You may use any computerized solver to check or verify answers, but questions where a sensitivity report is included are intended to be answered without resolving (or stating that the problem would have to be resolved).

1) Mr. Jones produces inexpensive furniture for students. He currently makes bookcases, chairs, and tables. Each bookcase contributes $16 to profit, each chair $9 and each table, $15. Each product passes through two manufacturing points, cutting and finishing. Bookcases take 2.5 hours a unit in cutting and 3.5 hours in finishing. Chairs require 1.5 hours of cutting and 2 hours of finishing per unit. Tables require 2 hours a unit in cutting and 4 in finishing. There are currently 35 hours available in cutting and 28 hours in finishing. Demand for bookcases will not exceed 10, chairs will not exceed 24, and tables will not exceed 7. Additionally, Mr. Jones has decided that bookcases should not account for more than half of the total items produced. Based on the data provided, formulate a linear program for Mr. Jones to maximize profits. Please include all necessary components of a linear program and clearly label all equations. **Do not solve**.

2) Find the complete optimal solution to the following linear programming problem.
   a) Graph the linear program.
   b) Highlight the feasible region.
   c) Verify the coordinate of extreme points.
   d) Determine objective value for each extreme point.
   e) Determine optimal solution.
   f) What is the equality form of linear program?

$$
\begin{aligned}
\text{Max. } Z &= 4A + 5B \\
3A - 2B &\geq 0 \\
2A - 1B &\leq 200 \\
1A \qquad &\leq 150 \\
1B &\leq 300 \\
A \qquad &\geq 0 \\
B &\geq 0
\end{aligned}
$$

c	d	e

3) Use the following output to answer the questions.

a. What would happen to dual price values if the right-hand side of constraint 1 increased by 1, right hand- side of constrain 2 decreased by 5 and right-hand side of constraint 3 increased by 5 units simultaneously? What is the new optimal objective function value?

b. Which constraints are binding?

c. What would happen to the optimal solution if the coefficient of X_2 increased by 2 and coefficient of X_3 decrease by 2? What is the new optimal value?

d. Which constrain(s) have **surplus** variable(s)?

e. What is the dual problem?

f. Use the dual prices and constraints to show the objective function value is optimal.

MAX $100X_1+120X_2+150X_3+125X_4$

S.T.

1) $X_1 + 2X_2 + 2X_3 + 2X_4 \leq 108$
2) $3X_1 + 5X_2 + X_4 \leq 120$
3) $X_1 + X_3 \leq 25$
4) $X_2 + X_3 + X_4 \geq 50$

$X_1,X_2,X_3,X_4 \geq 0$

OPTIMAL SOLUTION

Objective Function Value = 7475.000

Variable	Value	Reduced Cost
X_1	8.000	0.000
X_2	0.000	5.000
X_3	17.000	0.000
X_4	33.000	0.000

Constraint	Slack/Surplus	Dual Price
1	0.000	75.000
2	63.000	0.000
3	0.000	25.000
4	0.000	–25.000

OBJECTIVE COEFFICIENT RANGES

Variable	Lower Limit	Current Value	Upper Limit
X_1	87.500	100.000	No Upper Limit
X_2	No Lower Limit	120.000	125.000
X_3	125.000	150.000	162.500
X_4	120.000	125.000	150.000

RIGHT HAND SIDE RANGES

Constraint	Lower Limit	Current Value	Upper Limit
1	100.000	108.000	123.750
2	57.000	120.000	No Upper Limit
3	8.000	25.000	58.000
4	41.500	50.000	54.000

4) Use the following computer output to answer the questions.

a. What is the Optimal objective function value?

b. What would happen to dual price values if the right-hand side of constraint 1 increased by 5000, right hand- side of constrain 2 decreased by 5000 and right-hand side of constraint 3 increased by 10000 units simultaneously? What is the new optimal value?

c. What would happen to optimal solution if the coefficient of B increased by 3? What is the new optimal value?

d. You have a chance to do only a one unit change to the right hand side of one constraint. Which constraint you will pick and what will you do?

e. What is the dual problem?

Min $30A + 50B + 25C + 40D$

S.T.

1) $A + B \geq 50{,}000$
2) $C + D \geq 70{,}000$
3) $A + C \leq 80{,}000$
4) $B + D \leq 60{,}000$

$A, B, C, D \geq 0$

Variable	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
A	50000	0	30	5	45
B	0	5	50	1E+30	5
C	30000	0	25	15	5
D	40000	0	40	5	15

Constraint	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
1	50000	45	50000	20000	40000
2	70000	40	70000	20000	40000
3	80000	-15	80000	40000	20000
4	40000	0	60000	1E+30	20000

5) Solve the following problem using the two-phase simplex method and a simplex tableau. Use phase 1 to find a basic feasible solution, then solve to optimality with phase 2.

Min $8X_1+3X_2$

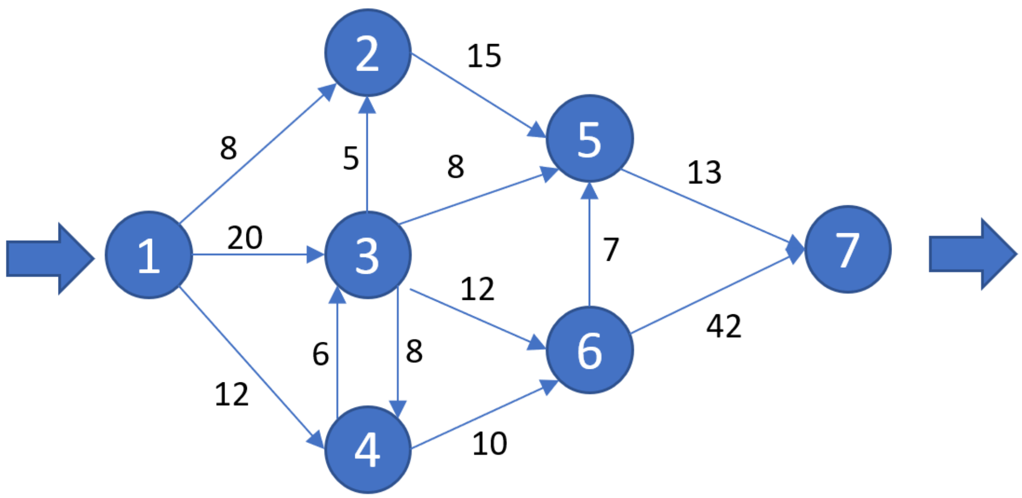
S.T.

$$
\begin{aligned}
50X_1 + 100X_2 &\leq 1200 \\
5X_1 + 4X_2 &\geq 60 \\
X_2 &\geq 3
\end{aligned}
$$

$$X_1, X_2 \geq 0$$

6) Formulate the following as linear programs, **do not solve**.

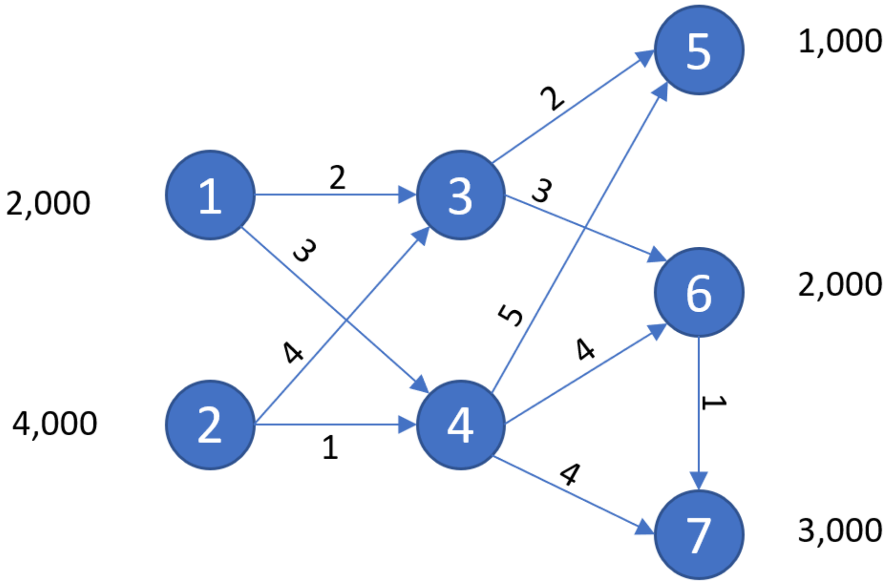
a.) Maximize the flow through the system (Source: Node 1, Sink: Node 7)



b.) Without solving what bound can you place on the max flow? Where does this come from? (there are multiple correct answers, none of which require anything beyond adding a few numbers)

7) Formulate the following as linear programs, **do not solve**.

a.) Minimize cost from the supply nodes (1,2) to the demand nodes (5,6,7), where the number adjacent to the node is the number of units supplied/demanded by the node.



b.) Write a constraint that would limit the flow through Node 3 to at most 2,000 units.

c.) Suppose that the transporter from 2 → 4 wants to implement tiered pricing, can either of the following be implemented in a linear program, and if so how:

i. $1 per unit for <500 units and $2 per unit there after

ii. $2 per unit for <500 units and $1 per unit there after