Question 1

A cellphone company owns two manufacturing plants and two distribution centres (DC). The DCs fulfil the demand of three retail stores (as shown in figure below).

Plant   
A

Plant   
B

Distribution

centre 1

Distribution

centre 2

Retailer 1

Retailer 2

Retailer 3

The company operations manager wants to know, given the cellphones in stock at their two manufacturing plants, the optimal shipping quantities (from the plants to DC, and then from DCs to retailers) that would minimize the transportation cost of restocking while fulfilling the demand of the retailers. The transportation costs from different plants to different DCs and from different DCs to different retailers may vary, depending on the distance. The stock levels, demands from the three retailers, and the transportation costs are provided in the tables below.

|  |  |
| --- | --- |
| Plant | Cellphones in stock |
| A | 120 |
| B | 90 |

|  |  |
| --- | --- |
| Retailer | Demand |
| 1 | 70 |
| 2 | 75 |
| 3 | 45 |

|  |  |  |
| --- | --- | --- |
| Shipping costs from plants to DCs  ($ per cellphone) | | |
|  | Distribution Center 1 | Distribution Center 2 |
| Plant A | 5 | 9 |
| Plant B | 11 | 7 |

|  |  |  |  |
| --- | --- | --- | --- |
| Shipping costs from DCs to retailers  ($ per cellphone) | | | |
|  | Retailer 1 | Retailer 2 | Retailer 3 |
| Distribution Center 1 | 12 | 4 | 13 |
| Distribution Center 2 | 8 | 17 | 10 |

Suppose the DCs have no constraint on the storage space for cellphones. Formulate a Linear Programming model to help the Operations Manager achieve her objective (with adequate descriptions in words). You are NOT required to solve the model.

Question 2

ABC Corporation produces two electronics products, A and B, which undergo three processes – Proc1, Proc2 and Proc3 – at its production facility. Details of unit processing times, profit, weight and hours available on each process are provided in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Processing Times/unit (in hours) | | |  |  |
| Product | Proc1 | Proc2 | Proc3 | Profit/unit ($) | Weight/unit (kgs) |
| A | 3.0 | 3.5 | 3.2 | 7.8 | 6.2 |
| B | 4.0 | 2.8 | 3.5 | 6.6 | 5.8 |
| Capacity Available  (hours/day) | 8000 | 6000 | 7500 |  |  |

Table: Process Details

The capacity available for each process can be switched from one process to another at a cost of $10/hour e.g., each hour of capacity switched from Proc1 to Proc2 costs $10/hour, from Proc2 to Proc3 costs $10/hour and so on. The maximum number of hours that can be switched between various processes daily is shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **From** | **To** | | |
|  | Proc1 | Proc2 | Proc3 |
| Proc1 | - | 500 | 200 |
| Proc2 | 400 | - | 400 |
| Proc3 | 200 | 400 | - |

Table: Process Capacity Switching Limits

Once the products (A and B) have been processed at the production facility, these are shipped immediately in trucks to the distribution center (DC). No products can be kept at the production facility due to lack of storage space. For shipping, ABC utilizes its own fleet of trucks which are of two types: (1) Volvo and (2) Tata. Each type of truck comes in two sizes – large (L) and small (S). ABC has 2 large and 7 small Volvo trucks and 3 large and 4 small Tata trucks.

The weight capacities of different types and sizes of trucks (in kgs) are shown in the table below.

|  |  |  |
| --- | --- | --- |
|  | Truck Size (in Kgs) | |
| Truck Type | L | S |
| Volvo | 5000 | 1500 |
| Tata | 4800 | 1500 |

Table: Weight Capacities of Different Truck Type-Size

To meet safety requirements, ABC must follow the following weight related guidelines for loading products into different trucks: (1) the aggregate weight capacity utilization of all large trucks taken together must be equal to the aggregate weight capacity utilization of all small trucks taken together (2) the weight capacity utilization of all Volvo trucks must be equal to the weight capacity utilization of all Tata trucks. Weight capacity utilization is defined as the actual weight carried in a given truck type-size as a proportion of its maximum weight capacity.

Formulate an LP model to ensure that ABC maximizes its daily profit. Clearly identify and define all decision variables.

Question 3

Shriram Transport (ST) has three container trucks regularly scheduled to make deliveries between Chennai and Bangalore in India. There are both weight and volume restrictions on each truck and these are summarized in the table below.

|  |  |  |
| --- | --- | --- |
| **Truck** | **Weight Capacity**  **(Tons)** | **Volume Capacity**  **(Cubic Feet)** |
| Mercedes Actros 2535 Diesel | 18.5 | 14,500 |
| Volvo FE-280 Hybrid | 27.0 | 18,750 |
| Navistar 280 All Electric | 11.5 | 9,650 |

ST as a company is deeply committed to the philosophy of green operations and sustainability and the company spares no effort to make its truck transportation more fuel-efficient. One practice adopted by ST to ensure fuel efficiency is that of “load balancing”. This is done by imposing a condition that the proportion of the total weight of cargo that is carried in each truck must be the same as the proportion of that truck’s weight capacity to the total weight capacity of all the trucks. The following five cargos are available for tomorrow’s trip from Chennai to Bangalore.

|  |  |  |  |
| --- | --- | --- | --- |
| **Cargo No.** | **Weight**  **(Tons)** | **Volume**  **(Cubic Feet per Ton)** | **Profit**  **($/Ton)** |
| 1 | 22.0 | 560 | 412 |
| 2 | 17.5 | 780 | 402 |
| 3 | 25.5 | 610 | 369 |
| 4 | 13.6 | 450 | 291 |
| 5 | 18.2 | 595 | 318 |

Any fraction of these cargos can be accepted. ST must decide how much (if any) of each cargo to accept as well as the allocation of the accepted cargo to each truck.

Formulate an LP model for ST’s cargo scheduling problem. Specify clearly the decision variables, objective function, constraints, and any assumptions that you make. You are NOT required to solve the model.