Case 1
LP Formulation

Formulate the LP Problems given below. Declare all decisions variable used. If possible, label your constraints or constraint clusters (ex. Demand Constraint)

Problem 1. (Winston) A company produces A, B, and C and can sell these products in unlimited quantities at the following unit prices: A, $10; B, $56; C, $100. Producing a unit of A requires 1 unit hour of labor; a unit of B, 2 hours of labor plus two units of A; and a unit of C, 3 hours of labor plus 1 unit of B. Any A that is used to produce B cannot be sold. Similarly, any B that is used to produce C cannot be sold. A total of 40 hours of labor are available. Formulate an LP to maximize the company's revenues.

Problem 2. (*Hillier, 7th Edition*) Web Mercantile sells many household products through an on-line catalog. The company needs substantial warehouse space for storing its goods. Plans now are being made for leasing warehouse storage space over the next 5 months. Just how much space will be required in each of these months is known. However, since these space requirements are quite different, it may be most economical to lease only the amount needed each month on a month-by-month basis. On the

Leasing Period (Months)	Cost per Sq. Ft. Leased
1	$65
2	$100
3	$135
4	$160
5	$190

Month	Required Space (Sq. Ft)
1	30,000
2	20,000
3	40,000
4	10,000
5	50,000

other hand, It may be less expensive to lease the maximum amount needed for the entire 5 months. Another option is the intermediate approach of changing the total amount of space leased (by adding a new lease and/or having an old lease expire) at least once but not every month. The space requirement and the leasing costs for the various leasing periods are shown below. The objective is to minimize the total leasing cost for meeting the space requirements

Problem 3 *(from Prof. Cagape's notes)* A manufacturing company produces a final product that is assembled from three different parts. The parts are manufactured within the company by two departments. Because of the specific setup of the machines, each department produces the three parts at different rates. The following table provides the production rates together with the maximum number of hours the two departments can allocate weekly to manufacturing the three parts.

Department	Max Weekly Capacity (hours)	Production Rate (units/hr)		
		Part 1	Part 2	Part 3
A	80	4	8	7
B	60	6.5	10	3

Problem 4 *(Stevenson)* Nowjuice, Inc. produces bottled juice. A planner has developed an aggregate forecast for demand (in cases) for the next six months. Develop a least-cost aggregate plan using the following information. Assume zero (0) beginning inventory. Holding Cost per month is $1.

Month	Forecast
May	4,000
June	4,800
July	5,600
August	7,200
September	6,400
Octonber	5,000

Mode of Production	Mo Capacity (in cases)	Production Cost per Case ($)
Regular	5,000	10
Overtime	500	16
Subcontracting	n/a	20

Problem 5 *(Winston)* Winstonoco is considering in three projects. If we fully invest in a project, the realized cash flows (in millions of dollars) will be as shown. For example, project 1 requires cash outflow of $3 million today and returns $5.5 million 3 years from now. Today we have $2 million in cash. At each time point (0, 0.5, ..., 2.5 years from today) we may, if desired, borrow up to $2 million at 3.5% (per 6 mos) interest. Left-over cash earns 3% (per 6 mos) interest. For example, if after borrowing and investing at time 0 we have $1 million we would receive $30,000 in interest at time 0.5 years. Winstonco's goal is to maximize cash on hand after it accounts for time 3 cash flows. What investment and borrowing strategy should be used? Remember that we may invest in a fraction of a project. For example, if we invest in 0.5 of project 3, then we have cash outflows of -$1 million at time 0 and 0.5.

Time	Cash Flow		
(years)	Proj 1	Proj 2	Proj 3
0.0	-3.0	-2.0	-2.0
0.5	-1.0	-0.5	-2.0
1.0	1.8	1.5	-1.8
1.5	1.4	1.5	1.0
2.0	1.8	1.5	1.0
2.5	1.8	0.2	1.0
3.0	5.5	-1.0	6.0

Problem 7 (*Winston*) Donovan Enterprises produces electric mixers. During the next four quarters, the following demands for mixers must be met on time: quarter 1—4,000; quarter 2—2,000; quarter 3—3,000; quarter 4—10,000. Each of Donovan's workers works three quarters of the year and gets one quarter off. Thus, a worker may work during quarters 1, 2, and 4 and get quarter 3 off. Each worker is paid $30,000 per year and (if working) can produce up to 500 mixers during a quarter. At the end of each quarter, Donovan incurs a holding cost of $30 per mixer on each mixer in inventory. Formulate an LP to help Donovan minimize the cost (labor and inventory) of meeting the next year's demand (on time). At the beginning of quarter 1, 600 mixers are available.
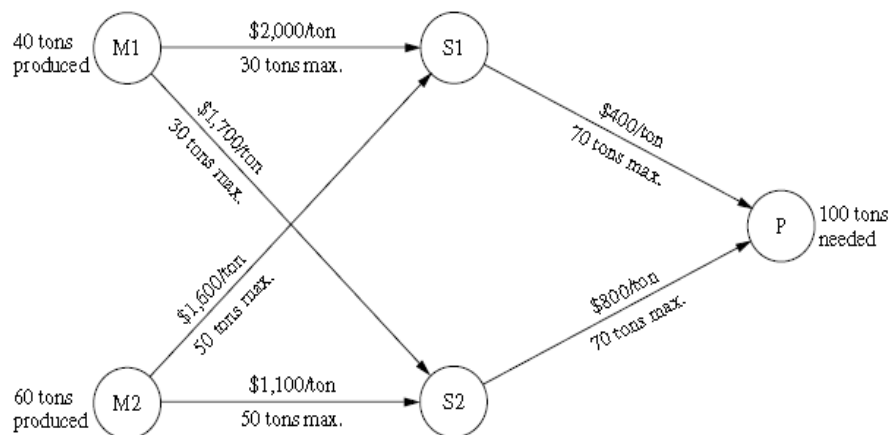
Problem 8 *(Hillier, 7th Edition)* The Fagersta Steelworks currently is working two mines to obtain its iron ore. This iron ore is shipped to either of two storage facilities. When needed, it then is shipped on to the company's steel plant. The diagram below depicts this distribution network, where M1 and M2 are the two mines, S1 and S2 are the two storage facilities, and P is the steel plant. The diagram also shows the monthly amounts produced at the mines and needed at the plant, as well as the shipping cost and the maximum amount that can be shipped per month through each shipping lane. (Go to the left column below the diagram.) Management now wants to determine the most economical plan for shipping the iron ore from the mines through the distribution network to the steel plant.