

**PSG COLLEGE OF ARTS & SCIENCE  
(AUTONOMOUS)**

*23BLU207R*

**BBA DEGREE EXAMINATION DECEMBER 2024  
(Second Semester)**

Branch – **BUSINESS ADMINISTRATION/ BUSINESS ADMINISTRATION (IS)/  
BUSINESS ADMINISTRATION (RM)**

**APPLIED OPERATIONS RESEARCH**

Time: Three Hours

Maximum: 75 Marks

**SECTION-A (10 Marks)**

Answer **ALL** questions

ALL questions carry **EQUAL** marks

(10 × 1 = 10)

| Module No. | Question No. | Question                                                                                                                                                                                                                                                                                   | K Level | CO  |
|------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-----|
| 1          | 1            | What is the origin of Operation Research (O.R.)?<br>a. 18th-century military strategies<br>b. Industrial revolution<br>c. World War II military operations<br>d. Ancient Greek mathematicians                                                                                              | K1      | CO1 |
|            | 2            | Which property ensures that the optimal solution of a linear programming problem lies at one of the extreme points of the feasible region?<br>a. Convexity<br>b. Linearity<br>c. Duality<br>d. Unboundedness                                                                               | K2      | CO1 |
| 2          | 3            | What does the assignment problem involve?<br>a. Allocating resources to maximize efficiency<br>b. Scheduling tasks to minimize time<br>c. Matching workers to jobs to minimize cost or maximize profit<br>d. Optimizing transportation routes in a network                                 | K1      | CO1 |
|            | 4            | Which method involves starting with the cell with the highest supply-demand ratio and iteratively allocating units until all supplies and demands are met?<br>a. North-West Corner Rule (NWC)<br>b. Least-Cost Method<br>c. Vogel's Approximation Method (VAM)<br>d. Stepping-Stone Method | K2      | CO1 |
| 3          | 5            | In game theory, what term describes games where the gain of one player equals the loss of the other?<br>a. Cooperative games<br>b. Zero-sum games<br>c. Non-zero-sum games<br>d. Perfect information games                                                                                 | K1      | CO1 |
|            | 6            | What term refers to the model where customers arrive at a service point according to a Poisson process and are served according to an exponential service time distribution with a single server and an infinite waiting area?<br>a. M/M/1<br>b. M/D/1<br>c. M/G/1<br>d. M/M/∞             | K2      | CO1 |
| 4          | 7            | What is the primary goal of sequencing in manufacturing processes?<br>a. Maximizing downtime.<br>b. Minimizing costs.<br>c. Increasing complexity.<br>d. Maximizing resource utilization.                                                                                                  | K1      | CO1 |

Cont...

|   |    |                                                                                                                                                                                                                                                                                                                      |    |     |
|---|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----|
| 4 | 8  | In a scenario where the value of money remains constant over time, what kind of replacement policy is suitable?<br>a. Time-based replacement.<br>b. Condition-based replacement.<br>c. Age-based replacement.<br>d. Cost-based replacement.                                                                          | K2 | CO1 |
| 5 | 9  | What does the critical path represent in a PERT/CPM network?<br>a. The path with the longest duration<br>b. The path with the shortest duration<br>c. The path with the most activities<br>d. The path with the least amount of resources required                                                                   | K1 | CO1 |
|   | 10 | In PERT analysis, what does the variance of an activity's duration represent?<br>a. The likelihood of the activity being completed early<br>b. The likelihood of the activity being completed late<br>c. The uncertainty associated with the activity's duration<br>d. The probability of the activity being skipped | K2 | CO1 |

**SECTION - B (35 Marks)**

Answer ALL questions

ALL questions carry EQUAL Marks (5 × 7 = 35)

ALL questions carry EQUAL Marks (50/100)

| Module No. | Question No. | Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | K Level | CO     |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
|------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------|--------|-------------|--|--|--------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|----|--------|---|
| 1          | 11.a.        | Discuss the historical development of Operations Research (O.R.) highlighting its origins and key milestones                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | K3      | CO1    |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
|            | 11.b.        | (OR)<br>Consider a manufacturing company that produces two types of products, A and B. The company has limited resources for production, including labor hours and raw materials. Each unit of product A requires 2 hours of labor and 3 units of raw material, while each unit of product B requires 3 hours of labor and 2 units of raw material. The company's objective is to maximize its profit. Product A generates a profit of \$100 per unit, and product B generates a profit of \$80 per unit.<br>a) Formulate the linear programming problem to maximize the company's profit.<br>b) Define the decision variables, objective function, and constraints for the formulated linear programming problem.<br>c) Explain how the formulated problem represents the optimization of the company's production process considering the given constraints and objective. |         |        |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
| 2          | 12.a.        | Describe how a Transportation Problem can be formulated as a Linear Programming (LP) model.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | K4      | CO2    |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
|            | 12.b.        | (OR)<br>To find the IBFS using Least Cost Method <table> <tr> <th rowspan="2">Source</th> <th colspan="3">Destination</th> <th rowspan="2">Supply</th> </tr> <tr> <th>A</th> <th>B</th> <th>C</th> </tr> <tr> <td>1</td> <td>2</td> <td>7</td> <td>4</td> <td>5</td> </tr> <tr> <td>2</td> <td>3</td> <td>3</td> <td>1</td> <td>8</td> </tr> <tr> <td>3</td> <td>5</td> <td>4</td> <td>7</td> <td>7</td> </tr> <tr> <td>4</td> <td>1</td> <td>6</td> <td>2</td> <td>14</td> </tr> <tr> <td>Demand</td> <td>7</td> <td>9</td> <td>18</td> <td>34</td> </tr> </table>                                                                                                                                                                                                                                                                                                          |         |        | Source | Destination |  |  | Supply | A | B | C | 1 | 2 | 7 | 4 | 5 | 2 | 3 | 3 | 1 | 8 | 3 | 5 | 4 | 7 | 7 | 4 | 1 | 6 | 2 | 14 | Demand | 7 |
| Source     | Destination  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |         | Supply |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
|            | A            | B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | C       |        |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
| 1          | 2            | 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 4       | 5      |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
| 2          | 3            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1       | 8      |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
| 3          | 5            | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 7       | 7      |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
| 4          | 1            | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2       | 14     |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |
| Demand     | 7            | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 18      | 34     |        |             |  |  |        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |        |   |

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| 3                     | 13.a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>Using dominance property, obtain the optimum strategies for both the players and determine the value of the game.</p> <table><tr><td colspan="2" rowspan="2"></td><th colspan="5">Player B</th></tr><tr><th>I</th><th>II</th><th>III</th><th>IV</th><th>V</th></tr><tr><th rowspan="4">Player A</th><th>I</th><td>2</td><td>4</td><td>8</td><td>3</td><td>4</td></tr><tr><th>II</th><td>5</td><td>6</td><td>7</td><td>3</td><td>8</td></tr><tr><th>III</th><td>6</td><td>7</td><td>8</td><td>9</td><td>7</td></tr><tr><th>IV</th><td>4</td><td>2</td><td>4</td><td>8</td><td>3</td></tr></table> |       |       | Player B |     |     |     |          | I   | II  | III | IV  | V   | Player A     | I     | 2     | 4     | 8     | 3    | 4                     | II   | 5    | 6    | 7    | 3    | 8              | III   | 6     | 7     | 8     | 9     | 7 | IV | 4 | 2 | 4 | 8 | 3 | K3 | CO4 |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|----------|-----|-----|-----|----------|-----|-----|-----|-----|-----|--------------|-------|-------|-------|-------|------|-----------------------|------|------|------|------|------|----------------|-------|-------|-------|-------|-------|---|----|---|---|---|---|---|----|-----|
|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       | Player B |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | I     | II    | III      | IV  | V   |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| Player A              | I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4     | 8     | 3        | 4   |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       | II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 6     | 7     | 3        | 8   |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       | III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 7     | 8     | 9        | 7   |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       | IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2     | 4     | 8        | 3   |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| (OR)                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |          |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| 13.b.                 | <p>A bank has a single teller (server) who processes customer transactions. Customers arrive at the bank following a Poisson distribution with an average arrival rate of 10 customers per hour. The teller processes transactions exponentially with an average service time of 6 minutes per customer.</p> <p>Assuming an M/M/1 queuing model (Poisson arrivals, exponential service, single server, infinite queue, FIFO service), calculate the following:</p> <ul style="list-style-type: none"><li>• Average number of customers in the queue (<math>L_q</math>).</li><li>• Average waiting time in the queue (<math>W_q</math>).</li><li>• Server utilization (<math>\rho</math>)</li></ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |          |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| 4                     | 14.a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>Explain how each of these terms contributes to understanding and solving sequencing problems.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |       |          |     | K3  | CO3 |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       | (OR)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |          |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       | 14.b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>The data collected in running a machine, the cost of which is Rs. 60,000 are given below</p> <table><tr><th>Year</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr><tr><td>Resale Value</td><td>42000</td><td>30000</td><td>20400</td><td>14400</td><td>9650</td></tr><tr><td>Cost of Spares</td><td>4000</td><td>4270</td><td>4880</td><td>5700</td><td>6800</td></tr><tr><td>Cost of Labour</td><td>14000</td><td>16000</td><td>18000</td><td>21000</td><td>25000</td></tr></table> <p>Determine the optimum period for the replacement of the machine.</p>                           |       |       |          |     |     |     | Year     | 1   | 2   | 3   | 4   | 5   | Resale Value | 42000 | 30000 | 20400 | 14400 | 9650 | Cost of Spares        | 4000 | 4270 | 4880 | 5700 | 6800 | Cost of Labour | 14000 | 16000 | 18000 | 21000 | 25000 |   |    |   |   |   |   |   |    |     |
| Year                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 3     | 4     | 5        |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| Resale Value          | 42000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 30000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 20400 | 14400 | 9650     |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| Cost of Spares        | 4000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 4270                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4880  | 5700  | 6800     |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| Cost of Labour        | 14000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 16000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 18000 | 21000 | 25000    |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| 5                     | 15.a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>How to Conduct a Program Evaluation and Review Technique</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |          |     | K2  | CO5 |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       | (OR)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |          |     |     |     |          |     |     |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
|                       | 15.b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>Draw the network diagram and determine the critical path for the following project:</p> <table><tr><th>Activity</th><th>1-2</th><th>1-3</th><th>1-4</th><th>2-5</th><th>3-6</th><th>3-7</th><th>4-7</th><th>5-8</th><th>6-8</th><th>7-9</th><th>8-9</th></tr><tr><td>Time estimate (Weeks)</td><td>5</td><td>6</td><td>3</td><td>5</td><td>7</td><td>10</td><td>4</td><td>2</td><td>5</td><td>6</td><td>4</td></tr></table>                                                                                                                                                                      |       |       |          |     |     |     | Activity | 1-2 | 1-3 | 1-4 | 2-5 | 3-6 | 3-7          | 4-7   | 5-8   | 6-8   | 7-9   | 8-9  | Time estimate (Weeks) | 5    | 6    | 3    | 5    | 7    | 10             | 4     | 2     | 5     | 6     | 4     |   |    |   |   |   |   |   |    |     |
| Activity              | 1-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1-4   | 2-5   | 3-6      | 3-7 | 4-7 | 5-8 | 6-8      | 7-9 | 8-9 |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |
| Time estimate (Weeks) | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 3     | 5     | 7        | 10  | 4   | 2   | 5        | 6   | 4   |     |     |     |              |       |       |       |       |      |                       |      |      |      |      |      |                |       |       |       |       |       |   |    |   |   |   |   |   |    |     |

**SECTION -C (30 Marks)**

Answer ANY THREE questions

ALL questions carry EQUAL Marks (3 × 10 = 30)

| Module No.                     | Question No. | Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | K Level     | CO  |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
|--------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|--------------------------------|-------------------------------|-----|-----|-----|-----|-----|-----|----|----|-----|--------------------------------|----|----|----|---|----|----|----|----|----|--------------------------------|----|----|----|----|----|----|-----|---|----|----|-----|
| 1                              | 16           | Solve the given linear programming problems graphically:<br>Minimize: $Z = 20x + 10y$<br>Constraints are,<br>$x + 2y \leq 40$<br>$3x + y \geq 30$<br>$4x + 3y \geq 60$<br>$x \geq 0, y \geq 0$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | K3          | CO1 |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 2                              | 17           | Solve the following assignment problem shown in Table using Hungarian method. The matrix entries are processing time of each man in hours.<br><table><tr><td></td><td>I</td><td>II</td><td>III</td><td>IV</td><td>V</td></tr><tr><td>1</td><td>20</td><td>15</td><td>18</td><td>20</td><td>25</td></tr><tr><td>2</td><td>18</td><td>20</td><td>12</td><td>14</td><td>15</td></tr><tr><td>3</td><td>21</td><td>23</td><td>25</td><td>27</td><td>25</td></tr><tr><td>4</td><td>17</td><td>18</td><td>21</td><td>23</td><td>20</td></tr><tr><td>5</td><td>18</td><td>18</td><td>16</td><td>19</td><td>20</td></tr></table>                                                                                                                                                                                            |             | I   | II  | III | IV  | V   | 1   | 20  | 15  | 18                             | 20                            | 25  | 2   | 18  | 20  | 12  | 14  | 15 | 3  | 21  | 23                             | 25 | 27 | 25 | 4 | 17 | 18 | 21 | 23 | 20 | 5                              | 18 | 18 | 16 | 19 | 20 | K4 | CO2 |   |    |    |     |
|                                | I            | II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | III         | IV  | V   |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 1                              | 20           | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 18          | 20  | 25  |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 2                              | 18           | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 12          | 14  | 15  |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 3                              | 21           | 23                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 25          | 27  | 25  |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 4                              | 17           | 18                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 21          | 23  | 20  |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 5                              | 18           | 18                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 16          | 19  | 20  |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 3                              | 18           | Solve by graphical method<br><table><tr><td></td><td>B1</td><td>B2</td></tr><tr><td>A1</td><td>1</td><td>2</td></tr><tr><td>A2</td><td>5</td><td>4</td></tr><tr><td>A3</td><td>-7</td><td>9</td></tr><tr><td>A4</td><td>-4</td><td>-3</td></tr><tr><td>A5</td><td>2</td><td>1</td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             | B1  | B2  | A1  | 1   | 2   | A2  | 5   | 4   | A3                             | -7                            | 9   | A4  | -4  | -3  | A5  | 2   | 1  | K3 | CO4 |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
|                                | B1           | B2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |             |     |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| A1                             | 1            | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |     |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| A2                             | 5            | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |     |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| A3                             | -7           | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |     |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| A4                             | -4           | -3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |             |     |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| A5                             | 2            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |     |     |     |     |     |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 4                              | 19           | The following failures have been observed for a certain type of transistors in a digital computer:<br><table><tr><td>End of Week</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td>Probability of failure to date</td><td>0.05</td><td>.13</td><td>.25</td><td>.43</td><td>.68</td><td>.88</td><td>.96</td><td>1</td></tr></table><br>Total number of transistors at the beginning of assembly is 1000 units. The cost of replacing the individual failed transistors is Rs. 1.25/-. The decision is made to replace all these transistors simultaneously at fixed intervals and to replace the individual transistors as they fails in service. If the cost of group replacement is 30 paise per transistors, what is the best interval between group replacement? | End of Week | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | Probability of failure to date | 0.05                          | .13 | .25 | .43 | .68 | .88 | .96 | 1  | K3 | CO3 |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| End of Week                    | 1            | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 3           | 4   | 5   | 6   | 7   | 8   |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| Probability of failure to date | 0.05         | .13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | .25         | .43 | .68 | .88 | .96 | 1   |     |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| 5                              | 20           | Find out the time, variance and standard deviation of the project with the following time estimates in weeks:<br><table><tr><td>Activity</td><td>1-2</td><td>1-6</td><td>2-3</td><td>2-4</td><td>3-5</td><td>4-5</td><td>6-7</td><td>5-8</td><td>7-8</td></tr><tr><td>Optimistic time estimate (to)</td><td>3</td><td>2</td><td>6</td><td>4</td><td>8</td><td>3</td><td>3</td><td>2</td><td>8</td></tr><tr><td>Most likely time estimate (tm)</td><td>6</td><td>5</td><td>12</td><td>5</td><td>11</td><td>7</td><td>9</td><td>4</td><td>16</td></tr><tr><td>Pessimistic time estimate (tp)</td><td>9</td><td>8</td><td>18</td><td>6</td><td>14</td><td>11</td><td>15</td><td>6</td><td>18</td></tr></table>                                                                                                        | Activity    | 1-2 | 1-6 | 2-3 | 2-4 | 3-5 | 4-5 | 6-7 | 5-8 | 7-8                            | Optimistic time estimate (to) | 3   | 2   | 6   | 4   | 8   | 3   | 3  | 2  | 8   | Most likely time estimate (tm) | 6  | 5  | 12 | 5 | 11 | 7  | 9  | 4  | 16 | Pessimistic time estimate (tp) | 9  | 8  | 18 | 6  | 14 | 11 | 15  | 6 | 18 | K2 | CO5 |
| Activity                       | 1-2          | 1-6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2-3         | 2-4 | 3-5 | 4-5 | 6-7 | 5-8 | 7-8 |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| Optimistic time estimate (to)  | 3            | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 6           | 4   | 8   | 3   | 3   | 2   | 8   |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| Most likely time estimate (tm) | 6            | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 12          | 5   | 11  | 7   | 9   | 4   | 16  |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |
| Pessimistic time estimate (tp) | 9            | 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 18          | 6   | 14  | 11  | 15  | 6   | 18  |     |     |                                |                               |     |     |     |     |     |     |    |    |     |                                |    |    |    |   |    |    |    |    |    |                                |    |    |    |    |    |    |     |   |    |    |     |