Exam 3 Practice Problems

1. Webb Wheel (WW) produces aftermarket replacement wheels and brake drums for commercial trucks and trailers. It currently operates a single manufacturing plant located in Cullman, Alabama which has a capacity of 50,000 tons and ships its products to five sales regions: Northeast (NE), Southeast (SE), Midwest (MW), Southwest (SW), and Northwest (NW). Because of recent demand increases, Webb Wheel needs additional production capacity. Webb Wheel can add additional capacity of 25,000 tons at its current plant in Cullman for a fixed cost of $200,000. Webb Wheel can also build new plants in Little Rock, Cincinnati, and Portland. The transportation costs ($ per ton), capacities (tons), demands (tons), and other fixed costs are provided in the table below.

	Sales Region						
Plant	NE	SE	MW	SW	NW	**Capacity**	**Fixed Cost**
Cincinnati	$11.00	$12.00	$8.00	$21.00	$18.00	35,000	$350,000
Little Rock	$16.00	$10.00	$12.00	$14.00	$16.00	35,000	$350,000
Portland	$22.00	$23.00	$18.00	$12.00	$7.00	30,000	$300,000
Cullman	$14.00	$8.00	$10.00	$17.00	$23.00	50,000	
Demand	30,000	25,000	25,000	15,000	10,000		

a. Construct an optimization model using Python in a Jupyter Notebook and use it to find an optimal solution for this problem.
b. What is the second-best solution for this problem?
c. What is the value of additional capacity at the Cincinnati plant, and describe how the optimal value changes as the Cincinnati capacity is increased?

2. Consider the problem faced by a summer camp recreation director who is trying to choose activities for a rainy day. Information about possible choices is given in the table below.

Category	Activity	Time (minutes)	Popularity with Campers	Popularity with Counselors
Art	1 - Painting	30	4	2
	2 - Drawing	20	5	2
	3 - Nature craft	30	3	1
Music	4 - Rhythm band	20	5	5
Sports	5 - Relay races	45	2	1
	6 - Basketball	60	1	3
Computer	7 - Internet	45	1	1
	8 - Creative writing	30	4	3
	9 - Games	40	1	2

Write constraints for these restrictions:
a. At most one art activity can be done.
b. No more than two computer activities can be done.
c. If basketball is chosen, then rhythm band must be chosen.
d. At least 120 minutes of activities must be selected.
e. No more than 165 minutes of activities may be selected.
f. To keep the staff happy, the counselor rating should be no higher than 10.

Construct an optimization model using Python in a Jupyter Notebook and use it to find an optimal solution that maximizes the total popularity. What is the second-best solution for this problem?

3. Tower Engineering Corporation is considering undertaking several proposed projects for the next fiscal year. The projects, the number of engineers and support personnel required for each project, and the expected profits for each project are summarized in the following table:

	Project					
	1	2	3	4	5	6
Engineers required	20	55	47	38	90	63
Support personnel required	15	45	50	40	70	70
Profit ($1,000,000s)	1.0	1.8	2.0	1.5	3.6	2.2

Formulate an integer program that maximizes Tower's profit subject to the following management constraints:

a. Use no more than 175 engineers.
b. Use no more than 150 support personnel.
c. If either project 6 or project 4 is done, both must be done.
d. Project 2 can be done only if project 1 is done.
e. If project 5 is done, project 3 must not be done and vice versa.
f. No more than three projects are to be done.

Construct an optimization model using Python in a Jupyter Notebook and use it to find an optimal solution for this problem. What is the second-best solution for this problem?

4. The Moore & Harman Company is in the business of buying and selling grain. An important aspect of the company's business is arranging for the purchased grain to be shipped to customers. If the company can keep freight costs low, profitability will improve. The company recently purchased three rail cars of grain at Muncie, Indiana; six rail cars at Brazil, Indiana; and five rail cars at Xenia, Ohio. Twelve carloads of grain have been sold. The locations and the amount sold at each location are as follow

Location	Number of Rail Car Loads
Macon, GA	2
Greenwood, SC	4
Concord, SC	3
Chatham, NC	3

All shipments must be routed through either Louisville or Cincinnati. Shown are the shipping costs per bushel (in cents) from the origins to Louisville and Cincinnati and the costs per bushel to ship from Louisville and Cincinnati to the destinations.

	Louisville	Cincinnati
Muncie	8	6
Brazil	3	8
Xenia	9	3

	Macon	Greenwood	Concord	Chatham
Louisville	44	34	34	32
Cincinnati	57	35	28	24

Determine a shipping schedule that will minimize the freight costs necessary to satisfy demand. Which (if any) rail cars of grain must be held at the origin until buyers can be found?