Learning Goal (critical/analytical thinking): Graduates will be able to apply theories and methods to solve problems within their respective disciplines.

Learning Objectives	Does Not Meet Expectations (score below 70%)	Meets Expectations (score 70% - 84%)	Exceeds Expectations (score above 85%)
Students can translate the verbal statement of a problem into a linear programming statement (to be assessed with any of the following questions: I	18 out of 86 Or 20.9%	26 out of 86 Or 30.2%	42 out of 86 Or 48.8%
Students can graph lines showing feasible area with linear programming and identify the optimal solution (to be assessed with question II	32 out of 86 Or 37.2%	23 out of 86 Or 26.7%	31 out of 86 Or 36.0%
Students can interpret linear programming solution with computer output. (to be assessed with question III	26 out of 86 Or 30.2%	23 out of 86 Or 26.7%	37 out of 86 Or 43.0%
Students can make evidence-based decisions. (to be assess with question IV	24 out of 86 Or 27.9%	22 out of 86 Or 25.6%	40 out of 86 Or 46.5%

Appendix: Candidate Assessment Problems (MGT 420)

I. **A papermill produces two types of paper; for books and for magazines. Each ton of paper for books requires 2 tons of spruce and 3 tons of fir; each ton of paper for magazines requires 4 tons of spruce and 5 tons of fir. The company must supply at least 50,000 tons of paper for books and 60,000 tons of paper for magazines a year. The yearly availability of materials is 200,000 tons of spruce and 400,000 tons of fir. The marketing department requires that the amount of paper manufactured for magazines be at least 2 times that which is manufactured for books. Each ton of paper for books is sold for $1,200 while that for magazines is sold for $1,500 per ton. The cost of spruce is $150 per ton while a ton of fir costs $100. Formulate this problem to maximize profit as a linear programming problem. Don't ever try to solve this problem.**

II. Consider the following LP problem to solve by graphs:

$$
\begin{array}{lrcrl}
\text{Max} & 6X_1 & + & 8X_2 & \\
\text{s.t.} & 5X_1 & + & 2X_2 & <= 20 \\
 & 7X_1 & + & 9X_2 & <= 63 \\
 & 10X_1 & - & 4X_2 & <= 20 \\
 & X_1 & + & X_2 & <= 10
\end{array}
$$

$$X_1 \;=>\; 0, \quad X_2 \;=>\; 0$$

(1) Show each constraint and the feasible region by graphs. Indicate the feasible region clearly.

(2) Are there any redundant constraints? If so, what constraint(s) is redundant?

(3) Identify the optimal point on your graph. What are the values of X_1 and X_2 at the optimal point? What is the optimal value of the objective function? Show your work for the full credit.

(4) What would be the optimal values of X_1 and X_2 and the optimal value of the objective function if the objective function is changed to Max $20X_1 + 8X_2$ while all constraints remain unchanged? Show your work for the full credit.

(5) Suppose there is one more constraint $X_2 => 10$ to be added to the original problem. What is the optimal solution? Explain why.

My Question # 2(Graphical Analysis)

Consider the following LP problem to solve by graphs:

$$\text{Max} \quad 5X_1 + 4X_2$$

$$\text{s.t.} \quad 12X_1 + 6X_2 \le 20{,}400$$

$$9X_1 + 15X_2 \le 25{,}200$$

$$6X_1 + 6X_2 \le 12{,}000$$

$$X_1 \Rightarrow 0, \quad X_2 \Rightarrow 0$$

1. What are the values of X_1 and X_2 at the optimal point? What is the optimal value of the objective function?

2. Which constraints are binding?

3. Find the value of slack/surplus variables.

4. What would be the new optimal values of X_1 and X_2 and the optimal value of the objective function if the objective function changes from Max $5x_1 + 4x_2$ to Max $4X_1 + 5X_2$ while all constraints remain unchanged?

III. The Erlanger Manufacturing Company makes two products. The profit estimates are $25 for each unit of product 1 sold and $20 for each unit of product 2 sold. The labor-hour requirements for the products in each of three production departments are summarized below:

	labor-hour requirements(hrs)		labor-hour
	product 1	product 2	availability
Department A	1.50	3.00	450
Department B	2.00	1.00	350
Department C	1.00	1.00	200

Assuming that the company is interested in maximizing profits, the following LP formulation and LINDO computer output are given:

Let X_1 = units of product 1 to be produced
X_2 = units of product 2 to be produced

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MAX     25 X1 + 20 X2

SUBJECT TO
 2)   1.5 X1 + 3 X2 <=   450
 3)   2 X1 + X2 <=   350
 4)      X1 + X2 <=   200

END
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LP OPTIMUM FOUND AT STEP      1

 OBJECTIVE FUNCTION VALUE

 1)    4750.00000

VARIABLE        VALUE          REDUCED COST
  X1       150.000000           .000000
  X2        50.000000           .000000


 ROW   SLACK OR SURPLUS     DUAL PRICES
  2)        75.000000           .000000
  3)          .000000          5.000000
  4)          .000000         15.000000

 NO. ITERATIONS=       1
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Based on the above computer output with LINDO, answer the following questions.

(1) How many units of each product should be produced in order to maximize the profit contribution? What is the projected profit?

(2) What are the <u>required labor hours in each department</u> for the above production and the <u>slack</u> <u>hours</u> <u>in each department</u>?

(3) This company is going to hire a new full-time employee and assign this person to Department A to increase production. Do you think this decision can help this company? <u>Justify your answer</u>.

IV. A company has two plants (A and B), two regional distribution centers (C and D), and three retail outlets (E, F, and G). The plant capacities, retail outlet demands, and per-unit shipping costs are shown in the following tables:

from \ to	Dist. Center C	Dist. Center D
Plant A	2	3
Plant B	3	1

from \ to	E	F	G
Dist. Center C	2	6	3
Dist. Center D	4	4	6

The supply capacities are 600 units for plant A and 400 units for plant B, respectively. The demand requirements are 300 units at retail outlet E, 250 units at retail outlet F, and 400 units at retail outlet G. Formulate the problem as a linear program to find a distribution system which minimizes total cost.