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# B.M.S. College of Engineering, Bengaluru-560019

**Autonomous Institute Affiliated to VTU**

## June 2025 Semester End Main Examinations

**Programme: B.E.** **Semester: V**

**Branch: Industrial Engineering & Management** **Duration: 3 hrs.**

**Course Code: 23IM5PCOPR / 22IM5PCOPR** **Max Marks: 100**

**Course: Operations Research**

**Instructions**: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.





| | | UNIT - I | *CO* | *PO* | Marks |
|---|---|---|---|---|---|
| 1 | a) | A factory produces two types of products, Product A and Product B. Each product requires different amounts of two resources, Resource 1 and Resource 2. The availability of resources and the resource requirements for each product are given below:<br>• Resource 1: 100 units available<br>• Resource 2: 120 units available<br>The resource requirements per unit of each product are:<br>• Product A:<br>o Resource 1: 2 units<br>o Resource 2: 3 units<br>• Product B:<br>o Resource 1: 4 units<br>o Resource 2: 2 units<br>The profit obtained from each unit of Product A is $30, and from each unit of Product B is $20.<br>Formulate the LPP model and determine the optimal production quantities of Product A and Product B that maximize the profit. | *CO1* | *PO2* | **14** |
| | b) | What are the different phases involved in Solving a real-life problem using Operations Research Methdlogy? | *CO1* | *PO1* | **06** |
| | | **OR** | | | |
| 2 | a) | A company produces two products, X and Y. Each product requires two types of resources: labor and material. The company wants to maximize its profit while considering the available resources. The details are as follows:<br>• Product X:<br>o Profit: $40 per unit<br>o Labor required: 2 hours per unit<br>o Material required: 1 unit per unit<br>• Product Y:<br>o Profit: $30 per unit<br>o Labor required: 1 hour per unit<br>o Material required: 2 units per unit | *CO1* | *PO2* | **14** |

- Resource Availability:
  - Labor: 20 hours
  - Material: 20 units

Formulate the LPP model and solve it using the Simplex method to determine the optimal production quantities of Product X and Product Y.

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|---|---|---|---|---|---|
| | b) | What are the steps involved in converting a given LPP problem into a standard format for solving the LPP using the simplex method? | *CO1* | *PO1* | **06** |
| | | **UNIT - II** | | | |
| 3 | a) | A company has four warehouses (W1, W2, W3, W4) that need to supply goods to four retail stores (S1, S2, S3, S4). The transportation cost per unit from each warehouse to each store is given in the following cost matrix: | *CO2* | *PO2* | **14** |

| Warehouses | S1 | S2 | S3 | S4 |
|---|---|---|---|---|
| 1 | 4 | 8 | 8 | 6 |
| 2 | 6 | 4 | 4 | 3 |
| 3 | 5 | 3 | 6 | 7 |
| 4 | 8 | 6 | 7 | 5 |

The supply available at each warehouse and the demand at each store are as follows:

- **Supply**:
  - W1: 20 units
  - W2: 30 units
  - W3: 25 units
  - W4: 25 units
- **Demand**:
  - S1: 25 units
  - S2: 35 units
  - S3: 20 units
  - S4: 20 units

**Objective:** Minimize the total transportation cost while meeting the demand at all stores and the supply constraints at all warehouses.

| | | | | | |
|---|---|---|---|---|---|
| | b) | Can a Transportation problem have Mutiple optimal solutions? If Yes how do you recognize the condition of Mutiple optimality? | *CO2* | *PO1* | **06** |
| | | **OR** | | | |
| 4 | a) | A company has four machines and four jobs to be assigned. Each machine can perform any job, but the time taken by each machine to perform each job is different. The goal is to assign the jobs to the machines in such a way that the total time taken to complete all jobs is minimized. The time (in hours) taken by each machine for each job is given in the following matrix: | *CO3* | *PO2* | **12** |

| Machine | Job 1 | Job 2 | Job 3 | Job 4 |
|---|---|---|---|---|
| A | 10 | 12 | 9 | 7 |
| B | 8 | 15 | 10 | 12 |
| C | 6 | 14 | 13 | 9 |
| D | 11 | 10 | 12 | 6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Solve the assignment problem so as to achieve the objective to Minimize the total time taken by assigning each machine to one job such that the total time is minimized. | | | |
| | | b) | Give the typical structure of a Travelling salesman problem. Mention any two areas of application for a Manufacturing organization for shop floor scheduling decsions. | *CO2* | *PO1* | **08** |
| | | | **UNIT - III** | | | |
| | 5 | a) | A bank has a single teller to serve customers. The customers arrive at the bank following a Poisson process with an average arrival rate (λ\lambda) of 10 customers per hour. The service time follows an exponential distribution with an average service rate (μ\mu) of 15 customers per hour.<br>i. What is the probability that the system (the teller) is idle (i.e., there are no customers in the system)?<br>ii. What is the average number of customers in the system (L)?<br>iii. What is the average number of customers in the queue (Lq)?<br>iv. What is the average time a customer spends in the system (W)?<br>v. What is the average time a customer spends waiting in the queue (Wq)? | *3* | *2* | **14** |
| | | b) | Explain the Kendall & Lee's Notation for Classifying Queuing theory problems. | *CO3* | *PO2* | **06** |
| | | | **OR** | | | |
| | 6 | a) | A call center has a single phone line available to take incoming calls. The arrival rate (λ\lambda) of calls follows a Poisson process with an average of 5 calls per hour. The service time follows an exponential distribution with an average service rate (μ\mu) of 8 calls per hour.<br>i. What is the probability that the system (the phone line) is idle (i.e., there are no calls in the system)?<br>ii. What is the average number of calls in the system (L)?<br>iii. What is the average number of calls in the queue (Lq)?<br>iv. What is the average time a call spends in the system (W)?<br>v. What is the average time a call spends waiting in the queue (Wq)? | *CO3* | *PO3* | **14** |
| | | b) | What are the assumptions behind the M/M/K; ∞/FCFS model? Why is a Poisson distribution and exponential distribution used in conjunction for modelling queues? | *CO3* | *PO2* | **06** |
| | | | **UNIT - IV** | | | |
| | 7 | a) | Two companies, Alpha and Beta, are competing in a market. Each company has two strategies: Lower Prices (L) and Increase Quality (Q). The payoff matrix below shows the profits for each company based on their chosen strategies:<br>In each cell, the first value represents Alpha's profit, and the second value represents Beta's profit. | *CO3* | *PO3* | **12** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | <table><tr><td></td><td>Beta (L)</td><td>Beta (Q)</td></tr><tr><td>Alpha (L)</td><td>(2,2)</td><td>(3,1)</td></tr><tr><td>Alpha (Q)</td><td>(1,3)</td><td>(4,4)</td></tr></table> i. Identify any dominated strategies for each company. Determine the point of equilibrium using the dominance principle. | | | |
| | | b) | Define the following terms clearly.<br>i. Pure Strategy.<br>ii. Mixed Strategy.<br>iii. Saddle point games.<br>iv. Two-person zero sum games. | *CO2* | *PO2* | **08** |
| | | | **OR** | | | |
| | 8 | a) | A company is considering three different projects to invest in: Project A, Project B, and Project C. The profitability of each project depends on the state of the market, which can be either Favorable or Unfavorable. The following payoff matrix shows the expected profit (in thousands of dollars) for each project under both market conditions:<br><table><tr><td></td><td>Favourable Market</td><td>Unfavourable Market</td></tr><tr><td>Project A</td><td>80</td><td>20</td></tr><tr><td>Project B</td><td>60</td><td>50</td></tr><tr><td>Project C</td><td>100</td><td>0</td></tr></table> i. Using the Maximin criterion, which project should the company choose?<br>ii. Using the Maximax criterion, which project should the company choose?<br>If the company believes there is a 70% chance of a Favorable Market and a 30% chance of an Unfavorable Market, use the Expected Monetary Value (EMV) criterion to determine which project the company should choose. | *CO3* | *PO3* | **12** |
| | | b) | What is the logic behind the Hurwitz criteria for Decision making? What is its institutive appeal? Give an example to illustrate the application of this criteria. | *CO2* | *PO2* | **08** |
| | | | **UNIT - V** | | | |
| | 9 | a) | A project consists of the following activities with their estimated completion times (in weeks):<br>The precedence relationships between the activities are as follows: | *CO4* | *PO11* | **14** |

<table>
<tr><td></td><td></td><td></td><td>
<ul>
<li>Activity A must be completed before activities B and C can start.</li>
<li>Activities B and C must be completed before activity D can start.</li>
<li>Activities D and E must be completed before activity F can start.</li>
</ul>
<table>
<tr><th>Activity</th><th>Optimistic Time (a)</th><th>Most Likely Time (m)</th><th>Pessimistic Time (b)</th></tr>
<tr><td>A</td><td>2</td><td>4</td><td>6</td></tr>
<tr><td>B</td><td>3</td><td>5</td><td>9</td></tr>
<tr><td>C</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>D</td><td>4</td><td>6</td><td>10</td></tr>
<tr><td>E</td><td>2</td><td>4</td><td>8</td></tr>
<tr><td>F</td><td>1</td><td>3</td><td>5</td></tr>
</table>
i. Calculate the expected time (TE) for each activity.<br>
ii. Determine the critical path and the expected project completion time.
</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>b)</td><td>Why is a Beta Distribution preferred to model the project duration in the PERT model? Explain using its Probability density function.</td><td>CO4</td><td>PO11</td><td>06</td></tr>
<tr><td></td><td>10</td><td>a)</td><td>A construction project consists of the following activities with their respective durations (in days) and precedence relationships:
<table>
<tr><th>Activity</th><th>Duration</th><th>Predecessors</th></tr>
<tr><td>A</td><td>4</td><td>-</td></tr>
<tr><td>B</td><td>6</td><td>A</td></tr>
<tr><td>C</td><td>5</td><td>A</td></tr>
<tr><td>D</td><td>7</td><td>B</td></tr>
<tr><td>E</td><td>3</td><td>B</td></tr>
<tr><td>F</td><td>6</td><td>C</td></tr>
<tr><td>G</td><td>6</td><td>D,E</td></tr>
<tr><td>H</td><td>4</td><td>F,G</td></tr>
</table>
i. Construct the project network diagram.<br>
ii. Determine the earliest start (ES) and earliest finish (EF) times for each activity.<br>
iii. Determine the latest start (LS) and latest finish (LF) times for each activity.<br>
iv. Identify the critical path and the total project duration.</td><td>CO4</td><td>PO11</td><td>12</td></tr>
<tr><td></td><td></td><td>b)</td><td>Explain the concept of the Critical Path Method (CPM) in project management. Additionally, explain the significance of the critical path and how it impacts project scheduling and resource allocation. Illustrate your answer with an example of a simple project.</td><td>CO4</td><td>PO11</td><td>08</td></tr>
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