assignment_01

January 18, 2025

1 Assignment 1

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1. **Road Maintenance Problem**

   The Chennai Unified Metropolitan Transport Authority (CUMTA) is planning to allocate ₹ 5,00,000 to maintain two major arterial routes - R_1 and R_2. Here, R_1 has a maintenance cost of ₹ 50,000 per kilometer, while R_2 amounts for ₹ 30,000 per kilometer for road maintenance. If CUMTA plans to finance upkeep of at least 5 kilometers on both the arterial routes to ensure a minimal level of service on the two routes, then,

   - Formulate a mathematical model optimising the total length of roads maintained. (3)
   - Clearly explain the objective function, decision variables, as well as technical and domain constraints. (1)
   - State the necessary assumptions. (2)
   - Appropiately categorise the optimisation problem. (1)

   Based on the formulation developed, develop figures showcasing,

   - Isocost lines (2)
   - Feasible region (2)
   - Optimal solution (decision variable and objective function value) (2)

2. **Holiday-Special Train Scheduling Problem**

   The operations team of the Southern Indian Railways wants to schedule holiday-special trains between Chennai and Hyderabad to cater to the increased passenger demand during the Pongal festival. The surge in passenger demand for the three days prior to the festival is expected to be 10k, 15k, and 12k passengers, respectively. If a holiday-special train can cater to a maximum of 1500 passengers at an operational cost of ₹ 150/km, then,

   - Formulate a mathematical model optimising railway operations. (4)
   - Clearly indicate the objective function, decision variables, as well as technical and domain constraints. (1)
   - State the necessary assumptions. (2)
   - Appropiately categorise the optimisation problem. (1)

3. **Amazon Last-Mile Delivery Problem**

Amazon plans to operate three types of delivery fleets T_1 (diesel van), T_2 (electric van), and T3 (motorbike) in Chennai. The table below presents key characteristics of these three delivery vehicles - purchase cost, operatonal cost (fuel cost + maintenance cost + driver wage), and capacity.

Vehicle Type	Purchase Cost ( )	Operational cost (per km)	Capacity (number of customers)
Diesel Van	6,00,000	$7 + 3 + 25 = 35$	200
Electric Van	9,00,000	$2 + 1 + 25 = 28$	150
Motorbike	1,50,000	$3 + 1 + 25 = 29$	20

Using the following notations, answer the questions below,

Notations:

- number of delivery vehicles purchased: $f_i \ \forall \in [1, 3]$
- number of delivery tours per vehicle: $m_i \ \forall \in [1, 3]$
- number of customer per delivery tour: $c_i \ \forall \in [1, 3]$

Questions:

- Formulate the daily amoritsed fixed cost assuming a planning horizon of 7 years with 330 working days, and a discount rate of 3%. (3)
- Formulate the operational cost if the length of one delivery tour is given by $l_i = 2\rho + kc_i/\sqrt{\delta}$, where $\rho = 25$ is the long-haul distance, $k = 0.57$ is last-mile constant, and $\delta = 25$ is customer density. (3)
- Formulate the constraints assuming that Amazon a) needs to serve a total of 12000 customers b) must purchase at least 5 diesel and 10 electric vans, and c) can have a delivery vehicle perform a maximum of 3 delivery tours only. (3)