**Operations Research**

**April 2025 Examination**

**1. An automobile manufacturing company is evaluating the expected demand for a new electric vehicle (EV) model to optimize its production plan. Due to uncertainty in market demand, the company has decided to use Monte Carlo simulation to estimate the likely range of monthly sales. Historical data suggests that demand follows a normal distribution with a mean of 1,000 units and a standard deviation of 200 units. Using random numbers, simulate the monthly sales for 10 months and compute the average sales over this period. Discuss the importance of Monte Carlo simulation in handling uncertainty in demand forecasting. Apply the simulation for the given scenario and analyze the results to suggest an optimal production plan for the EV model. (10 Marks)**

**Ans 1.**

## **Introduction**

Forecasting demand for a new electric vehicle (EV) is a complex task due to uncertainty in customer preferences, market trends, and economic factors. An automobile manufacturing company must carefully plan production to avoid overproduction (which leads to excess inventory and high holding costs) and underproduction (which causes stockouts and lost sales opportunities).

To address this challenge, the company can use **Monte Carlo simulation**, a probabilistic method that models uncertainty and generates multiple demand scenarios. This approach helps businesses make informed decisions by estimating the likely range of demand rather than relying on a single deterministic forecast. In this problem, we assume that the demand follows a **normal**

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**2. You are a procurement manager for an electronics manufacturing company tasked with optimizing the transportation of raw materials from multiple warehouses to various production facilities using transportation problem-solving techniques. There are four warehouses (W1, W2, W3, W4) and five production facilities (P1, P2, P3, P4, P5). The supply and demand at each location are as follows:**

|  |  |
| --- | --- |
| **Warehouse** | **Supply (in tons)** |
| **W1** | **40** |
| **W2** | **30** |
| **W3** | **25** |
| **W4** | **35** |
|  |  |
| **Production Facility** | **Demand (in tons)** |
| **P1** | **30** |
| **P2** | **25** |
| **P3** | **35** |
| **P4** | **20** |
| **P5** | **20** |

**The transportation costs (in $ per ton) from each warehouse to each production facility are:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **P1** | **P2** | **P3** | **P4** | **P5** |
| **W1** | **7** | **6** | **9** | **8** | **5** |
| **W2** | **6** | **5** | **7** | **4** | **6** |
| **W3** | **8** | **7** | **5** | **6** | **4** |
| **W4** | **5** | **4** | **6** | **7** | **8** |

**Firstly, derive an initial basic feasible solution using Vogel's Approximation Method (VAM) to find the initial feasible solution for transporting raw materials from warehouses to production facilities while minimizing transportation costs. Then, use the stepping stone method to identify potential improvements in the initial solution and determine the optimal solution, providing a step-by-step analysis of the stepping stone method, including detailed calculations, improvement possibilities, and the updated allocation in the transportation table. (10 Marks)**

**Ans 2.**

**Introduction**

Efficient transportation planning is crucial in supply chain management to minimize costs while ensuring smooth logistics operations. In an electronics manufacturing company, raw materials need to be transported from multiple warehouses to production facilities at the lowest possible cost. The Transportation Problem is a widely used optimization model that helps allocate resources efficiently while minimizing transportation expenses.

In this scenario, we have four warehouses supplying raw materials and five production facilities demanding these materials. The transportation costs between the warehouses and production

**3. You are managing a large-scale renewable energy power plant construction project. The project consists of multiple interdependent activities that must be carefully planned and executed to ensure timely commissioning of the facility. Consider the following activities and their dependencies:**

**1. Land Clearance (A)**

**2. Foundation Construction (B)**

**3. Turbine Installation (C)**

**4. Power Transmission Setup (D)**

**5. Control Room Configuration (E)**

**6. External Landscaping (F)**

**7. Final Testing and Handover (G)**

**The estimated durations and dependencies are as follows:**

|  |  |  |
| --- | --- | --- |
| **Activity** | **Duration (weeks)** | **Dependencies** |
| **A** | **2** | **-** |
| **B** | **5** | **A** |
| **C** | **6** | **A** |
| **D** | **4** | **B, C** |
| **E** | **3** | **D** |
| **F** | **2** | **D, E** |
| **G** | **1** | **F** |

**Part a: Using this data, create a project schedule to identify the earliest start and finish times for each activity. Determine the critical path for the project and calculate the total project duration. (5 Marks)**

**Now assume activity durations follow a normal distribution with the following means and standard deviations:**

|  |  |  |
| --- | --- | --- |
| **Activity** | **Mean Duration (weeks)** | **Standard Deviation (weeks)** |
| **A** | **2** | **0.3** |
| **B** | **5** | **0.8** |
| **C** | **6** | **0.9** |
| **D** | **4** | **0.4** |
| **E** | **3** | **0.5** |
| **F** | **2** | **0.3** |
| **G** | **1** | **0.2** |

**Ans 3a.**

#### **Introduction**

Project scheduling is a crucial aspect of project management, especially for large-scale construction projects like a renewable energy power plant. The aim is to plan activities efficiently to minimize delays and ensure timely project completion. The Critical Path Method (CPM) is a widely used technique that helps identify the sequence of dependent tasks that determine the project duration. By analyzing activity durations and dependencies, CPM provides

**Part b: Using the provided data, calculate the probability of completing the project in 14 weeks or less and the probability of completing the project between 13 and 15 weeks. (5 Marks)**

**Ans 3b.**

**Introduction**

In real-world projects, activity durations often fluctuate due to uncertainties such as weather, resource availability, or unforeseen technical issues. Instead of assuming fixed durations, we model **activity durations as a normal distribution** and calculate the probability of completing the project within a specific time frame. Using **PERT (Program Evaluation and Review Technique)**, we analyze the likelihood of completing the project within **14 weeks** and between