i.e.*, 1 *i.e.*, 3, 0, 1, 0, 0, − 1, 0, 1

New row − 1 is obtained by the relationship already known

i.e., $240 - 4 \times 3 = 228$, $3 - 4 \times 0 = 3$, $4 - 4 \times 1 = 0$, $1 - 4 \times 0 = 1$, $0 - 4 \times 0 = 0$
$0 - 4 \times -1 = 4$, $0 - 4 \times 0 = 0$,

New row 2 will remain the same as old row 2 as 0 is to be multiplied with new elements of row 3.

Now the second simplex table can be constructed as follows:

TABLE 3.41 Second Simplex Table

$C_j \rightarrow$			60000	120000	0	0	0	$-M$	
↓	Basic variables	Solution values	x_1	x_2	S_1	S_2	S_3	A_1	Minimum ratio
0	S_1	228	3	0	1	0	4	0	76
$-M$	A_1	2	①	0	0	-1	0	1	2 → key row
120000	x_2	3	0	1	0	0	-1	0	∞
	Z_j	$360000 - 2M$	$-M$	120000	0	$-M$	120000	$-M$	
	$(C_j - Z_j)$		$60000 + M$	0	0	M	120000	0	

↑ key column

Since $60000 + M$ is the largest value of $C_j - Z_j$, x_1 is the key column and since minimum ratio is that of A_1, row A_1 will be replaced by column x_1. New row A_1 is obtained by dividing all the elements of the row by key element, *i.e.*, 1.

New row S_1 is obtained by the relationship already known.

$228 - 3 \times 2 = 222$, $3 - 3 \times 1 = 0$, $0 - 3 \times 0 = 0$, $1 - 3 \times 0 = 1$, $0 - 3 \times -1 = 3$
$4 - 3 \times 0 = 4$

E.S.E.

New row x_1 elements are as follows:

3 − 0 × elements of departing row, so all elements remain the same.

Third Simplex table can be constructed as follows:

TABLE 3.42 Third Simplex Table

$C_B \downarrow$	$C_j \rightarrow$		60000	120000	0	0	0	
	Basic variables	Solution values	x_1	x_2	S_1	S_2	S_3	Minimum Ratio
0	S_1	222	0	0	1	3	④	55.5 → key row
60000	x_1	2	1	0	0	−1	0	∞
120000	x_2	3	0	1	0	0	−1	−ve
	Z_j	480000	60000	120000	0	−60000	−120000	
	$(C_j - Z_j)$		0	0	0	60000	120000	

↑ key column

S_3 has the largest positive value and S_1 has the minimum ratio so S_1 will be replaced by S_3. Key element is 4.

New row S_3 is obtained by dividing all its elements by key element, i.e., 4, 55.5, 0, 0, $\frac{1}{4}, \frac{3}{4}$, 1

New row x_1 element will be the same as for this row 0 occurs in the key column.

New row x_2 is obtained by using the relationship already known.

$$3-(-1)\times 55.5 = 58.5,\ 0-(-1)\times 0 = 0,\ 1-(-1)\times 0 = 1$$

$$0-(-1)\frac{1}{4} = \frac{1}{4},\ 0-(-1)\times\frac{3}{4} = \frac{3}{4},\ -1-(-1)\times 1 = 0$$

The Fourth Simplex table can be constructed as follows:

TABLE 3.43 Fourth Simplex Table

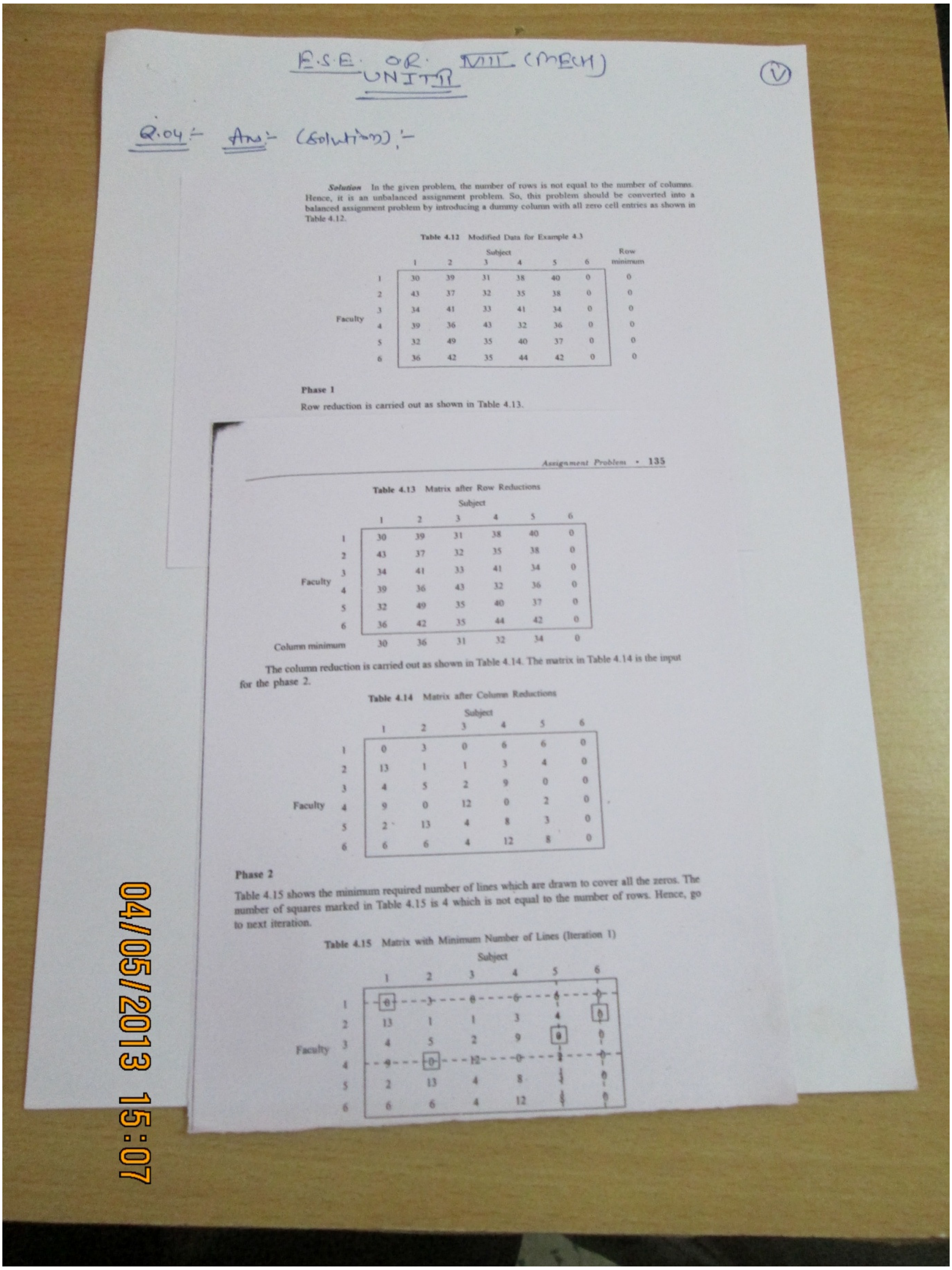
$C_B \downarrow$	$C_j \rightarrow$		60000	120000	0	0	0
	Basic variables	Solution values	x_1	x_2	S_1	S_2	S_3
0	S_3	55.5	0	0	$\frac{1}{4}$	$\frac{3}{4}$	1
60000	x_1	2	1	0	0	−1	0
120000	x_2	58.5	0	1	$\frac{1}{4}$	$\frac{3}{4}$	0
	Z_j	7140000	60000	120000	30000	30000	0
	$(C_j - Z_j)$		0	0	−30000	−30000	0

Since all the elements of $C_j - Z_j$ are ≤ 0

The optimal solution has been arrived.

$x_1 = 2$

$x_2 = 58.5$ $\qquad$ $Z = \underline{7140000}$



E.S.E. OR. VIII (MECH)
UNIT II

ⓥ

Q.04:- Ans:- (Solution):-

Solution In the given problem, the number of rows is not equal to the number of columns. Hence, it is an unbalanced assignment problem. So, this problem should be converted into a balanced assignment problem by introducing a dummy column with all zero cell entries as shown in Table 4.12.

Table 4.12 Modified Data for Example 4.3

		Subject						
		1	2	3	4	5	6	Row minimum
Faculty	1	30	39	31	38	40	0	0
	2	43	37	32	35	38	0	0
	3	34	41	33	41	34	0	0
	4	39	36	43	32	36	0	0
	5	32	49	35	40	37	0	0
	6	36	42	35	44	42	0	0

Phase 1

Row reduction is carried out as shown in Table 4.13.

Table 4.13 Matrix after Row Reductions

		Subject					
		1	2	3	4	5	6
Faculty	1	30	39	31	38	40	0
	2	43	37	32	35	38	0
	3	34	41	33	41	34	0
	4	39	36	43	32	36	0
	5	32	49	35	40	37	0
	6	36	42	35	44	42	0
Column minimum		30	36	31	32	34	0

The column reduction is carried out as shown in Table 4.14. The matrix in Table 4.14 is the input for the phase 2.

Table 4.14 Matrix after Column Reductions

		Subject					
		1	2	3	4	5	6
Faculty	1	0	3	0	6	6	0
	2	13	1	1	3	4	0
	3	4	5	2	9	0	0
	4	9	0	12	0	2	0
	5	2	13	4	8	3	0
	6	6	6	4	12	8	0

Phase 2

Table 4.15 shows the minimum required number of lines which are drawn to cover all the zeros. The number of squares marked in Table 4.15 is 4 which is not equal to the number of rows. Hence, go to next iteration.

Table 4.15 Matrix with Minimum Number of Lines (Iteration 1)

		Subject					
		1	2	3	4	5	6
Faculty	1	$\boxed{0}$	3	0	6	6	0
	2	13	1	1	3	4	$\boxed{0}$
	3	4	5	2	9	$\boxed{0}$	0
	4	9	$\boxed{0}$	12	0	2	0
	5	2	13	4	8	3	0
	6	6	6	4	12	8	0

E.S.E. VIII Mech (O.R.)

VI

The minimum among the undeleted entries in Table 4.15 is 1. The entries in Table 4.16 are obtained from Table 4.15 by applying step 5. Table 4.16 also shows the minimum required number of lines which are drawn to cover all the zeros.

In Table 4.16, the total number of cells marked with squares is 5 which is not equal to the number of rows of the matrix. Hence, go to the next iteration.

Table 4.16 Matrix with Minimum Number of Lines (Iteration 2)

Faculty \ Subject	1	2	3	4	5	6
1	$\boxed{0}$	3	0	6	7	1
2	12	0	$\boxed{0}$	2	4	0
3	3	4	1	8	$\boxed{0}$	0
4	9	0	12	$\boxed{0}$	3	1
5	1	12	3	7	3	$\boxed{0}$
6	5	5	3	11	8	0

The minimum among the unselected entries in Table 4.16 is 1. The entries in the Table 4.17 are obtained from Table 4.16 by applying step 5. Table 4.17 also shows the minimum required number of lines which are drawn to cover all the zeros.

Table 4.17 Matrix with Minimum Number of Lines (Iteration 3)

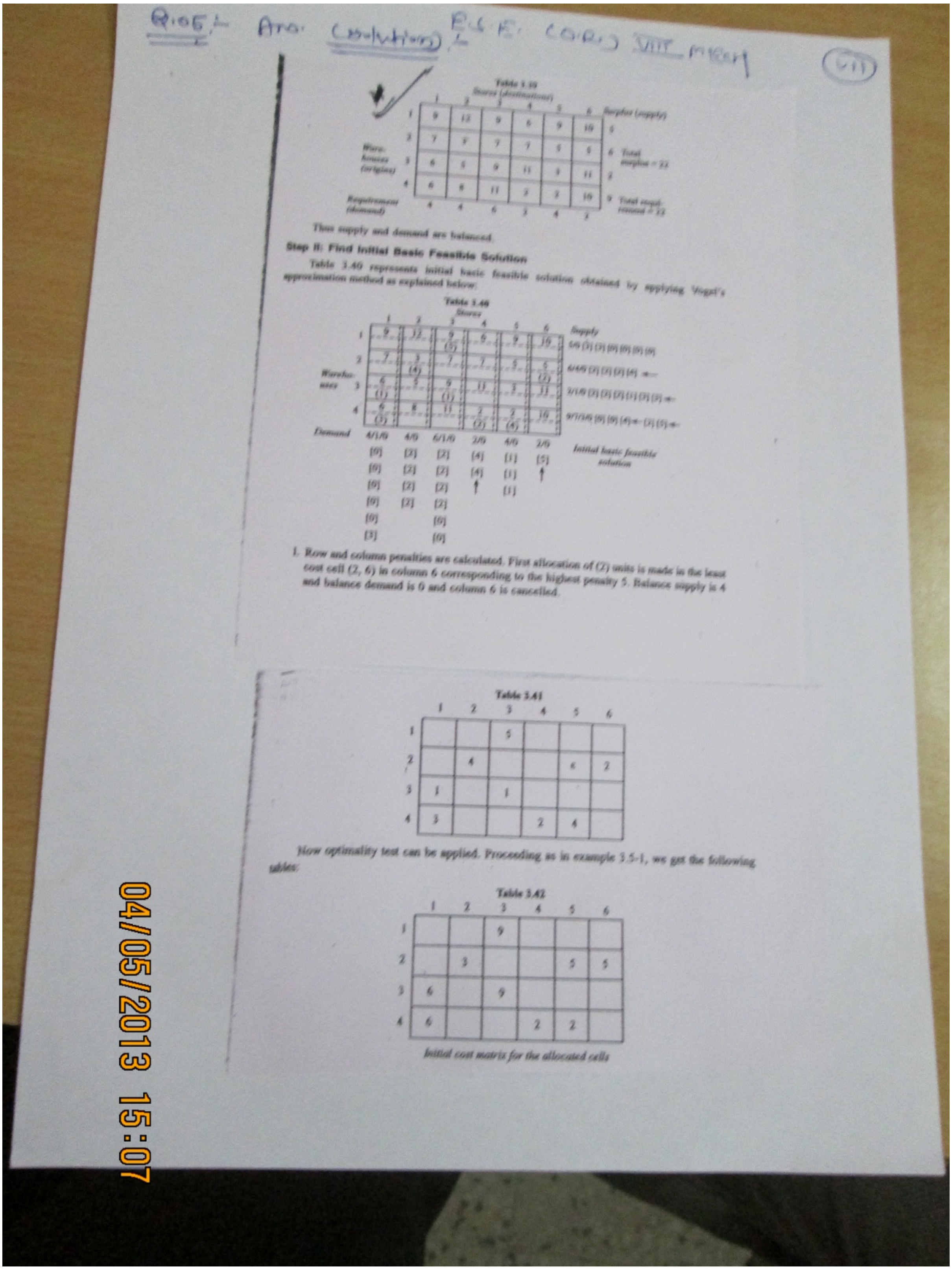
Faculty \ Subject	1	2	3	4	5	6
1	0	3	$\boxed{0}$	6	7	2
2	12	$\boxed{0}$	0	2	4	1
3	3	4	1	8	$\boxed{0}$	1
4	9	0	12	$\boxed{0}$	3	2
5	$\boxed{0}$	11	2	6	2	0
6	4	4	2	10	7	$\boxed{0}$

In Table 4.17, the total number of cells marked with squares is 6, which is equal to the number of rows of the square matrix. So, the solution of this iteration is feasible and optimal and the corresponding results are summarized in Table 4.18.

Table 4.18 Final Solution of Example 4.3

Faculty	Subject	Time
1	3	31
2	2	37
3	5	34
4	4	32
5	1	32
6	6 (Dummy)*	0

Total time is [illegible] hours, where faculty 6 is not assigned any subject.



Q.05:- Ans. (solution) :- E.S.E. (O.R.) VIII Mech (vii)

Table 3.39

Stores (destinations)

	1	2	3	4	5	6	Surplus (supply)
Warehouses (origins) 1	9	12	9	6	9	10	5
2	7	3	7	7	5	5	6
3	6	5	9	11	3	11	2
4	6	8	11	2	2	10	9
Requirement (demand)	4	4	6	2	4	2	

Total surplus = 22

Total requirement = 22

Thus supply and demand are balanced.

Step II: Find Initial Basic Feasible Solution

Table 3.40 represents initial basic feasible solution obtained by applying Vogel's approximation method as explained below:

Table 3.40

Stores

Warehouses	1	2	3	4	5	6	Supply
1	9	12	9 (5)	6	9	10	5/0 [3] [3] [0] [0] [0] [0]
2	7	3 (4)	7	7	5	5 (2)	6/4/0 [2] [2] [2] [4] ←
3	6 (1)	5	9 (1)	11	3	11	2/1/0 [2] [2] [2] [1] [3] [3] ←
4	6 (3)	8	11	2 (2)	2 (4)	10	9/7/3/0 [0] [0] [4] ← [2] [5] ←
Demand	4/1/0	4/0	6/1/0	2/0	4/0	2/0	
	[0] [0] [0] [0] [0] [3]	[2] [2] [2] [2]	[2] [2] [2] [2] [0] [0]	[4] [4] ↑	[1] [1] [1]	[5] ↑	

Initial basic feasible solution

1. Row and column penalties are calculated. First allocation of (2) units is made in the least cost cell (2, 6) in column 6 corresponding to the highest penalty 5. Balance supply is 4 and balance demand is 0 and column 6 is cancelled.

Table 3.41

	1	2	3	4	5	6
1			5			
2		4			6	2
3	1		1			
4	3			2	4	

Now optimality test can be applied. Proceeding as in example 3.5-1, we get the following tables:

Table 3.42

	1	2	3	4	5	6
1			9			
2		3			5	5
3	6		9			
4	6			2	2	

Initial cost matrix for the allocated cells [illegible] (44)

Table-3.47

		9			
	3			5	5
6		9			
6			2	2	

(u_i, v_j) matrix for allocated cells

Table-3.48

6	0	-	2	2	2
9	-	12	5	-	-
-	0	-	2	2	2
-	0	9	-	-	2

$(u_i + v_j)$ matrix for non-allocated cells

Table-3.49

		9			
	3	7			5
6		9			
6			2	2	

(u_i, v_j) matrix for occupied cells

Table-3.50

6	5	-	2	2	7
4	-	-	0	0	-
-	5	-	2	2	7
-	5	9	-	-	7

$(u_i + v_j)$ matrix for vacant cells

Table-3.51

3	7	-	4	7	3
3	-	-	7	5	-
-	0	-	9	1	4
-	3	2	-	-	3

Cell evaluation matrix

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Since all the cell values are positive, the 2nd feasible solution is an optimal solution. Since above matrix contains a zero entry, there exist alternative optimal solutions. Thus the optimal tion for our problem is

Table-3.52

Stores

		1	2	3	4	5	6	Supply
	1	9	12	9 (5)	6	9	10	5
	2	7	3 (4)	7	7	5	5 (2)	6
Warehouses	3	6 (1)	5	9 (1)	11	3	11	2
	4	6 (3)	8	11	2 (2)	2 (4)	10	9
Demand		4	4	6	2	4	2	

Total Transportation cost = Rs. 112

E.S.A. VIII Mech

UNIT-III :-

OR (B. Tech VIII Mech)

Q.-6 :- Solution :-

Solution Given,

Item cost, $C = \text{Rs. } 2$ per unit

Set-up cost, $C_3 = \text{Rs. } 500$ per order

Carrying cost, $C_1 = \text{Rs. } 0.15$ per unit, per month

Demand rate, $R = 18{,}000$ units per year $= 1{,}500$ units per month

Production rate, $K = 3{,}000$ units per month

(i) Optimum manufacturing quantity,

$$q^* = \sqrt{\frac{2RC_3}{C_1}}\sqrt{\frac{K}{K-R}}$$

$$= \sqrt{\frac{2\times1500\times500}{0.15}}\sqrt{\frac{3000}{3000-1500}} = 4{,}470 \text{ units}$$

(ii) Maximum inventory

$$= \frac{q}{K}(K-R)$$

$$= \frac{4470}{3000}(3000-1500) = 2{,}235 \text{ units}$$

(iii) Times between orders

$$= \frac{q^*}{R} = \frac{4470}{1500} = 3 \text{ months (approximately)}$$

(iv) Number of orders per year,

$$\frac{12}{3} = 4$$

(v) Times between orders

$$= \frac{q^*}{K} = \frac{4470}{3000} = 1.5 \text{ months}$$

(vi) The optimum annual cost/Total expected system cost

= item cost + ordering cost + holding cost

$$= 18000\times2 + \frac{18000}{4470}\times500 + \frac{2235}{36000}(36000-18000)\times1.8$$

$$= \text{Rs. } 40{,}025.$$

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E.S.E B.Tech VIII (OR) Mech.

Q.7. Soln

Solution Table 12.38 shows the payoff matrix with maximin and minimax values. Here, the maximin value (3) is equal to the minimax value (3). Hence, the game has a saddle point. As a result, each player has a pure strategy and the corresponding results are shown below.

A(1, 0), B(1, 0, 0, 0, 0) Value of the game, $V = 3$

However, the game is solved using graphical method to have a better insight of that method with the known results.

Table 12.38 Payoff Matrix with Maximin and Minimax Values

		Player B					
		1	2	3	4	5	
Player A	1	3	6	8	4	4	3 (maximin)
	2	−7	4	2	10	2	−7
		3 (minimax)	6	8	10	4	

In the payoff matrix shown in Table 12.38, column 2 is dominated by column 5. The resultant payoff matrix after deleting column 2 is shown in Table 12.39.

Table 12.39 Payoff Matrix after Deleting Column 2

		Player B			
		1	3	4	5
Player A	1	3	8	4	4
	2	−7	2	10	2

Let x be the probability of selection of Alternative 1 by Player A and $1 - x$ be the probability of selection of Alternative 2 by Player A. Therefore, the expected payoff to Player A with respect to different alternatives of Player B are summarized in Table 12.40.

Table 12.40 Expected Payoff Functions of Player A

B's alternative	A's expected payoff function
1	$3x + (-7)(1 - x) = 10x - 7$
3	$8x + 2(1 - x) = 6x + 2$
4	$4x + 10(1 - x) = -6x + 10$
5	$4x + 2(1 - x) = 2x + 2$

The computations of expected payoff of Player A with respect to each of the alternatives of Player B, when x is equal to 0 and 1, are summarized in Table 12.41.

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B.Sc. OR VIII MECH

Table 12.41 Expected Gain of Player A

B's alternative	A's expected payoff function	A's expected gain	
		$x = 0$	$x = 1$
1	$10x - 7$	-7	3
3	$6x + 2$	2	8
4	$-6x + 10$	10	4
5	$2x + 2$	2	4

The expected gain functions of Player A with respect to different alternatives of Player B are plotted in Figure 12.2.

Since, A is a maximin player, identify the highest intersection point in the lower boundary of the graph. The lower boundary consists of the intersection points *a* and *b*. Out of these two points,

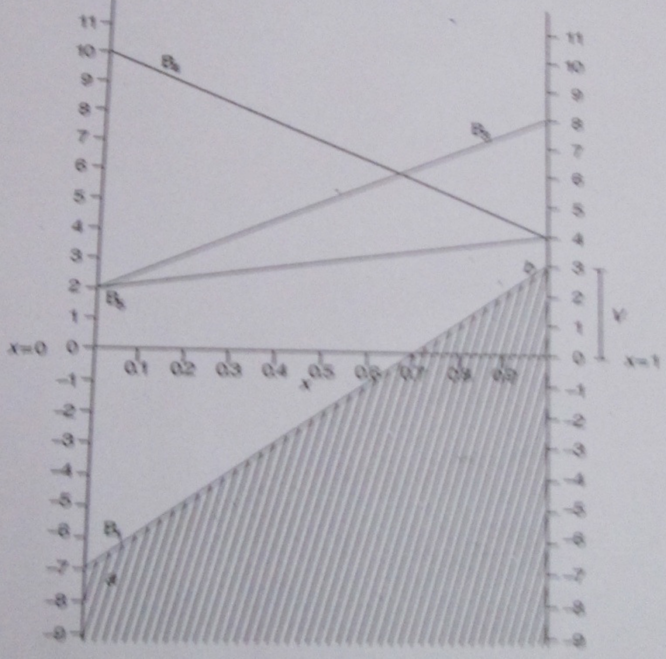

Figure 12.2 Graph with A's payoff function.

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Q.08:- (Solution) :-

Solution

The random numbers are established as in table below:

TABLE 13.4

Production/day	*Probability*	*Cumulative probability*	*Random number interval*
196	0.05	0.05	00 – 04
197	0.09	0.14	05 – 13
198	0.12	0.26	14 – 25
199	0.14	0.40	26 – 39
200	0.20	0.60	40 – 59
201	0.15	0.75	60 – 74
202	0.11	0.86	75 – 85
203	0.08	0.94	86 – 93
204	0.06	1.00	94 – 99

Based on the 15 random numbers given, we simulate the production per day in the table below.

TABLE 13.5

Day no.	*Random number*	*Production per day*	*No. of mopeds waiting*	*Empty spaces in the lorry*
1	82	202	2	-
2	89	203	5	-
3	78	202	7	-
4	24	198	5	-
5	53	200	5	-
6	61	201	6	-
7	18	198	4	-
8	45	200	4	-
9	04	196	-	-
10	23	198	-	2
11	50	200	-	-
12	77	202	2	-
13	27	199	1	-
14	54	200	1	-
15	10	197	-	2

$\therefore$ Average number of mopeds waiting in the factory

$$= \frac{1}{15}\,[2+5+7+5+5+6+4+4+2+1+1] = 2.8.$$

Average number of empty spaces in the lorry $= \frac{4}{15} = 0.27$.

Q.09 **Solution** :-

Arrival rate $\lambda = 5$ per hr

Service rate $\mu = 8$ per hr

(i) Equipment utilization $\rho = \frac{\lambda}{\mu} = \frac{5}{8} = 0.625$

(ii) The % time an arriving letter has to wait

$=$ % time the typewriter remains busy

$= 62.5\%$

(iii) Avg system time $W_s = \frac{1}{\mu-\lambda} = \frac{1}{3}$ hr

$= 20$ min

(iv) Avg. cost due to waiting on the part of the type writer per day

$= 8\left(1-\frac{5}{8}\right) \times 1.50$

$=$ Rs. 4.50

E.S.E. OR. VIII (MECH)

X14

7.10 (SOL):

Solution

The total normal direct cost of the project

$$= \text{Rs. } (20 + 15 + 8 + 11 + 9 + 5 + 3) \times 1{,}000$$
$$= \text{Rs. } 71{,}000.$$

The cost slope for each activity is calculated below :

Activity	:	A	B	C	D	E	F	G
Cost slope (Rs. '000/week)	:	10/3	2.5	6	2	2	3	0.25

Next, the network is drawn and the critical path is found. This is shown in Fig. 14.77. Project duration is 26 weeks and 1-2-3-4-6 is the critical path.

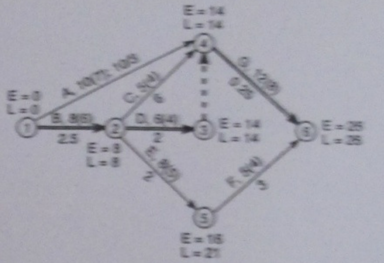

Fig. 14.77

To crash the network, time-scaled diagram is drawn first. This is shown in Fig. 14.78.

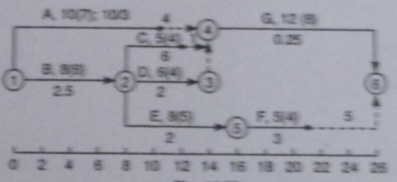

Fig. 14.78

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E.S.E. VIII (PECN) QR

Since the network is to be crashed to find the optimum duration and the indirect cost is Rs. 400/day or Rs. 2,800/week, the critical activities will be crashed so long as the cost of crashing them/week does not exceed Rs. 2,800.

Crash activity 4-6 by four weeks.

The various alternative activities and their crash costs are given below:

Activity	Cost (Rs.)	Activity	Cost (Rs.)	Activity	Cost (Rs.)
1-2 1-4	2,500 Nil	2-3 2-4 1-4 2-5/5-6	2,000 Nil Nil Nil	4-6 5-6	250 Nil
	2,500		2,000		250

Since activity 4-6 has the lowest associated cost of Rs. 250/week, it is crashed by 4 weeks.

∴ Project duration = 22 weeks.

Additional crash cost = Rs. (4 × 250) = 1,000.

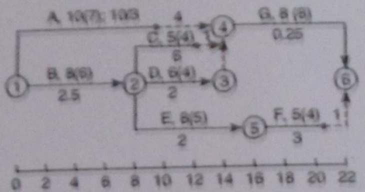

Fig. 14.79

The crashed network is shown in Fig. 14.79.

Crash activity 2-3 by one week.

As seen earlier, activity 2-3 can be crashed by one week at an additional crash cost of Rs. 2,000 per week.

∴ Project duration = 21 weeks,

total additional crash cost = Rs. (1,000 + 2,000) = Rs. 3,000.

The crashed network is shown in Fig. 14.80.

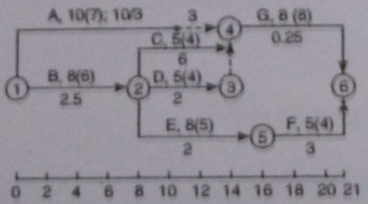

Fig. 14.80

ash activity 1-2 by 2 weeks.

indicated earlier, activity 1-2 can be crashed by 2 weeks at an additional crash cost of Rs. 2,50 week.

Project duration = 19 weeks,

total additional crash cost = Rs. (3,000 + 2,500 × 2)

= Rs. 8,000.

crashed network is shown in Fig. 14.81.

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Q.17:- Soln:-

Solution (a) The CPM network is shown in Figure 10.3.

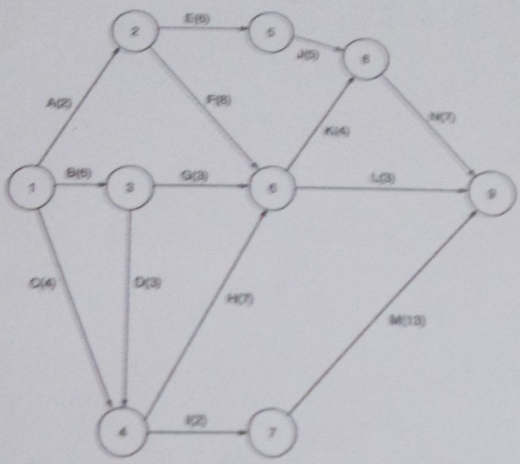

Figure 10.3 CPM network for Example 10.3.

(b) The *critical path* of a project network is the longest path in the network. This can be identified by simply listing out all the possible paths from the start node of the project (node 1) to the end node of the project (node 9) and then selecting the path with the maximum sum of activity times on that path.

This method has several drawbacks. In a large network, one may commit mistake in listing all the paths. Moreover, this method will not provide necessary details, such as total floats and free floats for further analysis. Hence, a different approach is to be used to identify the critical path. This consists of two phases: Phase 1 determines *earliest start times* (ES) of all the nodes. This is called *forward pass*; Phase 2 determines *latest completion times* (LC) of various nodes. This is called *backward pass*.

Let D_{ij} be the duration of the activity (i, j). ES_j be the earliest start times of all the activities which are emanating from node j (this is shown in the lower square which is by side of node j). LC_j be the latest completion times of all the activities which are ending at node j (this is shown in the upper square which is by the side of node j).

[illegible]

Determination of earliest start times (ES_j): During forward pass use the following formula to compute earliest start times for all nodes:

$$ES_j = \max_i (ES_i + D_{ij})$$

The calculations of ES_j are summarized below:

Node 1: For node 1, $ES_1 = 0$
Node [illegible]: $ES_{[illegible]} = ES_1 + D_{[illegible]} = 0 + [illegible] = [illegible]$
Node [illegible]: $ES_{[illegible]} = ES_1 + D_{[illegible]} = 0 + [illegible] = [illegible]$
Node [illegible]: $ES_{[illegible]} = \max_i (ES_i + D_{i,[illegible]})$
$= \max (ES_{[illegible]} + D_{[illegible]}, ES_{[illegible]} + D_{[illegible]})$
$= \max ([illegible]) = [illegible]$
Node [illegible]: $ES_{[illegible]} = ES_{[illegible]} + D_{[illegible]} = [illegible]$
Node [illegible]: $ES_{[illegible]} = \max_i (ES_i + D_{i,[illegible]})$
$= \max (ES_{[illegible]} + D_{[illegible]}, ES_{[illegible]} + D_{[illegible]}, ES_{[illegible]} + D_{[illegible]})$
$= \max ([illegible])$
$= \max ([illegible])$
$= [illegible]$

Similarly, the ES_j values for all other nodes are computed and summarized in Figure 10.4.

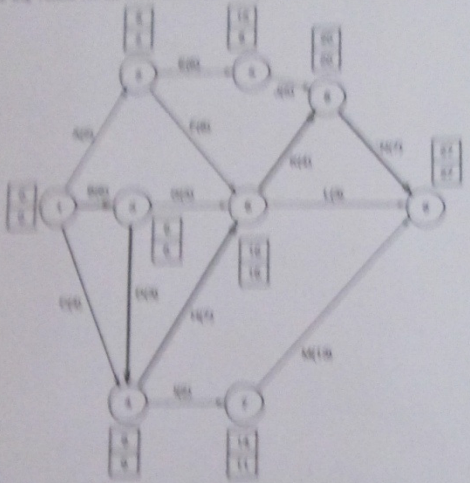

Figure 10.4 Network with critical path calculations.

Table 10.4 Summary of Total Floats and Free Floats

Activity (i, j)	Duration (D_{ij})	Total float (TF_{ij})	Free float (FF_{ij})
[illegible]	[illegible]	0	0
[illegible]	[illegible]	0	0
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0	0

Any critical activity will have zero total float and zero free float. Based on this property also, one can determine the critical activities. From Table 10.4, one can check that the total floats and free floats for the activities [illegible] are zero. Hence, they are critical activities. The corresponding critical path is [illegible].

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