Question 6: Using the two-phase method, find the optimal solution for the following linear programming model.

$$\begin{aligned} &\textit{Maximize} && Z = 5x_1 + 4x_2 \\ &\textit{Subject to} \\ & && 2x_1 + x_2 \le 10 \\ & && x_1 + 2x_2 = 8 \\ & && x_1 \le 0, \quad x_2 \ge 0 \end{aligned}$$

Question 1: Solve the following linear program graphically, showing the objective function, all constraints and the feasible region, and marking all basic feasible solutions.

$$\textit{Minimize} \quad Z = 5x_1 + 4x_2$$

Subject to

$$2x_1 + x_2 \geq 10$$
$$x_1 + 2x_2 \geq 8$$
$$x_1 \leq 0, \quad x_2 \geq 0$$

Question 5: Consider the transportation problem having the following parameters table. Use the northwest corner rule manually to construct a complete initial basic feasible solution.

Plants	Customer 1	Customer 2	Customer 3	Supply
Plant 1	20	20	50	40
Plant 2	30	60	50	60
Plant 3	40	50	30	40
Demand	50	50	40	

Question 2: For the following linear programming problem, use the SOB method to construct its dual problem.

$$\begin{aligned} &\textit{Minimize} && Z = 5x_1 + 4x_2 \\ &\textit{Subject to} \\ & && 2x_1 + x_2 \geq 10 \\ & && x_1 + 2x_2 \geq 8 \\ & && x_1 \ \textit{is unconstrained}, \quad x_2 \leq 0 \end{aligned}$$

Question 1: Solve the following linear program graphically, showing the objective function, all constraints and the feasible region, and marking all basic feasible solutions.

$$\textit{Minimize} \quad Z = 8x_1 + 4x_2$$

Subject to

$$4x_1 + 3x_2 \geq 6$$
$$2x_1 + 5x_2 \leq 10$$
$$4x_1 + x_2 \leq 4$$
$$x_1 \geq 0, \quad x_2 \geq 0$$

Question 8: Consider the following problem.

$$\text{Maximize} \quad Z = -5x_1 + 5x_2 + 13x_3,$$

subject to

$$\begin{aligned} -x_1 + x_2 + 3x_3 &\le 20 \\ 12x_1 + 4x_2 + 10x_3 &\le 90 \end{aligned}$$

and

$$x_j \ge 0 \qquad (j = 1, 2, 3).$$

If we let x_4 and x_5 be the slack variables for the respective constraints, the simplex method yields the following final set of equations:

$$\begin{array}{lrcl} (0) & Z + 2x_3 + 5x_4 & = & 100 \\ (1) & -x_1 + x_2 + 3x_3 + x_4 & = & 20 \\ (2) & 16x_1 - 2x_3 - 4x_4 + x_5 & = & 10. \end{array}$$

Use the sensitivity analysis procedure to revise the set of equations (in a tableau form) and find the optimal solution when the coefficient of x_2 is changed to be:

$$\begin{bmatrix} c_2 \\ a_{12} \\ a_{22} \end{bmatrix} = \begin{bmatrix} 6 \\ 2 \\ 5 \end{bmatrix}.$$

Question 4: WHSmith is a food company that produces two types of freeze dried food: Dragon fruit and Strawberry fruit. They used special treated sugar at a maximum rate 200kg per month. Each Dragon fruit requires 0.1kg of sugar and each Strawberry fruit requires 0.2kg of sugar. All the other ingredients are in plentiful. The WHSmith has currently hired 2 employees to work 60 hours per month. Each Dragon fruit requires 20 minutes of working hours, and each Strawberry fruit requires 30 minutes of working hours. Although Dragon fruit that yields a profit of $5 per unit is more expensive, the Strawberry fruit is more profitable, where the profit of a unit of Strawberry fruit is twice the profit of Dragon fruit. The WHSmith wants to know how many units of Dragon fruit and Strawberry fruit should produce each month so as to achieve the highest possible profit.

Question 3: The University of Jordan (UoJ) produces 3D printed medical parts in The Industrial Engineering Department (IED). Such parts can be sterilized either at the IED or the Jordan University Hospital (JUH), this leads to different sterilization cost. Four different department at the JUH have already placed orders for the next year. The table provided shows the number of parts required by each department, in addition to the number of parts that can be sterilized in the IED or the JUH. This table also provides the unit profit for the parts to be sold for each department. The UoJ wishes to know the number of parts to be sterilized in the IED and the JUH and then sold to these four departments. Formulate a LINEAR programming model for this case.

Sterilization place	Unit Profit				
	Department 1	Department 2	Department 3	Department 4	Sterilized parts
IED	$80	$70	$60	$90	1000
JUH	$60	$70	$50	$100	600
Ordered parts	400	500	200	500	

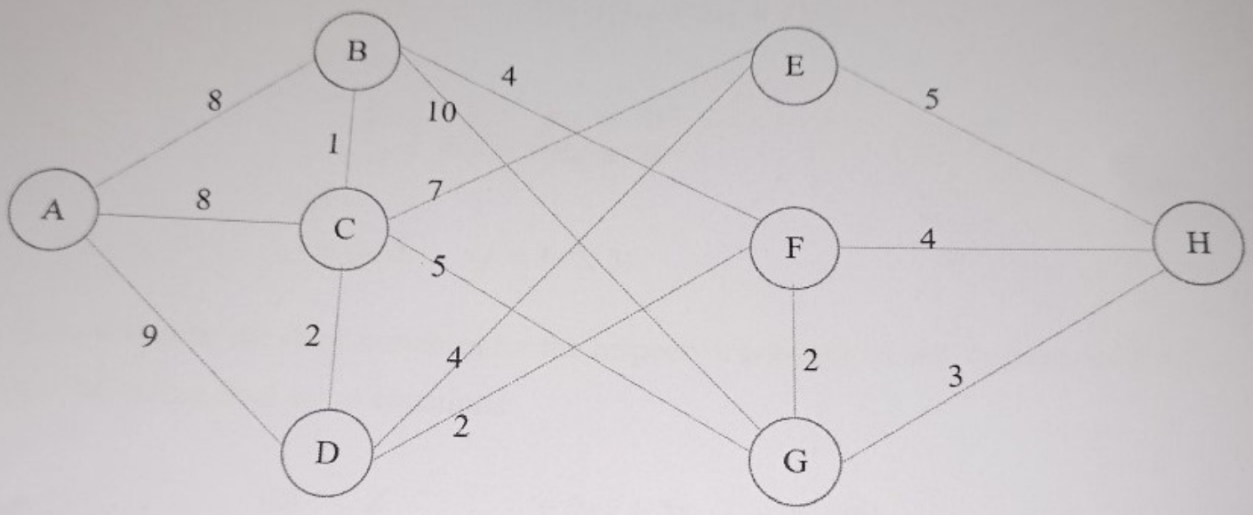
Question 5: For the following linear programming model, use the matrices form to find the optimal simplex tableau whose basic variables are x_1 and x_2. Find the value by which the optimal value will increase by when the RHS of the first constraint is increased one unit.

$$\begin{aligned} &\textit{Maximize} && Z = 5x_1 + 4x_2 \\ &\textit{Subject to} \\ & && 2x_1 + x_2 \le 10 \\ & && x_1 + 2x_2 \le 8 \\ & && x_1 \le 0, \quad x_2 \ge 0 \end{aligned}$$

Question 2: For the following linear programming problem, use the SOB method to construct its dual problem.

$$\begin{aligned} &\textit{Minimize} && Z = 8x_1 + 4x_2 \\ &\textit{Subject to} \\ & && 4x_1 + 3x_2 \geq 6 \\ & && 2x_1 + 5x_2 \leq 10 \\ & && 4x_1 + x_2 \leq 4 \\ & && x_1 \geq 0, \quad x_2 \textit{ is unconstrained} \end{aligned}$$

Question 7: Consider the following undirected network. Find the minimum spanning tree.



Question 3: In the master program at The University of Jordan, students bid for projects in the second year of this program. Each student has 100 points to bid (total) and must take one project. There are four projects related to: Management, Finance, Operations and Marketing. Each project should be assigned to one student only. The bids submitted for each of the 5 students are shown in the table below.

Students	Management	Finance	Operations	Marketing
Ahmad	60	10	10	20
Mohammed	20	30	40	10
Omar	30	20	20	30
Leen	40	40	10	10
Linda	50	10	20	20

Formulate this problem as an assignment problem (Just write the mathematical model and *do NOT solve it*).

Question 4: The WHR company produces a dried freeze Dragon fruit product at three plants for three customers. The three plants can produce 60, 80, and 40 units, respectively, during the next month. The company has made a commitment to sell 50 units to customer 1, 60 units to customer 2, and at least 20 units to customer 3 who also want to buy as many of the remaining units as possible. The net profit values associated with shipping a unit from the three plants to the three customers are given by the following table. Construct the appropriate parameters table and develop the mathematical model for such a problem in order to maximize the total net profit.

Plants	Customer 1	Customer 2	Customer 3
Plant 1	20	20	50
Plant 2	30	60	50
Plant 3	40	50	30

Question 6: Consider the following undirected network. Find the shortest path from node A to node H.