

**STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 86**  
**(For candidates admitted from the academic year 2025 – 2026)**

**B.Sc. DEGREE EXAMINATION, APRIL 2026**  
**MATHEMATICS WITH COMPUTER APPLICATIONS**  
**SECOND SEMESTER**

**COURSE : ELECTIVE**  
**PAPER : OPERATIONS RESEARCH**  
**SUBJECT CODE : 25MC/ME/OR23**  
**TIME : 3 HOURS**

**MAX. MARKS: 100**

| Q. No.  | SECTION A (2 × 5 = 10)<br>Answer ANY TWO questions   | CO        | KL                      |                                |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
|---------|--|-----------|-------------------------|--------------------------------|--------|--------------------------------|-----------|-----------|-----------|-------|----|----|---|-----|-------|----|---|----|-----|-------|---|---|---|-----|---|---|----|---|----|--------|---|---|---|---|--|---|---|
| 1.      | <p>A firm produces three products. These products are processed on three different machines. The time required to manufacture one unit of each of the three products and the daily capacity of the three machines are given in the table below.</p> <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Machine</th> <th colspan="3">Time per unit (minutes)</th> <th rowspan="2">Machine capacity (minutes/day)</th> </tr> <tr> <th>Product 1</th> <th>Product 2</th> <th>Product 3</th> </tr> </thead> <tbody> <tr> <td><math>M_1</math></td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> <td style="text-align: center;">440</td> </tr> <tr> <td><math>M_2</math></td> <td style="text-align: center;">4</td> <td style="text-align: center;">-</td> <td style="text-align: center;">3</td> <td style="text-align: center;">470</td> </tr> <tr> <td><math>M_3</math></td> <td style="text-align: center;">2</td> <td style="text-align: center;">5</td> <td style="text-align: center;">-</td> <td style="text-align: center;">430</td> </tr> </tbody> </table> <p>It is required to determine the daily number of units to be manufactured for each product. The profit per unit for product 1, 2 and 3 is Rs. 4, Rs. 3 and Rs. 6 respectively. It is assumed that all the amounts produced are consumed in the market. Formulate the linear programming problem that will maximize the daily profit.</p> | Machine   | Time per unit (minutes) |                                |        | Machine capacity (minutes/day) | Product 1 | Product 2 | Product 3 | $M_1$ | 2  | 3  | 2 | 440 | $M_2$ | 4  | - | 3  | 470 | $M_3$ | 2 | 5 | - | 430 | 1 | 1 |    |   |    |        |   |   |   |   |  |   |   |
| Machine | Time per unit (minutes)  |           |                         | Machine capacity (minutes/day) |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
|         | Product 1  | Product 2 | Product 3               |                                |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| $M_1$   | 2  | 3         | 2                       | 440                            |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| $M_2$   | 4  | -         | 3                       | 470                            |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| $M_3$   | 2  | 5         | -                       | 430                            |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| 2.      | <p>A dairy firm has three plants located in a state. Cost of shipping milk from each plant to each distribution centre is given in the following table in hundreds of rupees. Determine the total transportation cost using North West Corner rule.</p> <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Plants</th> <th colspan="4">Distribution Centres</th> <th rowspan="2">Supply</th> </tr> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> </tr> </thead> <tbody> <tr> <td>P</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">11</td> <td style="text-align: center;">7</td> <td style="text-align: center;">6</td> </tr> <tr> <td>Q</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">6</td> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> </tr> <tr> <td>R</td> <td style="text-align: center;">5</td> <td style="text-align: center;">8</td> <td style="text-align: center;">15</td> <td style="text-align: center;">9</td> <td style="text-align: center;">10</td> </tr> <tr> <td>Demand</td> <td style="text-align: center;">7</td> <td style="text-align: center;">5</td> <td style="text-align: center;">3</td> <td style="text-align: center;">2</td> <td></td> </tr> </tbody> </table>   | Plants    | Distribution Centres    |                                |        |                                | Supply    | A         | B         | C     | D  | P  | 2 | 3   | 11    | 7  | 6 | Q  | 1   | 0     | 6 | 1 | 1 | R   | 5 | 8 | 15 | 9 | 10 | Demand | 7 | 5 | 3 | 2 |  | 1 | 1 |
| Plants  | Distribution Centres   |           |                         |                                | Supply |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
|         | A  | B         | C                       | D                              |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| P       | 2  | 3         | 11                      | 7                              | 6      |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| Q       | 1  | 0         | 6                       | 1                              | 1      |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| R       | 5  | 8         | 15                      | 9                              | 10     |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| Demand  | 7  | 5         | 3                       | 2                              |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| 3.      | <p>Find the optimal assignment of jobs to the machines.</p> <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Jobs ↓</th> <th colspan="3">Machines →</th> </tr> <tr> <th>X</th> <th>Y</th> <th>Z</th> </tr> </thead> <tbody> <tr> <td>A</td> <td style="text-align: center;">25</td> <td style="text-align: center;">15</td> <td style="text-align: center;">22</td> </tr> <tr> <td>B</td> <td style="text-align: center;">31</td> <td style="text-align: center;">20</td> <td style="text-align: center;">19</td> </tr> <tr> <td>C</td> <td style="text-align: center;">35</td> <td style="text-align: center;">24</td> <td style="text-align: center;">17</td> </tr> </tbody> </table>   | Jobs ↓    | Machines →              |                                |        | X                              | Y         | Z         | A         | 25    | 15 | 22 | B | 31  | 20    | 19 | C | 35 | 24  | 17    | 1 | 1 |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| Jobs ↓  | Machines →   |           |                         |                                |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
|         | X  | Y         | Z                       |                                |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| A       | 25   | 15        | 22                      |                                |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| B       | 31   | 20        | 19                      |                                |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |
| C       | 35   | 24        | 17                      |                                |        |                                |           |           |           |       |    |    |   |     |       |    |   |    |     |       |   |   |   |     |   |   |    |   |    |        |   |   |   |   |  |   |   |

| Q. No.     | SECTION B (2 × 5 = 10)<br>Answer ANY TWO questions   | CO          | KL          |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
|------------|--|-------------|-------------|-------------|--------|---------------------|--------|------|------------|------|------|--------------------|-----|-----|----------------|-----|-----|----------------------|-----|-----|--------------------------|-----|-----|---------------------|--------|-----|---------------------|--------|-----|------------------|-----|-----|------------------|--------|-----|----------------------|-----|---|---|
| 4.         | Consider the game $G$ with the following payoff: <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th rowspan="2">Player A</th> <th colspan="2">Player B</th> </tr> <tr> <th>B1</th> <th>B2</th> </tr> </thead> <tbody> <tr> <th>A1</th> <td>2</td> <td>6</td> </tr> <tr> <th>A2</th> <td>-2</td> <td><math>\lambda</math></td> </tr> </tbody> </table> <p>(a) Show that <math>G</math> is strictly determinable, whatever <math>\lambda</math> may be.<br/>(b) Determine the value of <math>G</math>.</p>   | Player A    | Player B    |             | B1     | B2                  | A1     | 2    | 6          | A2   | -2   | $\lambda$          | 2   | 2   |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| Player A   | Player B   |             |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
|            | B1   | B2          |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| A1         | 2  | 6           |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| A2         | -2   | $\lambda$   |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| 5.         | Draw a network of the simple project of erection of steel works for a shed. The various activities of the project are as under: <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Activity</th> <th>Description</th> <th>Preceded by</th> </tr> </thead> <tbody> <tr> <td><math>A</math></td> <td>Erect site workshop</td> <td>-</td> </tr> <tr> <td><math>B</math></td> <td>Fence site</td> <td>-</td> </tr> <tr> <td><math>C</math></td> <td>Bend reinforcement</td> <td><math>A</math></td> </tr> <tr> <td><math>D</math></td> <td>Dig foundation</td> <td><math>B</math></td> </tr> <tr> <td><math>E</math></td> <td>Fabricate steel work</td> <td><math>A</math></td> </tr> <tr> <td><math>F</math></td> <td>Install concrete pillars</td> <td><math>B</math></td> </tr> <tr> <td><math>G</math></td> <td>Place reinforcement</td> <td><math>C, D</math></td> </tr> <tr> <td><math>H</math></td> <td>Concrete foundation</td> <td><math>G, F</math></td> </tr> <tr> <td><math>I</math></td> <td>Erect steel work</td> <td><math>E</math></td> </tr> <tr> <td><math>J</math></td> <td>Paint steel work</td> <td><math>H, I</math></td> </tr> <tr> <td><math>K</math></td> <td>Give finishing touch</td> <td><math>J</math></td> </tr> </tbody> </table> | Activity    | Description | Preceded by | $A$    | Erect site workshop | -      | $B$  | Fence site | -    | $C$  | Bend reinforcement | $A$ | $D$ | Dig foundation | $B$ | $E$ | Fabricate steel work | $A$ | $F$ | Install concrete pillars | $B$ | $G$ | Place reinforcement | $C, D$ | $H$ | Concrete foundation | $G, F$ | $I$ | Erect steel work | $E$ | $J$ | Paint steel work | $H, I$ | $K$ | Give finishing touch | $J$ | 2 | 2 |
| Activity   | Description  | Preceded by |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $A$        | Erect site workshop  | -           |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $B$        | Fence site   | -           |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $C$        | Bend reinforcement   | $A$         |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $D$        | Dig foundation   | $B$         |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $E$        | Fabricate steel work   | $A$         |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $F$        | Install concrete pillars   | $B$         |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $G$        | Place reinforcement  | $C, D$      |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $H$        | Concrete foundation  | $G, F$      |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $I$        | Erect steel work   | $E$         |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $J$        | Paint steel work   | $H, I$      |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $K$        | Give finishing touch   | $J$         |             |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| 6.         | (a) Define feasible solution of a linear programming problem.<br>(b) State the differences between Transportation and Assignment problem. <p style="text-align: right;">(2 + 3)</p>  | 2           | 2           |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| Q. No.     | SECTION C (2 × 10 = 20)<br>Answer ANY TWO questions  | CO          | KL          |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| 7.         | Find the minimum value of $Z = -x_1 + 2x_2$ subject to $-x_1 + 3x_2 \leq 10$ ; $x_1 + x_2 \leq 6$ ; $x_1 - x_2 \leq 2$ ; $x_1, x_2 \geq 0$ using graphical method.   | 3           | 3           |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| 8.         | Find the optimal solution to the following transportation problem so as to minimize the total transportation cost. <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th rowspan="2">Industries</th> <th colspan="4">Retailers</th> <th rowspan="2">Demand</th> </tr> <tr> <th><math>R1</math></th> <th><math>R2</math></th> <th><math>R3</math></th> <th><math>R4</math></th> </tr> </thead> <tbody> <tr> <td><math>I1</math></td> <td>6</td> <td>1</td> <td>9</td> <td>3</td> <td>70</td> </tr> <tr> <td><math>I2</math></td> <td>11</td> <td>5</td> <td>2</td> <td>8</td> <td>55</td> </tr> <tr> <td><math>I3</math></td> <td>10</td> <td>12</td> <td>4</td> <td>7</td> <td>70</td> </tr> <tr> <td>Supply</td> <td>85</td> <td>35</td> <td>50</td> <td>45</td> <td></td> </tr> </tbody> </table>   | Industries  | Retailers   |             |        |                     | Demand | $R1$ | $R2$       | $R3$ | $R4$ | $I1$               | 6   | 1   | 9              | 3   | 70  | $I2$                 | 11  | 5   | 2                        | 8   | 55  | $I3$                | 10     | 12  | 4                   | 7      | 70  | Supply           | 85  | 35  | 50               | 45     |     | 3                    | 3   |   |   |
| Industries | Retailers  |             |             |             | Demand |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
|            | $R1$   | $R2$        | $R3$        | $R4$        |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $I1$       | 6  | 1           | 9           | 3           | 70     |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $I2$       | 11   | 5           | 2           | 8           | 55     |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| $I3$       | 10   | 12          | 4           | 7           | 70     |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| Supply     | 85   | 35          | 50          | 45          |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |
| 9.         | In a game of matching coins, player A wins Rs. 2 if there are two heads, wins nothing if there are two tails and loses Re. 1 when there is one head and one tail. Determine the payoff matrix, best strategies for each player and the value of the game to player A.  | 3           | 3           |             |        |                     |        |      |            |      |      |                    |     |     |                |     |     |                      |     |     |                          |     |     |                     |        |     |                     |        |     |                  |     |     |                  |        |     |                      |     |   |   |

| Q. No.                   | SECTION D (2 × 20 = 40)<br>Answer ANY TWO questions  | CO                       | KL    |     |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
|--------------------------|--|--------------------------|-------|-----|--------|-----|--------|-----|-----|-----|-----|-----|-----------------|---|---|----|----|----|---|----|---|---|----|----|---|---|----|----|----|--------|----|----|----|----|---|--------------------------|---|---|---|---|----|----|----|----|----|---|----|----|----|----|---|----|----|----|----|---|----|----|----|----|---|---|
| 10.                      | Solve the following linear programming problem using simplex method:<br>Maximize $Z = 3x_1 + 2x_2 + 5x_3$ subject to the constraints<br>$x_1 + 4x_2 \leq 420$ ; $3x_1 + 2x_3 \leq 460$ ; $x_1 + 2x_2 + x_3 \leq 430$ ;<br>$x_1, x_2, x_3 \geq 0$ .   | 4                        | 4     |     |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 11.                      | (a) Solve the following transportation problem and find the optimal solution using MODI method:<br><table border="1"> <thead> <tr> <th rowspan="2">Factories</th> <th colspan="4">Shops</th> <th rowspan="2">Supply</th> </tr> <tr> <th>S1</th> <th>S2</th> <th>S3</th> <th>S4</th> </tr> </thead> <tbody> <tr> <td>F1</td> <td>6</td> <td>8</td> <td>8</td> <td>5</td> <td>30</td> </tr> <tr> <td>F2</td> <td>5</td> <td>11</td> <td>9</td> <td>7</td> <td>40</td> </tr> <tr> <td>F3</td> <td>8</td> <td>9</td> <td>7</td> <td>13</td> <td>50</td> </tr> <tr> <td>Demand</td> <td>35</td> <td>28</td> <td>32</td> <td>25</td> <td></td> </tr> </tbody> </table><br>(b) Four salesman and the profit per day in rupees for each salesman to four different districts is given below. Find the optimal assignment which maximizes the profit.<br><table border="1"> <thead> <tr> <th>District →<br/>Salesman ↓</th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>16</td> <td>10</td> <td>14</td> <td>11</td> </tr> <tr> <td>B</td> <td>14</td> <td>11</td> <td>15</td> <td>15</td> </tr> <tr> <td>C</td> <td>15</td> <td>15</td> <td>13</td> <td>12</td> </tr> <tr> <td>D</td> <td>13</td> <td>12</td> <td>14</td> <td>15</td> </tr> </tbody> </table><br>(14 + 6) | Factories                | Shops |     |        |     | Supply | S1  | S2  | S3  | S4  | F1  | 6               | 8 | 8 | 5  | 30 | F2 | 5 | 11 | 9 | 7 | 40 | F3 | 8 | 9 | 7  | 13 | 50 | Demand | 35 | 28 | 32 | 25 |   | District →<br>Salesman ↓ | 1 | 2 | 3 | 4 | A  | 16 | 10 | 14 | 11 | B | 14 | 11 | 15 | 15 | C | 15 | 15 | 13 | 12 | D | 13 | 12 | 14 | 15 | 4 | 4 |
| Factories                | Shops  |                          |       |     | Supply |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
|                          | S1   | S2                       | S3    | S4  |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| F1                       | 6  | 8                        | 8     | 5   | 30     |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| F2                       | 5  | 11                       | 9     | 7   | 40     |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| F3                       | 8  | 9                        | 7     | 13  | 50     |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| Demand                   | 35   | 28                       | 32    | 25  |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| District →<br>Salesman ↓ | 1  | 2                        | 3     | 4   |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| A                        | 16   | 10                       | 14    | 11  |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| B                        | 14   | 11                       | 15    | 15  |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| C                        | 15   | 15                       | 13    | 12  |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| D                        | 13   | 12                       | 14    | 15  |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 12.                      | The utility data for a network is given below. Determine the total, free, independent and interfering floats. Also, identify the critical path and the project duration.<br><table border="1"> <thead> <tr> <th>Activity</th> <th>0-1</th> <th>1-2</th> <th>1-3</th> <th>2-4</th> <th>2-5</th> <th>3-4</th> <th>3-6</th> <th>4-7</th> <th>5-7</th> <th>6-7</th> </tr> </thead> <tbody> <tr> <td>Duration (days)</td> <td>2</td> <td>8</td> <td>10</td> <td>6</td> <td>3</td> <td>3</td> <td>7</td> <td>5</td> <td>2</td> <td>8</td> </tr> </tbody> </table>   | Activity                 | 0-1   | 1-2 | 1-3    | 2-4 | 2-5    | 3-4 | 3-6 | 4-7 | 5-7 | 6-7 | Duration (days) | 2 | 8 | 10 | 6  | 3  | 3 | 7  | 5 | 2 | 8  | 4  | 4 |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| Activity                 | 0-1  | 1-2                      | 1-3   | 2-4 | 2-5    | 3-4 | 3-6    | 4-7 | 5-7 | 6-7 |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| Duration (days)          | 2  | 8                        | 10    | 6   | 3      | 3   | 7      | 5   | 2   | 8   |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| Q. No.                   | SECTION E (2 × 10 = 20)<br>Answer ANY TWO questions  | CO                       | KL    |     |        |     |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 13.                      | Solve the following game by using the principle of dominance:<br><table border="1"> <thead> <tr> <th>Player B →<br/>Player A ↓</th> <th>I</th> <th>II</th> <th>III</th> <th>IV</th> <th>V</th> <th>VI</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>4</td> <td>2</td> <td>0</td> <td>2</td> <td>1</td> <td>1</td> </tr> <tr> <td>2</td> <td>4</td> <td>3</td> <td>1</td> <td>3</td> <td>2</td> <td>2</td> </tr> <tr> <td>3</td> <td>4</td> <td>3</td> <td>7</td> <td>-5</td> <td>1</td> <td>2</td> </tr> <tr> <td>4</td> <td>4</td> <td>3</td> <td>4</td> <td>-1</td> <td>2</td> <td>2</td> </tr> <tr> <td>5</td> <td>4</td> <td>3</td> <td>3</td> <td>-2</td> <td>2</td> <td>2</td> </tr> </tbody> </table>  | Player B →<br>Player A ↓ | I     | II  | III    | IV  | V      | VI  | 1   | 4   | 2   | 0   | 2               | 1 | 1 | 2  | 4  | 3  | 1 | 3  | 2 | 2 | 3  | 4  | 3 | 7 | -5 | 1  | 2  | 4      | 4  | 3  | 4  | -1 | 2 | 2                        | 5 | 4 | 3 | 3 | -2 | 2  | 2  | 5  | 5  |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| Player B →<br>Player A ↓ | I  | II                       | III   | IV  | V      | VI  |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 1                        | 4  | 2                        | 0     | 2   | 1      | 1   |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 2                        | 4  | 3                        | 1     | 3   | 2      | 2   |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 3                        | 4  | 3                        | 7     | -5  | 1      | 2   |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 4                        | 4  | 3                        | 4     | -1  | 2      | 2   |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |
| 5                        | 4  | 3                        | 3     | -2  | 2      | 2   |        |     |     |     |     |     |                 |   |   |    |    |    |   |    |   |   |    |    |   |   |    |    |    |        |    |    |    |    |   |                          |   |   |   |   |    |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |    |    |    |    |   |   |

| 14.       | <p>A salesman wants to visit cities 1, 2, 3 and 4. The cost of going from one city to another is given in rupees. Find the least cost route.</p> <table border="1"> <tr> <td colspan="2" rowspan="2"></td> <td colspan="4">To city</td> </tr> <tr> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td rowspan="4">From city</td> <td>1</td> <td>0</td> <td>30</td> <td>80</td> <td>50</td> </tr> <tr> <td>2</td> <td>40</td> <td>0</td> <td>140</td> <td>30</td> </tr> <tr> <td>3</td> <td>40</td> <td>50</td> <td>0</td> <td>20</td> </tr> <tr> <td>4</td> <td>70</td> <td>80</td> <td>130</td> <td>0</td> </tr> </table>   |          |       | To city |       |     |   | 1 | 2 | 3   | 4 | From city | 1 | 0   | 30 | 80 | 50 | 2   | 40 | 0 | 140 | 30  | 3 | 40 | 50 | 0   | 20 | 4 | 70 | 80  | 130 | 0 | 5  | 5 |   |
|-----------|---|----------|-------|---------|-------|-----|---|---|---|-----|---|-----------|---|-----|----|----|----|-----|----|---|-----|-----|---|----|----|-----|----|---|----|-----|-----|---|----|---|---|
|           |   |          |       | To city |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
|           |   | 1        | 2     | 3       | 4     |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| From city | 1   | 0        | 30    | 80      | 50    |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
|           | 2   | 40       | 0     | 140     | 30    |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
|           | 3   | 40       | 50    | 0       | 20    |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
|           | 4   | 70       | 80    | 130     | 0     |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 15.       | <p>The time estimates (in weeks) for the activities of a PERT network are given below:</p> <table border="1"> <thead> <tr> <th>Activity</th> <th><math>t_o</math></th> <th><math>t_m</math></th> <th><math>t_p</math></th> </tr> </thead> <tbody> <tr> <td>1-2</td> <td>1</td> <td>1</td> <td>7</td> </tr> <tr> <td>1-3</td> <td>1</td> <td>4</td> <td>7</td> </tr> <tr> <td>1-4</td> <td>2</td> <td>2</td> <td>8</td> </tr> <tr> <td>2-5</td> <td>1</td> <td>1</td> <td>1</td> </tr> <tr> <td>3-5</td> <td>2</td> <td>5</td> <td>14</td> </tr> <tr> <td>4-6</td> <td>2</td> <td>5</td> <td>8</td> </tr> <tr> <td>5-6</td> <td>3</td> <td>6</td> <td>15</td> </tr> </tbody> </table> <p>(a) Draw the project network and identify all the paths through it.<br/>           (b) Determine the expected project length.<br/>           (c) Calculate the standard deviation and variance of the project length.<br/>           (d) What is the probability that the project will be completed<br/>           (i) at least 4 weeks earlier than expected time?<br/>           (ii) no more than 4 weeks later than expected time?</p> | Activity | $t_o$ | $t_m$   | $t_p$ | 1-2 | 1 | 1 | 7 | 1-3 | 1 | 4         | 7 | 1-4 | 2  | 2  | 8  | 2-5 | 1  | 1 | 1   | 3-5 | 2 | 5  | 14 | 4-6 | 2  | 5 | 8  | 5-6 | 3   | 6 | 15 | 5 | 5 |
| Activity  | $t_o$   | $t_m$    | $t_p$ |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 1-2       | 1   | 1        | 7     |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 1-3       | 1   | 4        | 7     |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 1-4       | 2   | 2        | 8     |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 2-5       | 1   | 1        | 1     |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 3-5       | 2   | 5        | 14    |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 4-6       | 2   | 5        | 8     |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |
| 5-6       | 3   | 6        | 15    |         |       |     |   |   |   |     |   |           |   |     |    |    |    |     |    |   |     |     |   |    |    |     |    |   |    |     |     |   |    |   |   |

