# SRM VALLIAMMAI ENGINEERING COLLEGE

**(An Autonomous Institution)**

SRM Nagar, Kattankulathur – 603 203

## DEPARTMENT OF MANAGEMENT STUDIES

## QUESTION BANK

## II SEMESTER

## 1915201 – APPLIED OPERATIONS RESEARCH

**Regulation – 2019**

**Academic Year 2022 - 2023**

**Prepared by**

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**Course Coordinator: Dr. T.Isaiyarasi**

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**DEPARTMENT OFMANAGEMENT STUDIES**

**QUESTION BANK**

**SUBJECT : 1915201- APPLIED OPERATIONS RESEARCH**

**SEM / YEAR: II / I year M.B.A.**

| **UNIT – I** | | | |
|---|---|---|---|
| **Introduction to applications of operations research in functional areas of management-Linear Programming-formulation--solution by graphical and Simplex methods-Special cases-Dual simplex method- Principles of Duality-Sensitivity Analysis.** | | | |
| **PART- A** | | | |
| **S.NO** | **QUESTIONS** | **BT LEVEL** | **COMPETENCE** |
| **1.** | Define Operations Research (OR) | Level 1 | Remembering |
| **2.** | Discuss the Linear programming problem | Level 2 | Understanding |
| **3.** | Define optimum basic feasible solution | Level 1 | Remembering |
| **4.** | What is the difference between feasible solution and basic feasible solution? | Level 1 | Remembering |
| **5.** | State the applications of Linear programming problem | Level 3 | Applying |
| **6.** | Define unbounded solution. | Level 1 | Remembering |
| **7.** | Define Infeasible solution | Level 1 | Remembering |
| **8.** | Interpret the usage of Sensitivity Analysis in LPP. | Level 6 | Creating |
| **9.** | Discuss degenerate solution. | Level 1 | Remembering |
| **10.** | What are the assumptions and requirements of LPP? | Level 2 | Understanding |
| **11.** | Identify the Advantages of duality. | Level 3 | Applying |
| **12.** | A person requires 10, 12 and12 units of chemicals A, B and C respectively for his garden. A liquid product contains 5, 2 and 1 units of A, B and C respectively per jar. A dry product contains 1,2 and4 units ofA, B and C per carton. If the liquid product sells for Rs. 30 per jar and the dry product sells for Rs. 20 per carton, formulate the linear programming problem in order to minimize the purchase cost and meet the requirement | Level 4 | Analyzing |
| **13.** | A factory manufactures nails and screws. The profit earned is Rs.2/kg nails and Rs.3/kg screws. Three units of labors are required to manufacture 1 kg nails and 6 units to make 1 kg screws. Twenty four units of labor are available. Two units of raw materials are needed to make 1kg nails and 1 unit for 1 kg screws. Formulate the problem as an LP model which yields maximum profit from 10 units of raw materials. | Level 5 | Evaluating |
| **14.** | Analyze the graphical solution of a LPP | Level 4 | Analyzing |
| **15.** | Solve the following L.P.P by using graphical method<br>Maximize $Z = 5x_1 + 3x_2$,<br>Subject to<br>$3x_1 + 5x_2 \leq 15, 5x_1 + 2x_2 \leq 10, x_1, x_2 \geq 0$ | Level 1 | Remembering |

| | | | |
|---|---|---|---|
| **16.** | Compare graphical and simplex methods for solving LPP | Level 2 | Understanding |
| **17.** | Give some example for the role of Surplus variable & Slack Variable in the simplex method | Level 3 | Applying |
| **18.** | Compare Slack variable & Surplus Variable | Level 4 | Analyzing |
| **19.** | Define basic variables and artificial variables | Level 1 | Remembering |
| **20.** | Distinguish simplex and Big M method | Level 2 | Understanding |
| **21.** | What do you mean by Duality? List the Rules for primal and dual. | Level 1 | Remembering |
| **22.** | What is Shadow price? | Level 1 | Remembering |
| **23.** | How would you apply Artificial variable? | Level 2 | Understanding |
| **24.** | What is Two phase method? | Level 3 | Applying |
| **25.** | Conclude your understanding on the mathematical formulation of LPP. | Level 3 | Applying |

| S.NO. | QUESTIONS | BT LEVEL | COMPTENCE |
|---|---|---|---|
| **1.** | Maximize: $Z = 3x + 4y$<br>Subject to<br>$2x + 5y \leq 60$,<br>$4x + 2y \leq 40$,<br>$x, y > 0$.<br>Solve by Graphical Method<br>(i) Plot the graph<br>(ii) Obtain the optimal solution | Level 1 | Remembering |
| **2.** | Minimize: $Z = 20x_1 + 10\,x_2$<br>$Subject\ to$<br>$x_1 + 2x_2 \leq 40$,<br>$3x_1 + x_2 \geq 30$,<br>$4x_1 + 3x_2 \geq 60$,<br>$x_1, x_2 \geq 0$.<br>(i) Plot the graph<br>(ii) Predict the value of $x_1$& $x_2$ that optimizes the objective function | Level 1 | Remembering |
| **3.** | Solve the following LPP by graphical method.<br>Maximize Z= $3x_1 + 5x_2$<br>Subject to<br>$-3x_1 + 4x_2 \leq 12$<br>$x_1 \leq 4$<br>$2x_1 - x_2 \leq -2$<br>$2x_1 + 3x_2 \geq 12$<br>$x_1, x_2 \geq 0$ | Level 2 | Understanding |
| **4.(a)** | A company manufactures two types of products, $P_1$ and $P_2$. Each product uses lathe and milling machine. The processing time per unit of $P_1$ on the lathe in 5 hours and on the milling machine is 4 hours. The processing time per unit of $P_2$ on the lathe is 10 hours and milling machine, 4 hours. The maximum number of hours available per week on the lathe and the milling machine are 60 hours and 40 hours respectively. Also the profit per unit of selling $P_1$ and $P_2$ are Rs. 6 and Rs. 8 respectively Formulate LP model to determine the production volume of each of the product such that the total profit is maximized. | Level 3 | Applying |

<table>
<tr><td>4.(b)</td><td>Analyze the maximum value of Z = $5x_1 + 7x_2$<br>Subject to<br>$x_1 + x_2 \leq 4$<br>$3x_1 + 8x_2 \leq 24$<br>$10x_1 + 7x_2 \leq 35$<br>$x_1, x_2 \geq 0$<br>By Graphical method</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>5.</td><td>Apply Graphical method to solve the following LPP<br>Maximize Z = $3x_1 + 4x_2$ subject to<br>$5x_1 + 4x_2 \leq 200$<br>$3x_1 + 5x_2 \leq 150$<br>$5x_1 + 4x_2 \geq 100$<br>$8x_1 + 4x_2 \geq 80$<br>$x_1, x_2 \geq 0$</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>6.</td><td>A Plant Manufacturer 2 Product A & B. The Profit Contribution of each product has been estimated as Rs.300 for product A and Rs.400 for Product B. Each Product passes through 3 departments of the plant. The time required for each product and total time available in each department is as follows.
<table>
<tr><td rowspan="2">Department</td><td>Hours Required</td><td>Hours Required</td><td rowspan="2">Available Hours during month</td></tr>
<tr><td>Product A</td><td>Product B</td></tr>
<tr><td>I</td><td>2</td><td>3</td><td>1600</td></tr>
<tr><td>II</td><td>3</td><td>2</td><td>1500</td></tr>
<tr><td>III</td><td>1</td><td>1</td><td>700</td></tr>
</table>
The company has a contract to supply at least 300 units of Product B per month.<br>(i) Formulate the LPP<br>(ii) Solve through Graphical Method</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>7.</td><td>A company produces 2 types of hats A & B. Every hat B requires twice as much as labour time as hat A. The company can produce a total of 500 hats a day. The market limits daily sales of the A & B to 150 and 250 hats respectively. The Profits on hats A & B are Rs..8 & Rs.5 respectively.<br>(i) Summarize the given situation as a LPP.<br>(ii) Predict the optimum solution.</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>8.</td><td>A firm produces three products. These products are processors on 3 different machines. The time required for manufacturing one unit of cost of the products and the daily capacity of the three machines is given in the table below. Analyze and find the optimum solution.
<table>
<tr><td rowspan="2">Machine</td><td>Time/Unit (Minutes)</td><td>Time/Unit (Minutes)</td><td>Time/Unit (Minutes)</td><td rowspan="2">Machine Capacity Min /Day</td></tr>
<tr><td>Product 1</td><td>Product 2</td><td>Product 3</td></tr>
<tr><td>M1</td><td>2</td><td>8</td><td>2</td><td>940</td></tr>
<tr><td>M2</td><td>4</td><td>-</td><td>8</td><td>970</td></tr>
</table></td><td>Level 4</td><td>Analyzing</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| | M3 | 2 | 5 | - | 430 |
| | It is required to determine the daily no. of units to be manufactured for each product. The profit for unit for product 1, 2, 3 is Rs.4, Rs.8, and Rs.6 respectively. It is assumed that all the amount produced are consumed in the market | | | | |
| **9.** | Maximize Z =$6x_1 + 8x_2$<br>Subject to<br>$5x_1 + 10x_2 \leq 60$<br>$4x_1 + 4x_2 \leq 40$<br>$x_1, x_2 \geq 0$<br>(i) Develop a Simplex Table<br>(ii) Analyze and find the value of $x1and\ x2$. | | | | Level 4 | Analyzing |
| **10.** | Solve the following LPP using Simplex method<br>$Maximize\ Z = 10x_1 + 15x_2 + 20x_3$<br>Subject to<br>$2x_1 + 4x_2 + 6x_3 \leq 24$<br>$3x_1 + 9x_2 + 6x_3 \leq 30$<br>$x_1, x_2, x_3 \geq 0$ | | | | Level 2 | Understanding |
| **11.** | Analyze the following LPP by Simplex Method:<br>Develop a Simplex Table and Solve<br>Maximize Z = $3x_1 + 2x_2$<br>Subject to<br>$x_1 + x_2 \leq 4$<br>$x_1 - x_2 \leq 2$<br>$x_1, x_2 \geq 0$ | | | | Level 4 | Analyzing |
| **12.** | Apply the simplex algorithm to solve the following LPP<br>Maximize Z = $x_1 + x_2 + 3x_3$<br>Subject to<br>$3x_1 + 2x_2 + x_3 \leq 3$<br>$2x_1 + x_2 + 2x_3 \leq 2$<br>$x_1, x_2, x_3 \geq 0$ | | | | Level 3 | Applying |
| **13.** | Consider the linear programming model given below and solve it using the simplex method<br>Maximize $Z = 3x_1 + 2x_2 + 5x_3$<br>Subject to<br>$x_1 + 2x_2 + x_3 \leq 430$<br>$3x_1 + 2x_3 \leq 260$<br>$x_1 + 4x_2 \leq 420$<br>$x_1, x_2, x_3 \geq 0$<br>(i) Evaluate the simplex table<br>(ii) Obtain the optimal solution | | | | Level 2 | Understanding |
| **14.** | Consider the following LPP and apply Simplex Method to :<br>Maximize Z =$4x_1 + 3x_2 + 6x_3$<br>Subject to<br>$2x_1 + 3x_2 + 6x_3 \leq 440$<br>$4x_1 + 3x_3 \leq 470$<br>$2x_1 + 5x_2 \leq 430$<br>$x_1, x_2, x_3 \geq 0$<br>(i) Develop a Simplex Table<br>(ii) Solve and find the value of $x_1, x_2 and\ x_3$ | | | | Level 3 | Applying |
| **15.** | Solve the following LPP by simplex method: | | | | | |

| | | | |
|---|---|---|---|
| | Minimize $Z = 2x_1 + 5x_2$<br>Subject to<br>$x_1 + 4x_2 \leq 24$<br>$3x_1 + x_2 \leq 21$<br>$x_1 + x_2 \leq 9$<br>$x_1, x_2 \geq 0$<br>(i) Develop a Simplex Table<br>(ii) Solve and find the value of $x_1, x_2$ | Level 2 | Understanding |
| **16.** | Review the LPP and solve by simplex method<br>$Minimize\ Z = x_1 - 3x_2 + 3x_3$<br>Subject to the constraints<br>$3x_1 - x_2 + 2x_3 \leq 7$<br>$2x_1 + 4x_2 \geq -12$<br>$-4x_1 + 3x_2 + 8x_3 \leq 10$<br>$x_1, x_2, x_3 \geq 0$ | Level 6 | Creating |
| **17.** | Point out the solution of the following LPP by using dual simplex method<br>Maximize Z= $3x_1 - x_2$<br>Subject to<br>$x_1 + x_2 \geq 1$<br>$2x_1 + 3x_2 \geq 2$<br>$x_1, x_2 \geq 0$ | Level 5 | Evaluating |
| **18.** | Evaluate by using dual simplex method and solve the LPP.<br>$Minimize\ Z = 2x_1 + 4x_2$<br>Subject to<br>$2x_1 + x_2 \geq 4$<br>$x_1 + 2x_2 \geq 3$<br>$2x_1 + 2x_2 \leq 12$<br>$x_1, x_2 \geq 0$<br>(i) Determine the simplex table.<br>(ii) Find the value of $x_1, x_2$ | Level 5 | Evaluating |
| | **PART-C** | | |
| **1.** | $Max\ Z = 300x + 400y$<br>Subject to<br>$2x + 3y \leq 1600,$<br>$3x + 2y \leq 1500,$<br>$x + y \leq 700,$<br>$y \geq 300, x, y \geq 0$<br>Solve by Graphical Method, choose the value of x & y which maximizes profit. | Level 2 | Understanding |
| **2.** | Apply graphical method to predict the solution of the following LPP<br>Minimize $Z = 6000x_1 + 4000x_2$<br>Subject to<br>$3x_1 + x_2 \geq 40$<br>$x_1 + 2.5x_2 \geq 22$<br>$3x_1 + 3x_2 \geq 40$<br>$x_1, x_2 \geq 0$ | Level 3 | Applying |
| **3.** | Analyze the following LPP by simplex method:<br>Maximize $Z = 3x_1 + 2x_2$<br>Subject to | Level 4 | Analyzing |

| | | | |
|---|---|---|---|
| | $2x_1 + x_2 \leq 2$<br>$3x_1 + 4x_2 \geq 12$<br>$x_1, x_2 \geq 0$ | | |
| **4.** | Evaluate the solution by using Big M Method.<br>Maximize $Z = 3x + 2y$<br>Subject to the constraints<br>$2x + y \leq 2$<br>$3x + 4y \geq 12$<br>$x, y \geq 0$ | Level 5 | Evaluating |
| **5.** | Using dual simplex method, create the optimum solution for the given LPP.<br>$Minimize\ Z = 5x_1 + 6x_2$<br>Subject to<br>$x_1 + x_2 \geq 2$<br>$4x_1 + x_2 \geq 2$<br>$x_1, x_2 \geq 0$ | Level 6 | Creating |

**UNIT – II**

**SYLLABUS:** Transportation Models (Minimizing and Maximizing Problems) – Balanced and unbalanced Problems – Initial Basic feasible solution by N-W Corner Rule, Least cost and Vogel's approximation methods. Check for optimality. Solution by MODI /. Case of Degeneracy. Trans-shipment Models. Assignment Models (Minimizing and Maximizing Problems) – Balanced and Unbalanced Problems. Solution by Hungarian and Branch and Bound Algorithms. Travelling Salesman problem.

**PART- A**

| S.NO | QUESTIONS | BT LEVEL | COMPETENCE |
|---|---|---|---|
| **1.** | Define feasible solution | Level 1 | Remembering |
| **2.** | Define basic feasible solution | Level 1 | Remembering |
| **3.** | Define Non-degenerate basic feasible solution | Level 1 | Remembering |
| **4.** | Discuss the methods to find the initial solution for transportation problem | Level 1 | Remembering |
| **5.** | Evaluate the initial basic feasible solution of a transportation problem using North West Corner<br>Origin/Destination \| $D_1$ \| $D_2$ \| $D_3$ \| Supply<br>$O_1$ \| 2 \| 7 \| 4 \| 5<br>$O_2$ \| 3 \| 3 \| 1 \| 8<br>$O_3$ \| 5 \| 4 \| 7 \| 7<br>$O_4$ \| 1 \| 6 \| 2 \| 14<br>Demand \| 7 \| 9 \| 18 \| 34 | Level 2 | Understanding |
| **6.** | Define Transportation & Transshipment. | Level 1 | Remembering |
| **7.** | Differentiate balanced transportation problem & Unbalanced Transportation Problem. | Level 3 | Applying |
| **8.** | How would you show your understanding on unbalanced transportation problem? | Level 4 | Analyzing |
| **9.** | Categorize the Phases of transportation model. | Level 3 | Applying |
| **10.** | Interpret the need for Optimum solution in transportation. | Level 5 | Evaluating |
| **11.** | Construct the basic feasible solution for the following transportation problem. | Level 6 | Creating |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | SUPPLY | | |
| | 1 | 2 | 3 | 11 | 7 | 6 | | |
| | 2 | 1 | 0 | 6 | 1 | 1 | | |
| | 3 | 5 | 8 | 15 | 9 | 10 | | |
| | DEMAND | 7 | 5 | 3 | 2 | | | |
| **12.** | What do you mean by Least cost method (LCM)? | | | | | | Level 1 | Remembering |
| **13.** | Compare Vogel approximation method (VAM) & Least Cost Method. | | | | | | Level 2 | Understanding |
| **14.** | How do you represent a travelling salesman problem through mathematical formulation? | | | | | | Level 3 | Applying |
| **15.** | Analyze rules of travelling salesman Problem | | | | | | Level 4 | Analyzing |
| **16.** | Discuss the meaning of Assignment | | | | | | Level 5 | Evaluating |
| **17.** | Compare Balanced assignment problem & Unbalanced Assignment Problem. | | | | | | Level 6 | Creating |
| **18.** | What example can you give for Unbalanced assignment problem? | | | | | | Level 1 | Remembering |
| **19.** | How will you resolve degeneracy in Transportation Problem? | | | | | | Level 2 | Understanding |
| **20.** | Classify transportation problem. | | | | | | Level 3 | Applying |
| **21.** | Examine the Steps in Hungarian algorithm. | | | | | | Level 4 | Analyzing |
| **22.** | What is Branch and bound algorithm in Assignment? | | | | | | Level 1 | Remembering |
| **23.** | Compare Assignment and transportation Problem. | | | | | | Level 2 | Understanding |
| **24.** | What do you mean by Travelling Salesman Problem? | | | | | | Level 1 | Remembering |
| **25.** | What is Restricted Assignment? | | | | | | Level 1 | Remembering |

| S.NO | QUESTIONS | BT LEVEL | COMPETENCE |
|---|---|---|---|
| **1.** | Consider the transportation problem shown below<br>Market<br>Plant 1 2 3 4 5 Supply<br>1 10 2 16 14 10 300<br>2 6 18 12 13 16 500<br>3 8 4 14 12 10 825<br>4 14 22 20 8 18 375<br>Demand 350 400 250 150 400<br>Find the initial basic feasible solution using each of the following methods and compare their total costs<br>(a) North west corner method<br>(b) Least cost cell method<br>(c) Vogel's approximation method | Level 1 | Remembering |
| **2.** | Solve and find the Transportation Problem and Which method will you select if you want to Minimize Cost?<br>Destination: 1 2 3 4; Supply<br>I 21 16 25 13 11<br>II 17 18 14 23 13<br>III 32 27 18 41 19<br>Demand 6 10 12 15 | Level 1 | Remembering |

<table>
<tr>
<td>3.</td>
<td>Find the Initial Basic Feasible solution for following TP. Using NW Rule, LCM, and VAM. Which method will you select if you want to Minimize Cost?
<table>
<tr><td></td><td>D1</td><td>D2</td><td>D3</td><td>Supply</td></tr>
<tr><td>S1</td><td>7</td><td>3</td><td>2</td><td>2</td></tr>
<tr><td>S2</td><td>2</td><td>1</td><td>3</td><td>3</td></tr>
<tr><td>S3</td><td>3</td><td>4</td><td>6</td><td>5</td></tr>
<tr><td>Demand</td><td>4</td><td>1</td><td>5</td><td>10</td></tr>
</table>
</td>
<td>Level 2</td>
<td>Understanding</td>
</tr>
<tr>
<td>4.</td>
<td>Find the initial basic feasible solution for the following transportation problem by VAM.<br>Distribution Centers
<table>
<tr><td></td><td>D1</td><td>D2</td><td>D3</td><td>D4</td><td>Availability</td></tr>
<tr><td>S1</td><td>11</td><td>13</td><td>17</td><td>14</td><td>250</td></tr>
<tr><td>S2</td><td>16</td><td>18</td><td>14</td><td>10</td><td>300</td></tr>
<tr><td>S3</td><td>21</td><td>24</td><td>13</td><td>10</td><td>400</td></tr>
<tr><td>Requirements</td><td>200</td><td>225</td><td>275</td><td>250</td><td></td></tr>
</table>
</td>
<td>Level 3</td>
<td>Applying</td>
</tr>
<tr>
<td>5.</td>
<td>Analyze & solve the following transportation problem to maximize profit.
<table>
<tr><td>Source</td><td>A</td><td>B</td><td>C</td><td>D</td><td>Supply</td></tr>
<tr><td>1</td><td>15</td><td>51</td><td>42</td><td>33</td><td>23</td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>80</td><td>42</td><td>26</td><td>81</td><td>44</td></tr>
<tr><td>Demand</td><td>90</td><td>40</td><td>66</td><td>60</td><td>33</td></tr>
<tr><td></td><td>23</td><td>31</td><td>16</td><td>30</td><td>100</td></tr>
</table>
(i) Examine Initial solution using VAM<br>
(ii) Analyze and find out the final Solution by using MODI Method.
</td>
<td>Level 4</td>
<td>Analyzing</td>
</tr>
<tr>
<td>5.</td>
<td>Solve the following transportation problem using<br>
(i) North West Corner method<br>
(ii) Least Cost Method and<br>
(iii) Vogel’s Approximation method
<table>
<tr><td>1</td><td>2</td><td>6</td><td>7</td></tr>
<tr><td>0</td><td>4</td><td>2</td><td>12</td></tr>
<tr><td>3</td><td>1</td><td>5</td><td>11</td></tr>
<tr><td>10</td><td>10</td><td>10</td><td></td></tr>
</table>
</td>
<td>Level 5</td>
<td>Evaluating</td>
</tr>
<tr>
<td>6.</td>
<td>
<table>
<tr><td></td><td colspan="4">Destination</td><td>Supply</td></tr>
<tr><td>I</td><td>2</td><td>1</td><td>25</td><td>13</td><td>11</td></tr>
<tr><td>II</td><td>1</td><td>1</td><td>14</td><td>23</td><td>13</td></tr>
<tr><td>III</td><td>3</td><td>2</td><td>18</td><td>41</td><td>19</td></tr>
</table>
</td>
<td>Level 6</td>
<td>Creating</td>
</tr>
</table>

| | | | | |
|---|---|---|---|---|
| | Demand \| 6 \| 1 \| 22 \| 15 \|<br>(i) Solve the transportation problem and decide using VAM for initial solution<br>(ii) Evaluate using NWC and Least Cost method for initial solution. | | | |
| **8.** | Evaluate the optimal solution for the transportation problem starting with the initial solution obtained by VAM<br>\| \| $D_1$ \| $D_2$ \| $D_3$ \| $D_4$ \| Supply \|<br>\| $O_1$ \| 2 \| 2 \| 2 \| 1 \| 3 \|<br>\| $O_2$ \| 10 \| 8 \| 5 \| 4 \| 7 \|<br>\| $O_3$ \| 7 \| 6 \| 6 \| 8 \| 5 \|<br>\| Demand \| 4 \| 3 \| 4 \| 4 \| 15 \| | Level 5 | Evaluating |
| **9.** | The following is the transshipment problem with 4 sources and 2 destinations. The supply values of the sources $S_1, S_2, S_3, S_4$ are 100,200,150, and 350 units respectively. The demand values destinations $D_1, D_2$ are 350 and 450 units respectively. Transportation cost per unit between various defined sources and destinations are given in the following table. Solve the transshipment problem.<br>\| Source \| Destination \| | | | | | |<br>\| \| $S_1$ \| $S_2$ \| $S_3$ \| $S_4$ \| $D_1$ \| $D_2$ \|<br>\| $S_1$ \| 0 \| 4 \| 20 \| 5 \| 25 \| 12 \|<br>\| $S_2$ \| 10 \| 0 \| 6 \| 10 \| 5 \| 20 \|<br>\| $S_3$ \| 15 \| 20 \| 0 \| 8 \| 45 \| 7 \|<br>\| $S_4$ \| 20 \| 25 \| 10 \| 0 \| 30 \| 6 \|<br>\| $D_1$ \| 20 \| 18 \| 60 \| 15 \| 0 \| 10 \|<br>\| $D_2$ \| 10 \| 25 \| 30 \| 23 \| 4 \| 0 \| | Level 3 | Applying |
| **10.** | A batch of 4 jobs can be assigned to 5 different machines. The set up time (in hours) for each job on various machines is given below.<br>Machines<br>JOB ↓ \| \| 1 \| 2 \| 3 \| 4 \| 5 \|<br>\| 1 \| 10 \| 11 \| 4 \| 2 \| 8 \|<br>\| 2 \| 7 \| 11 \| 10 \| 14 \| 12 \|<br>\| 3 \| 5 \| 6 \| 9 \| 12 \| 14 \|<br>\| 4 \| 13 \| 15 \| 11 \| 10 \| 7 \| | Level 1 | Remembering |
| **11.** | A company has one surplus truck in each of the cities A, B, C, D, & E and one deficit trucks in each of the cities 1, 2, 3,4,5,6. The distance between the cities in kms is shown in the matrix below. Can you select the assignment of trucks from cities in surplus to cities in deficiency .so that total distance covered by the vehicles is minimum?<br>\| \| 1 \| 2 \| 3 \| 4 \| 5 \| 6 \|<br>\| A \| 12 \| 10 \| 15 \| 22 \| 18 \| 8 \|<br>\| B \| 10 \| 18 \| 25 \| 15 \| 16 \| 12 \|<br>\| C \| 11 \| 10 \| 3 \| 8 \| 5 \| 9 \|<br>\| D \| 6 \| 4 \| 10 \| 13 \| 13 \| 12 \|<br>\| E \| 8 \| 12 \| 11 \| 7 \| 13 \| 10 \| | Level 2 | Understanding |
| **12.** | Solve the following travelling salesman problem so as to minimize the cost per cycle. | | |

| | | | |
|---|---|---|---|
| | FROM↓ TO →<br>\| \| A \| B \| C \| D \| E \|<br>\| A \| - \| 3 \| 6 \| 2 \| 3 \|<br>\| B \| 3 \| - \| 5 \| 2 \| 3 \|<br>\| C \| 6 \| 5 \| - \| 6 \| 4 \|<br>\| D \| 2 \| 2 \| 6 \| - \| 6 \|<br>\| E \| 3 \| 3 \| 4 \| 6 \| - \| | Level 3 | Applying |
| **13.** | The assignment cost of assigning any one operator to any one machine is given in the following table.<br>MACHINE↓ OPERATORS →<br>\| \| I \| II \| III \| IV \|<br>\| A \| 10 \| 5 \| 13 \| 15 \|<br>\| B \| 3 \| 9 \| 18 \| 3 \|<br>\| C \| 10 \| 7 \| 3 \| 2 \|<br>\| D \| 5 \| 11 \| 9 \| 7 \|<br>Find the optimal assignment by Hungarian method. | Level 4 | Analyzing |
| **14.** | A machine shop purchased a drilling machine and two lathes of different capacities. The Positioning of the machines among 4 possible locations on the shop floor is important forms the standard of materials handling. Given the cost estimate per unit time of materials below, find the optimum location of the machines.<br>LOCATIONS<br>\| \| 1 \| 2 \| 3 \| 4 \|<br>\| Lathe 1 \| 12 \| 9 \| 12 \| 9 \|<br>\| Drill \| 15 \| Not suitable \| 13 \| 20 \|<br>\| Lathe 2 \| 4 \| 8 \| 10 \| 6 \| | Level 1 | Remembering |
| **15.** | Solve the assignment problem for maximization given profit matrix (profit in rupees).<br>\| \| Machines \| \| \| \|<br>\| \| P \| Q \| R \| S \|<br>\| JOB \| 51 \| 53 \| 54 \| 50 \|<br>\| \| 47 \| 50 \| 48 \| 50 \|<br>\| \| 49 \| 50 \| 60 \| 61 \|<br>\| \| 63 \| 64 \| 60 \| 60 \| | Level 2 | Understanding |

**16.** The processing time in hours for the jobs when allocated to the different machines is indicated below. Select the best assignment of the machines for the jobs so that the total processing time is Minimum.

| | | Machines | | | | |
|---|---|---|---|---|---|---|
| | | M1 | M2 | M3 | M4 | M5 |
| JOB | J1 | 9 | 22 | 58 | 11 | 19 |
| | J2 | 43 | 78 | 72 | 50 | 63 |
| | J3 | 41 | 28 | 91 | 37 | 45 |
| | J4 | 74 | 42 | 27 | 49 | 39 |
| | J5 | 36 | 11 | 57 | 22 | 25 |

Level 4 | Analyzing

**17.** For the given travelling salesman problem, Minimize the total cost.

| | To | | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| From | A | - | 46 | 16 | 40 |
| | B | 41 | - | 50 | 40 |
| | C | 82 | 32 | - | 60 |
| | D | 40 | 40 | 36 | - |

(i) Observe the above travelling salesman problem and find out minimize the cost per cycle.

(ii) Find whether path is satisfied.

Level 1 | Remembering

**18.** A company has a team of four salesman and four districts where the company wants to start its business. After taking into account the capabilities of salesmen and the nature of hundreds of rupees for each salesmen in each district is as below. Create the assignment of salesmen to various district which will yield maximum profit

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| A | 16 | 10 | 14 | 11 |
| B | 14 | 11 | 15 | 15 |
| C | 15 | 15 | 13 | 12 |
| D | 13 | 12 | 14 | 15 |

Level 6 | Creating

## PART - C

| S.NO | QUESTIONS | BT LEVEL | COMPETENCE |
|---|---|---|---|
| **1.** | Assume that you are an OR specialist. Identify the procedure for each of the following Method to the employees in order to help them achieve solution to Transportation Problems.<br>(i)Northwest Corner Cell Method<br>(ii)Least Cost cell Method (4 marks) | Level 1 | Remembering |

| | | | |
|---|---|---|---|
| | (iii)Vogel's Approximation Method (4 marks)<br>(iv)U V Method. (4 marks) | | |
| **2.** | Solve the following transportation problem, in which $a_i$ is the availability at Origin .$O_i$ and $b_j$ is the requirement at the destination $D_j$ and cell entries are unit costs of transportation from any origin to any destination:<br><br>D1 D2 D3 D4 D5 $a_i$<br>O1 4 7 3 8 2 2<br>O2 1 4 7 3 8 7<br>O3 7 2 4 7 7 9<br>O4 4 8 2 4 7 2<br>$b_j$ 8 3 7 2 2<br>Predict the allocation to minimize the cost. | Level 2 | Understanding |
| **3.** | Five new machines are to be located in a machine shop. There are five possible locations in which the machines can be located, $a_j$, the cost of placing machine $i$ in place j is given in the table below. Solve the problem by assignment problem.<br><br>1 2 3 4 5<br>1 15 10 25 25 10<br>2 1 8 10 20 2<br>3 8 9 17 20 10<br>4 14 10 25 27 15<br>5 10 8 25 27 12 | Level 3 | Applying |
| **4.** | Five operators have to be assigned to Five Machines. The assignment costs are given in the table below.<br><br>Machines →<br>Operator↓ I II III IV V<br>A 5 5 - 2 6<br>B 7 4 2 3 4<br>C 9 3 5 - 3<br>D 7 2 6 7 2<br>E 6 5 7 9 1 | Level 4 | Analyzing |
| **5.** | A travelling salesman has to visit 5 cities. He wishes to start from a particular city visit each city once and then return to his starting point, cost of going from one city to another is shown below. Point out the least cost route<br><br>A B C D E<br>A ∞ 4 10 14 2<br>B 12 ∞ 6 10 4<br>C 16 14 ∞ 8 14<br>D 24 8 12 ∞ 10<br>E 2 6 4 16 ∞ | Level 5 | Evaluating |

## UNIT – III

**SYLLABUS:** Integer Programming – Introduction and types - Game Theory-Two-person Zero sum games- Saddle point- Dominance Rule-graphical and LP solutions- Nash Equilibrium

### PART- A

| S.NO | QUESTIONS | BT LEVEL | COMPETENCE |
|---|---|---|---|
| **1.** | What do you mean by integer programming problem? | Level 1 | Remembering |
| **2.** | In what respect a mixed IPP differs from pure IPP? | Level 2 | Understanding |
| **3.** | How do you show your understanding on Gomory's fractional cut algorithm or Gomory's slack? | Level 3 | Applying |
| **4.** | Point out the algorithms available to solve integer programming problem | | |
| **5.** | State the types of integer programing problems | Level 4 | Analyzing |
| **6.** | State the properties of Gomory's algorithm | | |
| **7.** | Explain the cutting method in integer programming problem. | | |
| **8.** | Point out the applications of integer programming. | | |
| **9.** | Compile the Characteristics of game. | Level 5 | Evaluating |
| **10.** | Classify the different types of strategy. | Level 6 | Creating |
| **11.** | Define Game. | Level 1 | Remembering |
| **12.** | State the types of Games | | |
| **13.** | Compare Mixed Strategy and Pure Strategy. | Level 2 | Understanding |
| **14.** | How would you make use of the concept of Game theory in Managerial Decision Making? | Level 3 | Applying |
| **15.** | Conclude your understanding about Payoff Matrix. | Level 4 | Analyzing |
| **16.** | How will you find the optimal strategies and value of the following game?<br>Player B: H, T<br>Player A: H (2, -1); T (-1, 0) | Level 5 | Evaluating |
| **17.** | Interpret the concept of two person zero sum game. | Level 6 | Creating |
| **18.** | What is Saddle point? | Level 1 | Remembering |
| **19.** | Compare Dominance Principle of Rows and Columns. | Level 2 | Understanding |
| **20.** | Identify the basic assumptions of the Game. | Level 3 | Applying |
| **21.** | Conclude the advantages of Game theory. | Level 4 | Analyzing |
| **22.** | What are the Methods of Matrices? | Level 1 | Remembering |
| **23.** | Summarize how graphs and LP solution are used in Game theory. | Level 2 | Understanding |
| **24.** | What is a Decision Tree? | Level 1 | Remembering |
| **25.** | Define Dominance principle. | Level 1 | Remembering |

### PART- B

| S.NO | QUESTIONS | BT LEVEL | COMPETENCE |
|---|---|---|---|
| **1.** | **(i)** What do you mean by Pure IPP?<br>(ii) What do you mean by Mixed IPP?<br>(iii) List out the difference between Pure and Mixed IPP. | Level 1 | Remembering |

<table>
<tr><td>2.</td><td>Solve the Integer Programming Problem:<br>Maximize $Z = 2x_1 + 2x_2$<br>Subject to<br>$5x_1 + 3x_2 \leq 8$<br>$2x_1 + 4x_2 \leq 8$<br>$x_1, x_2 \geq 0$</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>3.</td><td>Apply Branch and bound technique to solve the integer programming problem<br>Maximize $Z = x_1 + 4x_2$<br>Subject to<br>$2x_1 + 4x_2 \leq 7$<br>$5x_1 + 3x_2 \leq 15$<br>$x_1, x_2 \geq 0$</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>4.(a)</td><td>Write down the assumptions of game theory.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>4.(b)</td><td>
<table>
<tr><td></td><td>$B_1$</td><td>$B_2$</td><td>$B_3$</td></tr>
<tr><td>$A_1$</td><td>λ</td><td>6</td><td>2</td></tr>
<tr><td>$A_2$</td><td>-1</td><td>λ</td><td>-7</td></tr>
<tr><td>$A_3$</td><td>-2</td><td>4</td><td>λ</td></tr>
</table>
(i) For what value of λ, the game with the following matrix is strictly determined.
</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>5.(a)</td><td>Explain the concept of Nash Equilibrium.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>5.(b)</td><td>Solve the game whose pay-off matrix is given by
<table>
<tr><td></td><td>$B_1$</td><td>$B_2$</td><td>$B_3$</td></tr>
<tr><td>$A_1$</td><td>1</td><td>3</td><td>1</td></tr>
<tr><td>$A_2$</td><td>0</td><td>-4</td><td>-3</td></tr>
<tr><td>$A_3$</td><td>1</td><td>5</td><td>-1</td></tr>
</table>
</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>6(a)</td><td>Point out the ranges of value p and q which will render the entry (2, 3) a saddle point for the game.
<table>
<tr><td></td><td>$B_1$</td><td>$B_2$</td><td>$B_3$</td></tr>
<tr><td>$A_1$</td><td>2</td><td>4</td><td>5</td></tr>
<tr><td>$A_2$</td><td>10</td><td>7</td><td>q</td></tr>
<tr><td>$A_3$</td><td>4</td><td>p</td><td>6</td></tr>
</table>
</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>6.(b)</td><td>The payoff matrix of game is given below. Evaluate the solution of the game A and B.
<table>
<tr><td></td><td>I</td><td>II</td><td>III</td><td>IV</td><td>V</td></tr>
<tr><td>I</td><td>-4</td><td>-2</td><td>-2</td><td>3</td><td>1</td></tr>
<tr><td>II</td><td>1</td><td>0</td><td>-1</td><td>0</td><td>0</td></tr>
<tr><td>III</td><td>-6</td><td>-5</td><td>-2</td><td>-4</td><td>4</td></tr>
<tr><td>IV</td><td>3</td><td>1</td><td>-6</td><td>0</td><td>-8</td></tr>
</table>
</td><td>Level 5</td><td>Evaluating</td></tr>
</table>

<table>
<tr><td>7.</td><td>Reduce the following game by dominance and create the game value:<br><br>Player B<br><table><tr><td></td><td></td><td>I</td><td>II</td><td>III</td><td>IV</td></tr><tr><td rowspan="4">Player A</td><td>I</td><td>3</td><td>2</td><td>4</td><td>0</td></tr><tr><td>II</td><td>3</td><td>4</td><td>2</td><td>4</td></tr><tr><td>III</td><td>4</td><td>2</td><td>4</td><td>0</td></tr><tr><td>IV</td><td>0</td><td>4</td><td>0</td><td>8</td></tr></table></td><td>Level 6</td><td>Creating</td></tr>
<tr><td>8.</td><td>Analyze the Value of the game graphically<br><table><tr><td></td><td>B1</td><td>B2</td></tr><tr><td>A1</td><td>4</td><td>4</td></tr><tr><td>A2</td><td>2</td><td>7</td></tr><tr><td>A3</td><td>5</td><td>3</td></tr><tr><td>A4</td><td>6</td><td>2</td></tr></table></td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>9.</td><td>For the game with payoff matrix, determine the best strategies for players A and B and also the value of the game.<br><table><tr><td></td><td></td><td>Player B</td><td></td></tr><tr><td>Player A</td><td>-1</td><td>2</td><td>-2</td></tr><tr><td></td><td>6</td><td>4</td><td>-6</td></tr></table></td><td>Level 5</td><td>Evaluating</td></tr>
<tr><td>10.</td><td>How would you evaluate the following game whose Pay-Off matrix is Given Below?<br><br>9 3 1 8 0<br><br>6 5 4 6 7<br><br>2 4 3 3 8<br><br>5 6 2 2 1</td><td>Level 6</td><td>Creating</td></tr>
<tr><td>11.</td><td>Two players A&B match coins. If the coins match then A wins one unit value, if the coins do not match then B wins one unit of value.<br>(i) Determine pay-off matrix which strategy is to be chosen<br>(ii) Find the value of game.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>12.</td><td>Predict the Value of the Game given above Pay Off Matrix.<br><table><tr><td></td><td colspan="4">Player B</td></tr><tr><td rowspan="4">Player A</td><td></td><td>B1</td><td>B2</td><td>B3</td></tr><tr><td>A1</td><td>-2</td><td>5</td><td>-3</td></tr><tr><td>A2</td><td>1</td><td>3</td><td>5</td></tr><tr><td>A3</td><td>-3</td><td>-7</td><td>11</td></tr></table></td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>13.</td><td>Apply graphical analysis to Solve the game.<br><table><tr><td>A/B</td><td>B1</td><td>B2</td><td>B3</td><td>B4</td></tr><tr><td>A1</td><td>3</td><td>3</td><td>4</td><td>0</td></tr><tr><td>A2</td><td>5</td><td>4</td><td>3</td><td>7</td></tr></table></td><td>Level 3</td><td>Applying</td></tr>
</table>

<table>
<tr><td>14.</td><td>Solve the following game by graphical method.
<table>
<tr><td></td><td></td><td colspan="3">Player B</td></tr>
<tr><td rowspan="3">Player A</td><td></td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>1</td><td>6</td><td>4</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>4</td><td>8</td></tr>
</table></td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>15.</td><td>A and B play a Match(Game) in which each has 3 coins 5 paise, 10 paise and 20 paise. Each player selects a coin without the knowledge of others choice. IF the sum is even, B wins A’s Coin. If sum is Odd, A wins B’s coin.<br>(i) How will you find the pay-off matrix?<br>(ii) Find the Best Strategy & value of the Game.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>16.</td><td>Consider the Pay Off Matrix of player A as shown in the table below and solve it optimally using the graphical method.
<table>
<tr><td></td><td colspan="6">Player B</td></tr>
<tr><td rowspan="3">Player A</td><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>1</td><td>3</td><td>6</td><td>8</td><td>4</td><td>4</td></tr>
<tr><td>2</td><td>-7</td><td>4</td><td>2</td><td>10</td><td>2</td></tr>
</table></td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>17.(a)</td><td>Explain Key elements in game theory and Classification of game theory.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>17.(b)</td><td>Analyze the Game Graphically:
<table>
<tr><td></td><td colspan="2">Player A</td></tr>
<tr><td>Player A</td><td>B1</td><td>B2</td></tr>
<tr><td>A1</td><td>-3</td><td>1</td></tr>
<tr><td>A2</td><td>5</td><td>3</td></tr>
<tr><td>A3</td><td>6</td><td>-1</td></tr>
<tr><td>A4</td><td>1</td><td>4</td></tr>
<tr><td>A5</td><td>2</td><td>2</td></tr>
<tr><td>A6</td><td>0</td><td>-5</td></tr>
</table>
(i) Plot the graph.<br>(ii) Analyze and find the value of the game</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>18.</td><td>Solve the following 2X5 game by graphical method
<table>
<tr><td></td><td></td><td colspan="5">Player B</td></tr>
<tr><td>Player A</td><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td></td><td>1</td><td>-5</td><td>5</td><td>0</td><td>-1</td><td>8</td></tr>
<tr><td></td><td>2</td><td>8</td><td>-4</td><td>-1</td><td>6</td><td>-5</td></tr>
</table></td><td>Level 2</td><td>Understanding</td></tr>
</table>

| PART – C | | | |
|---|---|---|---|
| **S.NO** | **QUESTIONS** | **BT LEVEL** | **COMPETENCE** |
| **1.** | Solve the following game without Saddle point.<br>**B**<br>**A** \| 2 5<br>4 1 | Level 1 | Remembering |

<table>
<tr><td>2.</td><td>Examine the 2 * n Game by the Method of Sub Game:<br><table><tr><td></td><td>B1</td><td>B2</td><td>B3</td></tr><tr><td>A1</td><td>1</td><td>3</td><td>11</td></tr><tr><td>A2</td><td>8</td><td>5</td><td>2</td></tr></table></td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>3.</td><td>In a game of matching coins with 2 players, A wins 1 unit value when there are 2 heads, wins nothing when there are 2 tails and loses ½ unit value when there are one head and one tail. Develop Pay Off matrix and value of the game.</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>4.</td><td>Analyze the game and find the value.<br><table><tr><td></td><td>B1</td><td>B2</td><td>B3</td></tr><tr><td>A1</td><td>80</td><td>70</td><td>60</td></tr><tr><td>A2</td><td>90</td><td>80</td><td>100</td></tr><tr><td>A3</td><td>40</td><td>30</td><td>40</td></tr></table></td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>5.</td><td>Consider the 4X4 game played by Players A and B given in the following table<br><table><tr><td></td><td></td><td>Player B</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td></td><td>1</td><td>6</td><td>2</td><td>4</td><td>8</td></tr><tr><td>Player A</td><td>2</td><td>2</td><td>-1</td><td>1</td><td>12</td></tr><tr><td></td><td>3</td><td>2</td><td>3</td><td>3</td><td>9</td></tr><tr><td></td><td>4</td><td>5</td><td>2</td><td>6</td><td>10</td></tr></table>Create the solution to the problem optimally</td><td>Level 6</td><td>Creating</td></tr>
</table>

<table>
<tr><th colspan="4">UNIT – IV</th></tr>
<tr><td colspan="4">SYLLABUS: Inventory Models – EOQ and EBQ Models (With and without shortages), Quantity Discount Models. Decision making under risk – Decision trees – Decision making under uncertainty. Monte-Carlo simulation.</td></tr>
<tr><th colspan="4">PART- A</th></tr>
<tr><th>S.NO</th><th>QUESTIONS</th><th>BT LEVEL</th><th>COMPETENCE</th></tr>
<tr><td>1.</td><td>Define inventory.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>2.</td><td>State the reason for maintaining inventories</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>3.</td><td>Classify the Forms of inventory.</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>4.</td><td>Identify the Objectives/significance of inventory model.</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>5.</td><td>Highlight the importance of Reorder level.</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>6.</td><td>Discuss the concept of Lead time.</td><td>Level 5</td><td>Evaluating</td></tr>
<tr><td>7.</td><td>Interpret the Types of stock replenishment.</td><td>Level 6</td><td>Creating</td></tr>
<tr><td>8.</td><td>List the Basic inventory models.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>9.</td><td>Point out the categories of inventory costs</td><td>Level 5</td><td>Evaluating</td></tr>
<tr><td>10.</td><td>Compare Ordering Cost and Carrying Cost.</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>11.</td><td>Identify when shortage cost and stock out cost arises?</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>12.</td><td>Analyze why safety stock is maintained.</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>13.</td><td>Discuss the factors involved in inventory analysis</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>14.</td><td>List the deterministic inventory models</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>15.</td><td>Discuss the concept of Quantity Discount Model.</td><td>Level 5</td><td>Evaluating</td></tr>
<tr><td>16.</td><td>Interpret the meaning of EOQ & EBQ.</td><td>Level 6</td><td>Creating</td></tr>
</table>

| | | | |
|---|---|---|---|
| **17.** | What are random and pseudo random numbers? | Level 1 | Remembering |
| **18.** | Explain Monte Carlo Method. | Level 2 | Understanding |
| **19.** | Summarize the concept of EMV. | Level 3 | Applying |
| **20.** | What inference can you make about holding cost? | Level 4 | Analyzing |
| **21.** | What is Shortage Cost? | Level 1 | Remembering |
| **22.** | Classify and explain the various conditions under which decisions are made. | Level 2 | Understanding |
| **23.** | What is meant by the following terms in inventory management:<br>i)Carrying cost ii) shortage costs | Level 1 | Remembering |
| **24.** | What is Decision theory? List the problems that can be solved by Simulation. | Level 1 | Remembering |
| **25.** | State the steps involved in decision tree analysis. | Level 1 | Remembering |

**PART- B**

| **S.NO** | **QUESTIONS** | **BT LEVEL** | **COMPETENCE** |
|---|---|---|---|
| **1.** | Alpha industry needs 5400 units per year of a bought out component which will be used in its main product. The ordering cost is Rs.250 per order and the carrying cost per unit per year is Rs.30.<br>(i) Obtain the Economic order quantity (EOQ)<br>(ii) Find the number of order per year<br>(iii) Find the frequency of orders? | Level 1 | Remembering |
| **2.** | An industry needs 15,000 units per year of a bought-out component which will be used in its main product. The ordering cost is Rs.125 per order and carrying cost per unit per year is 20% of the purchase price per unit. The purchase price per unit is Rs.75. Obtain the<br>(i) Economic order quantity<br>(ii) Number of orders per year<br>(iii) Time between successive orders | Level 3 | Applying |
| **3.** | A stockiest has to supply 12000 units of a product per year to his customer. Demand is fixed and known. Shortage cost is assumed to be infinite. Inventory holding cost is 20 paise per unit per month. Ordering Cost is Rs. 250 and purchase price is Rs.10 per unit.<br>(i) Estimate the EOQ<br>(ii) Find the Frequency of orders and total inventory cost. | Level 2 | Understanding |
| **4.** | The annual demand of an item in the stores of a foundry is 9000 units. Its annual carrying cost is 15% of the purchase price of the item per year, where the purchase price is Rs.20 per unit. The ordering cost is Rs.15 per order. Presently, the order size of the item is the average monthly demand of that item. Find the economic order quantity and compare its cost with the present ordering system and find the corresponding cost advantage if exists. | Level 2 | Understanding |
| **5.** | Demand for an item in a company is 18,000 units per year. The company can produce the items at a rate of 3000 units per month. The Cost of one setup is Rs.500 and the holding cost of one unit per month is 15 paise. Shortage cost of one unit is Rs.20 per year.<br>(i) Analyze and find the optimum manufacturing quantity.<br>(ii) Find the number of shortages and frequency of Production run. | Level 3 | Applying |
| **6.** | Explain the deterministic Inventory model with examples. | Level 4 | Analyzing |

<table>
<tr><td>7.</td><td>The Demand for an item is 6000 units per year. Its production rate is 1000 units per month. The carrying cost is Rs. 50 /unit/year and the set – up cost is Rs. 2000 per set-up. The shortage cost is Rs.1000 per unit per year. Find various parameters of the inventory system.</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>8.</td><td>A company has a demand of 12000 units/year for an item and it can produce 2000 units per month. The cost of one setup is Rs.400 and the holding cost/unit/month is 15 paise. Select the optimum lot size and total cost per year assuming the cost of 1 unit as Rs.4. Find EBQ, the number of set ups & total cost.</td><td>Level 5</td><td>Evaluating</td></tr>
<tr><td>9.</td><td>Find the optimal order quantity for a product when the annual demand for the product is 500 units. The Cost of storage per unit per year is 10% of the unit cost. Ordering cost per order is Rs. 180.<br>(i) Determine EOQ.<br>(ii) Evaluate the Total Cost.</td><td>Level 6</td><td>Creating</td></tr>
<tr><td>10.</td><td>Formulate the Optimal order quantity and total cost for a product for which the price breaks are as follows.
<table>
<tr><th>Quantity</th><th>Unit Cost(Rs.)</th></tr>
<tr><td>$0 < Q < 500$</td><td>1000</td></tr>
<tr><td>$500 \leq Q \leq 750$</td><td>925</td></tr>
<tr><td>$750 \leq Q$</td><td>875</td></tr>
</table></td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>11.</td><td>Compute the EOQ and the total variable cost for the following:<br>Annual demand: 25 units<br>Unit price: Rs.2.50<br>Order cost: Rs.4.00<br>Storage rate: 1% per year</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>12.</td><td>Identify the profit under three states of nature & three decision alternative.
<table>
<tr><td></td><td></td><td>State of Nature</td><td>State of Nature</td><td>State of Nature</td></tr>
<tr><td></td><td></td><td>N1</td><td>N2</td><td>N3</td></tr>
<tr><td>Decision Making</td><td>D1</td><td>150</td><td>250</td><td>300</td></tr>
<tr><td>Decision Making</td><td>D2</td><td>450</td><td>250</td><td>200</td></tr>
<tr><td>Decision Making</td><td>D3</td><td>100</td><td>180</td><td>290</td></tr>
</table>
(i) Hurwitz criterion for alpha = 0.5<br>(ii) Laplace condition<br>(iii) Minimax Condition</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>13.</td><td>A Bakery keeps a stock of particular brand of cake. Daily demand of past experience.
<table>
<tr><td>Daily demand</td><td>0</td><td>15</td><td>25</td><td>35</td><td>45</td><td>50</td></tr>
<tr><td>Probability</td><td>0.01</td><td>0.15</td><td>0.20</td><td>0.50</td><td>0.12</td><td>0.02</td></tr>
</table>
Consider the following sequence of random numbers.<br>48 78 9 51 56 77 15 14 68 9<br>Using this sequence simulate the demand for next 10 days.</td><td>Level 4</td><td>Analyzing</td></tr>
</table>

<table>
<tr><td></td><td>Find the stock situation if the owner makes 35 cakes every day. Examine the daily average demand.</td><td></td><td></td></tr>
<tr><td>14.</td><td>
<table>
<tr><td>Nature</td><td>Probability</td><td>Don’t Expand</td><td>Expand 200</td><td>Expand 400</td></tr>
<tr><td>High Demand</td><td>0.4</td><td>2500</td><td>3500</td><td>5000</td></tr>
<tr><td>Medium Demand</td><td>0.4</td><td>2500</td><td>3500</td><td>2500</td></tr>
<tr><td>Low Demand</td><td>0.2</td><td>2500</td><td>1500</td><td>1000</td></tr>
</table>
Given above is the following pay off matrix.<br>Using EMV criterion. Decide which of the act can be chosen at the best. Find EVPI & EOL</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>15.</td><td>Explain the Types of inventory and cost involved in Inventory management.</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>16.</td><td>Consider the details of two competing alternatives as shown in the table below. The initial outlay of each of the alternatives is Rs.10, 00,000. The life of each alternative is 10 years. Evaluate the best alternative, when the interest rate is 0%.
<table>
<tr><td colspan="4">Annual Revenue of Alternatives</td></tr>
<tr><td colspan="2">Alternative 1</td><td colspan="2">Alternative 2</td></tr>
<tr><td>Annual Revenue (Rs)</td><td>Probability</td><td>Annual revenue (Rs)</td><td>Probability</td></tr>
<tr><td>3,00,000</td><td>0.3</td><td>4,00,000</td><td>0.1</td></tr>
<tr><td>4,00,000</td><td>0.4</td><td>5,00,00</td><td>0.5</td></tr>
<tr><td>5,00,000</td><td>0.3</td><td>6,00,000</td><td>0.4</td></tr>
</table></td><td>Level 5</td><td>Evaluating</td></tr>
<tr><td>17.</td><td>(i)A company uses annually 50,000 units of an item each costing Rs.1.20. Each order costs Rs.45 and inventory carrying costs are 15% of the annual average inventory value.<br>(ii) Find EOQ. If the company operates 250 days a year and the procurement time is 10 days and safety stock is 500 units, find reorder level, maximum, minimum and average inventory.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>18.</td><td>A retail store desires to determine the optimal daily order size for a perishable item. The store buys the perishable item at the rate of Rs. 80 per kg and sells at the rate of Rs.100 per kg. If the order size is more than the demand, the excess quantity can be sold at Rs.70 per kg in a secondary market; otherwise, the opportunity cost for the store is Rs.15 per kg for the unsatisfied portion of the demand. Based on the past experience, it is found that the demand varies from 50 kg to 250 kg in steps of 50 kg. The possible values of the order size are from 76 kg to 300 kg in steps of 75 kg. Determine the optimal order size which will maximize the daily profit of the store.</td><td></td><td></td></tr>
<tr><td colspan="4">PART – C</td></tr>
<tr><td>S.NO</td><td>QUESTIONS</td><td>BT LEVEL</td><td>COMPETENCE</td></tr>
</table>

<table>
<tr><td>1.</td><td>A contractor has to supply 10000 bearings per day to an automobile manufacturer. He finds that when he starts a production run he can produce 25000 bearings per day. The cost of holding a bearing in stock for one year is 2 paise and the set up cost of the production run is Rs.18. How frequently should production run be made and which is the Best Economic Batch Quantity? How much would be the No. of Setup and Total Inventory Cost.</td><td>Level 1</td><td>Remembering</td></tr>
<tr><td>2.</td><td>Find the most economic batch quantity of a product on a machine if the production rate of that item on the machine is Rs.200 pieces per day and the demand is uniform at the rate of 100 pieces per day. The set up cost is Rs.200 per batch and the cost of holding one item in inventory is Rs.200 per batch and cost of holding one item in Inventory is Rs.0.81 per day. How will the batch quantity vary if the machine production rate is Infinite?</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>3.</td><td>Identify the profit under three states of nature & three decision alternative.
<table>
<tr><td></td><td colspan="4">State<br>Nature</td></tr>
<tr><td rowspan="4">Decision Making</td><td></td><td>N1</td><td>N2</td><td>N3</td></tr>
<tr><td>D1</td><td>100</td><td>200</td><td>300</td></tr>
<tr><td>D2</td><td>400</td><td>200</td><td>200</td></tr>
<tr><td>D3</td><td>200</td><td>160</td><td>390</td></tr>
</table>
(i) Hurwitz criterion for alpha=0.5<br>
(ii) Laplace Condition<br>
(iii) Minimax Condition</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>4.</td><td>A certain item costs Rs.250 per ton. The monthly requirements are 10 tons and each time the stock is replenished there is a setup cost of Rs.1000.The cost of carrying inventory has been estimated as 12% of the value of the stock per year. What is the optimal order quantity and how frequently should orders be placed?</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>5.</td><td>The estimated sales of proposed types of perfumes are given as below.
<table>
<tr><td>Types of perfumes</td><td colspan="3">Estimated levels of sales (units)</td></tr>
<tr><td></td><td>Rs.20,000</td><td>Rs.10,000</td><td>Rs. 25,000</td></tr>
<tr><td>A</td><td>25</td><td>15</td><td>10</td></tr>
<tr><td>B</td><td>40</td><td>20</td><td>5</td></tr>
<tr><td>C</td><td>60</td><td>25</td><td>3</td></tr>
</table>
What will be the best alternative if a person adopts the Laplace criterion?</td><td>Level 3</td><td>Applying</td></tr>
<tr><td colspan="4">UNIT-5</td></tr>
<tr><td colspan="4">SYLLABUS: Queuing Theory –Single and Multi-Channel models-infinite number of customers and infinite calling resource. Replacement Models-Individuals replacement Models (With and without time value of money) – Group Replacement Models.</td></tr>
<tr><td colspan="4">PART- A</td></tr>
<tr><td>S.NO</td><td>QUESTIONS</td><td>BT LEVEL</td><td>COMPETENCE</td></tr>
<tr><td>1.</td><td>State the characteristics of a Queueing model.</td><td>Level 1</td><td>Remembering</td></tr>
</table>

| | | | |
|---|---|---|---|
| **2.** | Write Kendall's notation for Queueing Model. | Level 1 | Remembering |
| **3.** | What are the service disciplines available in the queueing model? | Level 1 | Remembering |
| **4.** | Classify the types of Queue. | | |
| **5.** | For (M/M/1): ($\infty$/FIFO) model, Write the Little's formula. | Level 1 | Remembering |
| **6.** | Find the probability of at least 10 customers in the system (M/M/1): ($\infty$/FIFO) queue system, if $\lambda$=6 *per hour* and $\mu$= 8 *per hour?* | Level 2 | Understanding |
| **7.** | For a (M/M/1): ($\infty$/FIFO) queue system, if $\lambda$=4 per hour and $\mu$=6 per hour, find the average queue length. | Level 2 | Understanding |
| **8.** | If the inter arrival time and service time in a public telephone booth with a single phone follow exponential distribution with means of 10 and 8 minutes respectively. Find the average number of callers in the booth at any time. | Level 3 | Applying |
| **9.** | How would you explain consumer behavior? | Level 1 | Remembering |
| **10.** | Compare Serial and parallel Queue with Examples. | Level 1 | Remembering |
| **11.** | What is "Collusion" in Queue Discipline? | Level 1 | Remembering |
| **12.** | Describe Kendall's Notation for identifying a Queue Model with two channels, Poisson arrivals, exponential service and infinite calling population. | Level 2 | Understanding |
| **13.** | In a bank, 20 customers on an average are served by a cashier in an hour. If the service time has exponential distribution, what is the probability that it will take more than 10 minutes to serve a customer? | Level 2 | Understanding |
| **14.** | In a 3 server infinite capacity Poisson queue model if $\frac{\lambda}{\mu C} = \frac{2}{3}$ Calculate $P_0$. | Level 2 | Understanding |
| **15.** | For (M/M/C): (N/FIFO) model, Write the formula for<br>(*a*) Average number of customers in the queue.<br>(*b*) Average waiting time in the system. | Level 3 | Applying |
| **16.** | How waiting time cost is related to queuing system? | Level 3 | Applying |
| **17.** | Discuss about replacement theory. | Level 4 | Analyzing |
| **18.** | Classify the types of Replacement model. | Level 5 | Evaluating |
| **19.** | Discuss the advantages of simulation. | Level 6 | Creating |
| **20.** | Define present worth factor. | Level 1 | Remembering |
| **21.** | Define Discount rate. | Level 2 | Understanding |
| **22.** | Distinguish between individual replacement and group replacement? | Level 3 | Applying |
| **23.** | Distinguish between breakdown maintenance and preventive maintenance. | Level 4 | Analyzing |
| **24.** | State the types of failures. | Level 5 | Evaluating |
| **25.** | Interpret the need for fixing Reorder Point. | Level 6 | Creating |

**PART- B**

| **S.NO** | **QUESTIONS** | **BT LEVEL** | **COMPETENCE** |
|---|---|---|---|
| **1.** | In a Public telephone booth the arrivals are on the Average 15 per hour. A call on the average takes 3 minutes .If there is just one phone, find expected number of callers in the booth at any time and the proportion of the time the booth is expected to be idle? | Level 1 | Remembering |
| **2.** | Cars arrive at a petrol pump, having one petrol unit, in Poisson fashion with an average of 10 cars per hour. The service time is distributed exponentially with a mean of 3 minutes. Find the following<br>(i) Predict Average number of cars in the system and Average waiting time in the queue | Level 2 | Understanding |

<table>
<tr><td></td><td>(ii) Average queue length and the probability that the number of cars in the system is</td><td></td><td></td></tr>
<tr><td>3.</td><td>A T.V repairman finds that the time spent on his job has an exponential distribution with mean 30 minutes. If he repairs sets in the order in which they came in and if the arrival of sets is Poisson with an average rate of 10 per 8 hour day, how will you calculate the expected idle time day? How much is the queue length and how many TV sets would be in the shop?</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>4.</td><td>In a Super market, the average arrival rate of customer is 10 in every 30 minutes following Poisson process. The average time taken by the cashier to list and calculate the customer’s purchases is 2.5 minutes, following exponential distribution. What is the probability that the queue length exceeds 6?</td><td>Level 2</td><td>Understanding</td></tr>
<tr><td>5.</td><td>Customers arrive at a one-man barber shop according to a Poisson with a mean inter arrival time of 20 min Customers spend an average of 15 min in the barber’s chair<br>1. What is the expected number of customers in the barber shop?<br>2. What is the expected number of customers in the Queue?<br>3. What is the probability that a customer will not have to wait for a haircut?<br>4. How much can a customer expect to spend in the barbershop?<br>5. What are the average time customers spend in the queue?</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>6.</td><td>In a given M / M / 1 queueing system, the average arrivals is 4 customers per minute, $\rho = 0.7$. Find the<br>(i) Mean number of customers $L_s$ in the system<br>(ii) Mean number of customers $L_q$ in the queue<br>(iii) The probability that the server is idle<br>(iv) Mean waiting time $W_s$ in the system<br>(v) Mean waiting time $W_q$ in the queue</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>7.</td><td>There are three typists in an office. Each typist can type an average of 6 Letters per hour .If letters arrive for being typed at the rate of 15 letters per hour, Analyze the following<br>a) What fraction of the time all the typists will be busy?<br>b) What is the average number of letters waiting to be typed?<br>c) What is the average time a letter has to spend for waiting and for being typed?<br>d) What is the probability that a letter will take longer than 20 min waiting to be typed?</td><td>Level 3</td><td>Applying</td></tr>
<tr><td>8.</td><td>A supermarket has two girls attending to sales at the counters. If the service time for each customer is exponential with mean 4 min and if people arrive in Poisson fashion at the rate of 10 per hour<br>a) What is the probability that a customer has to wait for service?<br>b) What is the expected percentage of idle time for each girl?<br>c) If the customer has to wait in the queue, what is the expected length of the waiting time?</td><td>Level 4</td><td>Analyzing</td></tr>
<tr><td>9.</td><td>A machine owner finds from his past records that the cost per year of maintaining a machine, whose purchase price is Rs.6,000 are as given below.
<table>
<tr><td>Year</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>Maintenance Cost</td><td>100</td><td>1200</td><td>1400</td><td>1800</td><td>2300</td><td>2800</td><td>3400</td><td>4000</td></tr>
</table></td><td>Level 4</td><td>Analyzing</td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| | <table><tr><td>Release Price</td><td>3000</td><td>1500</td><td>750</td><td>375</td><td>200</td><td>200</td><td>200</td><td>200</td></tr></table> Find at what age a replacement is due, assuming time value is 10% | | |
| **10.** | The cost of machine is Rs.16, 00 and scrap value is Rs.1,100.<br>Maintenance Cost form for machine are as follows:<br><table><tr><td>Year</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>Maintenance cost</td><td>300</td><td>459</td><td>600</td><td>800</td><td>100</td><td>1200</td><td>1500</td><td>2000</td></tr></table>When should the machine be the replaced? | Level 1 | Remembering |
| **11.** | The following table gives to cost of spares per year, overhead cost of maintenance per year and resale value of certain equipment whose purchase price is Rs. 50,000: Illustrate when the machine can be replaced.<br><table><tr><td>Year</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>Cost of Spares</td><td>10000</td><td>12000</td><td>14000</td><td>15000</td><td>17000</td></tr><tr><td>Overhead Maintenance Cost</td><td>5000</td><td>5000</td><td>6000</td><td>6000</td><td>8000</td></tr><tr><td>Resale Value</td><td>40000</td><td>32000</td><td>28000</td><td>25000</td><td>22000</td></tr></table> | Level 2 | Understanding |
| **12.** | A cost of a machine is 6100 and its scrap value is Rs. 100. The maintenance Cost from the experience are as follows:<br><table><tr><td>Year</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>Maintenance cost</td><td>100</td><td>250</td><td>400</td><td>600</td><td>900</td><td>1200</td><td>1600</td><td>2000</td></tr></table>(i) Examine the average cost of replacement<br>(ii) Analyze when the asset can be replaced | Level 3 | Applying |
| **13.** | A Taxi owner estimates from his past records that the cost per year for operating a taxi whose purchase price when new is Rs.60, 000 are as follows.<br><table><tr><td>Age</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>Operating cost</td><td>10000</td><td>12000</td><td>15000</td><td>18000</td><td>20000</td></tr></table>After 5 years the operating cost is Rs.6000 x K, Where “k” is 6, 7, 8,9,10 (age). If the resale value decreases by 10% of purchase price each year, calculate the best time of replacement if time value is not implemented? | Level 4 | Analyzing |
| **14.** | <table><tr><td>Week</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td>Conditional Probability</td><td>0.07</td><td>0.15</td><td>0.25</td><td>0.45</td><td>0.75</td><td>0.9</td><td>1</td></tr></table>IRP Cost is Rs.1.25 per item<br>GRP Cost is Rs.60 Paise Per item.<br>(i) Estimate the IRP Cost<br>(ii) Predict GRP cost<br>(iii) Infer whether GRP or IRP is the Best Policy, | Level 5 | Evaluating |
| **15.** | A manufacturer offered two machines A and B. A has cost price of Rs.2,500, its running cost is Rs. 400 for each of first years and increased by Rs. 100 every subsequent year, Taking money’s value as 10% per year, when machine should be replaced? | Level 1 | Remembering |

| | | | |
|---|---|---|---|
| **16.** | The maintenance cost and resale value per year of a machine whose purchase price is Rs.7000 is given below :<br><br>When should the machine be replaced? | Level 2 | Understanding |
| **17.** | A truck owner finds from his past experience that the maintenance costs rs.200 for the first year and then increases by rs.2000 every year, The cost of the truck type A is rs.9000. Determine the best age at which to replace the truck. Truck B type cost rs.10000.Annual Maintenance costs are rs.400 and increased by Rs.800 every year. The truck owner now has truck type A which is one year old and should be replaced by Type B and if so when? | Level 3 | Applying |
| **18.** | IRP cost Rs4 / item. GRP cost is 80 paise / item.<br>(i) Find the IRP cost<br>(ii) Compare IRP or GRP and conclude which is best. | Level 4 | Analyzing |

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Operating Cost | 900 | 1200 | 1600 | 2100 | 2800 | 3700 | 4700 | 5900 |
| Resale Value | 400 | 2000 | 1200 | 600 | 500 | 400 | 400 | 400 |

| Week | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Probability | 0.09 | 0.25 | 0.49 | 0.85 | 0.97 | 1 |

**PART – C**

| S.NO | QUESTIONS | BT LEVEL | COMPETENCE |
|---|---|---|---|
| **1.** | Customers arrive at a watch repair shop according to a Poisson process at a rate of one per every10 minutes, and the service time is exponential random variable with 8 minutes. Apply M/M/1 queueing model<br>a) Find the average number of customers $L_s$ in the shop.<br>b) Find the average number of customers $L_q$ in the queue.<br>c) Find the average time a customer spends in the system in the shop $W_s$.<br>d) What is the probability that the server is idle? | Level 1 | Remembering |
| **2.** | In a reservation counter with a single server, customer arrive with the inter- arrival time as the exponential distribution with mean 10 minutes. The service time is also assumed to be exponential with mean 8 minutes. Predict<br>(i) The idle time of the server<br>(ii) The average length of the Queue<br>(iii) Expected time that a customer spends in the system. | Level 2 | Understanding |
| **3.** | Assume an insurance company has three claims adjusters in its branch office. People with claims against the company are found to arrive in a Poisson fashion, at an average rate of20 per 8-hour day. The amount of time that an adjuster spends with a claimant is found to have an exponential distribution, with mean service time 40 minutes. Claimants are processed in the order of their appearance.<br>(i) How many hours a week can an adjuster expect to spend with claimants?<br>**(ii)** How much time, on the average, does a claimant spend in the branch office? | Level 3 | Applying |

<table>
<tr>
<td>4.</td>
<td>An electronic equipment contains 500 resistors. When any resistor fails, it is replaced. The cost of replacing a resistor individually is Rs.20. If all the resistors are replaced at the same time, the cost per resistor is Rs. 5. The percentage of surviving, S(i) at the end of month i is given below; Apply IRP &GRP & Find which is best.
<table>
<tr><td>Month i</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>S (i)</td><td>100</td><td>90</td><td>75</td><td>55</td><td>30</td><td>0</td></tr>
</table>
</td>
<td>Level 3</td>
<td>Applying</td>
</tr>
<tr>
<td>5.</td>
<td>The failure rates of 1000 street bulbs in a colony are summarized in table:
<table>
<tr><td>End Of Month</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Probability of failure to date</td><td>0.05</td><td>0.20</td><td>0.40</td><td>0.65</td><td>0.85</td><td>1.00</td></tr>
</table>
The cost of replacing an individual bulb is Rs.60. If all the bulbs are replaced simultaneously it would cost Rs.25 Per bulb. Any one of the following two options can be followed to replace the bulbs.<br>
(i) Replace the bulbs individually when they fail (Individual replacement policy)<br>
(ii) Replace all the bulbs simultaneously at fixed intervals and replace the individual bulbs as and when they fail in service during the fixed interval (Group replacement policy).<br>
Analyze & find out the optimal replacement policy, i.e., Individual replacement policy or group replacement policy? If group replacement policy is optimal, then find at what equal intervals should all bulbs are replaced?
</td>
<td>Level 4</td>
<td>Analyzing</td>
</tr>
</table>