BDM - Problem Sheet

1) MKS inc manufactures and sells bikes in 3 different markets across Canada (Ottawa, Calgary and Vancouver). Through market research they have determined the following revenues and costs in each market:

Ottawa	Sale Price = $300/unit	Manufacturing Cost = $125/unit	Shipping Cost = $44/Unit
Calgary	Sale Price = $400/unit	Manufacturing Cost = $125/unit	Shipping Cost = $125/Unit
Montreal	Sale Price = $450/unit	Manufacturing Cost = $125/unit	Shipping Cost = $88/Unit

MKS currently owns manufacturing plant A in eastern Canada that they can use to manufacture bikes. MKS Inc would like to know how may bikes to ship to each location in order to maximize profit.

a) Define the variables
b) Define the optimization function
c) MKS has a shipping budget of $25,000, write this constraint
d) MKS wants to make sure that exactly twice as many bikes are sent to Calgary as are sent to Ottawa, write this constraint
e) No more then 100 units can be shipped to Montreal, write this constraint
f) MKS does not want the total costs of selling in Ottawa to be higher then $45,000, write this constraint
g) More then 35% of the bikes must be sent to calgary, write this constraint
h) Their Current Manufacturing Plant has a capacity of 1000 units for this production period, write this constraint

KMS has the option of renting out 2 more manufacturing plants in western Canada, but there are a few restrictions. Set up costs for the new plants are as follows:

Plant B - $10,000
Plant C - $15,000

Bikes can be produced in Plant B at a cost of $113/Unit and in Plant C at a cost of $110/Unit. Bikes produced in Plant B can ONLY be shipped to Calgary at a savings of 40% on the shipping. Bikes produced at Plant C can be shipped anywhere in Canada costing $100 to ship to Ottawa, $90 to ship to Calgary and $110 to ship to Montreal. If KMS decides to start prodution on western canada, they MUST use BOTH plants.

i) Will the variables change in part a)? If so, define the new changing cells.
j) Write the new Optimization Function
k) Define any production set-up constraints
l) Plants A,B,C have the following capacities: 1000units, 300units, 1500units, define the production constraints:
m) Demand for bikes in Ottawa, Calgary and Montreal are as follows and must be met exactly: 700 units, 1400 units, 500 units, define the demand constraints

---

Figure 5.0 - The sensitivity analysis below will be used for question #5

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B12	Production Clock (Grandfather)	3.33	0.00	300	100	100
C12	Production Clock (Wall)	3.33	0.00	200	100	50

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
D6	Assembly (David) Used	33	0	40	1E+30	6.667
D7	Carving (LaDeana) Used	40	25	40	13.333	13.333
D8	Shipping (Lydia) Used	20	33.33	20	10	5

2) Comfortable Hands is a company that features a product line of winter gloves for the entire family—men, women, and children. They are trying to decide what mix of these three types of gloves to produce.

Comfortable Hands' manufacturing labor force is unionized. Each full-time employee works a 40-hour week. In addition, by union contract, the number of full-time employees can never drop below 20. Nonunion, part-time workers can also be hired with the following union-imposed restrictions: (1) each part-time worker works 20 hours per week and (2) there must be at least 2 full-time employees for each part-time employee.

All three types of gloves are made out of the same 100 percent genuine cowhide leather. Comfortable Hands has a long-term contract with a supplier of the leather and receives a 5,000-square-foot shipment of the material each week. The material requirements and labor requirements, along with the *gross profit* per glove sold (not considering labor costs), are given in the following table.

Glove	*Material Required (Square Feet)*	*Labor Required (Minutes)*	*Gross Profit (per Pair)*
Men's	2	30	$ 8
Women's	1.5	45	$10
Children's	1	40	$ 6

Each full-time employee earns $13 per hour, while each part-time employee earns $10 per hour. Management wishes to know what mix of each of the three types of gloves to produce per week, as well as how many full-time and part-time workers to employ. They would like to maximize their *net profit*—their gross profit from sales minus their labor costs.

a. Formulate and solve a linear programming model for this problem on a spreadsheet.
b. Summarize this formulation in algebraic form.

3). Joyce and Marvin run a day care for preschoolers. They are trying to decide what to feed the children for lunches. They would like to keep their costs down, but they also need to meet the nutritional requirements of the children. They have already decided to go with peanut butter and jelly sandwiches, and some combination of graham crackers, milk, and orange juice. The nutritional content of each food choice and its cost are given in the table below.

Food Item	*Calories from Fat*	*Total Calories*	*Vitamin C (mg)*	*Protein (g)*	*Cost (¢)*
Bread (1 slice)	10	70	0	3	5
Peanut butter (1 tbsp.)	75	100	0	4	4
Strawberry jelly (1 tbsp.)	0	50	3	0	7
Graham cracker (1 cracker)	20	60	0	1	8
Milk (1 cup)	70	150	2	8	15
Juice (1 cup)	0	100	120	1	35

The nutritional requirements are as follows. Each child should receive between 400 and 600 calories. No more than 30 percent of the total calories should come from fat. Each child should consume at least 60 milligrams (mg) of vitamin C and 12 grams (g) of protein. Furthermore, for practical reasons, each child needs exactly 2 slices of bread (to make the sandwich), at least twice as much peanut butter as jelly, and at least 1 cup of liquid (milk and/or juice).

Joyce and Marvin would like to select the food choices for each child that minimize cost while meeting the above requirements.

4) The Build-Em-Fast Company has agreed to supply its best customer with three widgits during *each* of the next three weeks, even though producing them will require some overtime work. The relevant production data are as follows:

	Maximum Production		
Week	*Regular Time*	*Overtime*	*Production Cost per Unit, Regular Time*
1	2	2	$300
2	3	2	500
3	1	2	400

The cost per unit produced with overtime for each week is $100 more than for regular time. The cost of storage is $50 per unit for each week it is stored. There is already an inventory of two widgets on hand currently, but the company does not want to retain any widgets in inventory after the three weeks.

Management wants to know how many units should be produced in each week to minimize the total cost of meeting the delivery schedule. Formulate and solve a spreadsheet model for this problem.

5) David, LaDeana, and Lydia own a company that manufactures clocks. David and LaDeana are each available to work 40 hours per week, Lydia is only available for 20 hours. They make 2 different types of clocks, grandfather and wall. David assembles, LaDeana carves and Lydia ships. The grandfather clock requires 6 hours assembly, 8 hours of carving, 3 hours to ship and yields a profit of $300. The wall clock requires 4 hours assembly, 4 hours of carving, 3 hours to ship and yields a profit of $200. Answer all of the questions below based on the sensitivity analysis in figure 5.0.

a) How many of each type of clock are produced?
b) How many hours do David, LaDeana and Lydia each work?
c) What is the Maximized Profit?
For this optimal solution,
d) What are the allowable ranges for unit profits of each clock?
e) What are the allowable ranges for each persons hours?
f) If you could increase 1 persons available hours, whose would it be?
g) Would it be beneficial to increase David's hours?
h) Would this optimal solution remain valid if Lydia increased her hours by 5? If so, how much would profit increase?
i) Would the optimal solution change if Lydia increased her hours by 5 and David decreased his by 5?

6) Four cargo ships will be used for shipping goods from one port to four other ports (labeled 1, 2, 3, 4). Any ship can be used for making any one of these four trips. However, because of differences in the ships and cargoes, the total cost of loading, transporting, and unloading the goods for the different ship–port combinations varies considerably, as shown in the following table:

	Port			
	1	*2*	*3*	*4*
Ship				
1	$500	$400	$600	$700
2	600	600	700	500
3	700	500	700	600
4	500	400	600	600

The objective is to assign the four ships to four different ports in such a way as to minimize the total cost for all four shipments.

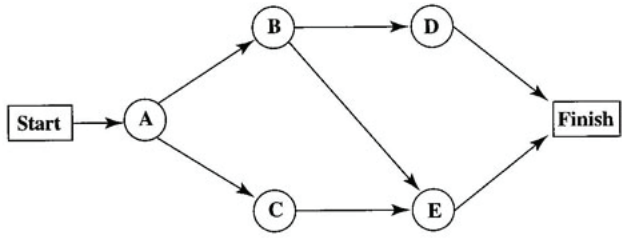
7) You and several friends are about to prepare a lasagna dinner. The tasks to be performed, their immediate predecessors, and their estimated durations are as follows:

Task	*Task Description*	*Tasks That Must Precede*	*Time (Minutes)*
A	Buy the mozzarella cheese*	—	30
B	Slice the mozzarella	A	5
C	Beat 2 eggs	—	2
D	Mix eggs and ricotta cheese	C	3
E	Cut up onions and mushrooms	—	7
F	Cook the tomato sauce	E	25
G	Boil large quantity of water	—	15
H	Boil the lasagna noodles	G	10
I	Drain the lasagna noodles	H	2
J	Assemble all the ingredients	I, F, D, B	10
K	Preheat the oven	—	15
L	Bake the lasagna	J, K	30

*There is none in the refrigerator.

a. Construct the project network.
b. Find all the paths and path lengths through this project network. Which of these paths is a critical path?

8) Good Homes Construction Company is about to begin the construction of a large new home. The company's president, Michael Dean, is currently planning the schedule for this project. Michael has identified the five major activities (labeled A, B, . . . , E) that will need to be performed according to the following project network.



He also has gathered the following data about the normal point and crash point for each of these activities.

Activity	*Normal Time (Weeks)*	*Crash Time (Weeks)*	*Normal Cost*	*Crash Cost*
A	3	2	$54,000	$60,000
B	4	3	62,000	65,000
C	5	2	66,000	70,000
D	3	1	40,000	43,000
E	4	2	75,000	80,000

These costs reflect the company's direct costs for the material, equipment, and direct labor required to perform the activities. In addition, the company incurs indirect project costs such as supervision and other customary overhead costs, interest charges for capital tied up, and so forth. Michael estimates that these indirect costs run $5,000 per week. He wants to minimize the overall cost of the project. Therefore, to save some of these indirect costs, Michael concludes that he should shorten the project by doing some crashing to the extent that the crashing cost for each additional week saved is less than $5,000.

a. To prepare for analyzing the effect of crashing, find the earliest times, latest times, and slack for each activity when they are done in the normal way. Also identify the corresponding critical path(s) and project duration.
b. Use marginal cost analysis to determine which activities should be crashed and by how much to minimize the overall cost of the project. Under this plan, what is the duration and cost of each activity? How much money is saved by doing this crashing?

9) Reconsider Problem 8) involving the Good Homes Construction Co. project to construct a large new home. Michael Dean now has generated the plan for how to crash this project (as given as an answer in the back of the book). Since this plan causes all three paths through the project network to be critical paths, the earliest start time for each activity also is its latest start time.

Michael has decided to use PERT/Cost to schedule and control project costs.

a. Find the earliest start time for each activity and the earliest finish time for the completion of the project.
b. Construct a table like Table 7.11 to show the budget for this project.
c. Construct a table like Figure 7.16 (by hand) to show the schedule of costs based on earliest times for each of the eight weeks of the project.
d. Now use the corresponding Excel template in your MS Courseware to do parts *b* and *c* on a single spreadsheet.
e. After four weeks, activity A has been completed (with an actual cost of $65,000) and activity B has just now been completed (with an actual cost of $55,000), but activity C is just 33 percent completed (with an actual cost to date of $44,000). Construct a PERT/Cost report after week 4. Where should Michael concentrate his efforts to improve cost performances?

10) The Toys-R-4-U Company has developed two new toys for possible inclusion in its product line for the upcoming Christmas season. Setting up the production facilities to begin production would cost $50,000 for toy 1 and $80,000 for toy 2. Once these costs are covered, the toys would generate a unit profit of $10 for toy 1 and $15 for toy 2.

The company has two factories that are capable of producing these toys. However, to avoid doubling the start-up costs, just one factory would be used, where the choice would be based on maximizing profit. For administrative reasons, the same factory would be used for both new toys if both are produced.

Toy 1 can be produced at the rate of 50 per hour in factory 1 and 40 per hour in factory 2. Toy 2 can be produced at the rate of 40 per hour in factory 1 and 25 per hour in factory 2. Factories 1 and 2, respectively, have 500 hours and 700 hours of production time available before Christmas that could be used to produce these toys.

It is not known whether these two toys would be continued after Christmas. Therefore, the problem is to determine how many units (if any) of each new toy should be produced before Christmas to maximize the total profit. Formulate and solve a mixed BIP model on a spreadsheet for this problem.

11) Montega is a developing country that has 15,000,000 acres of publicly controlled agricultural land in active use. Its government currently is planning a way to divide this land among three basic crops (labeled 1, 2, and 3) next year. A certain percentage of each of these crops is exported to obtain badly needed foreign capital (dollars), and the rest of each of these crops is used to feed the populace. Raising these crops also provides employment for a significant proportion of the population. Therefore, the main factors to be considered in allocating the land to these crops are (1) the amount of foreign capital generated, (2) the number of citizens fed, and (3) the number of citizens employed in raising these crops. The following table shows how much each 1,000 acres of each crop contributes toward these factors, and the last column gives the goal established by the government for each of these factors.

	Contribution per 1,000 Acres of Crop			
Factor	*1*	*2*	*3*	*Goal*
Foreign capital	$3,000	$5,000	$4,000	≥ $70,000,000
Citizens fed	150	75	100	≥ 1,750,000
Citizens employed	10	15	12	= 200,000

In evaluating the relative seriousness of *not* achieving these goals, the government has concluded that the following deviations from the goals should be considered *equally undesirable:* (1) each $100 under the foreign-capital goal, (2) each person under the citizens-fed goal, and (3) each deviation of one (in either direction) from the citizens-employed goal.

a. Describe why this problem is a goal-programming problem by giving quantitative expressions for the goals and the overall objective.
b. Formulate and solve this problem as a linear programming model on a spreadsheet.
c. Interpret this solution to management in its language.

12) Dwight Moody is the manager of a large farm with 1,000 acres of arable land. For greater efficiency, Dwight always devotes the farm to growing one crop at a time. He now needs to make a decision on which one of four crops to grow during the upcoming growing season. For each of these crops, Dwight has obtained the following estimates of crop yields and net incomes per bushel under various weather conditions.

	Expected Yield, Bushels/Acre			
Weather	*Crop 1*	*Crop 2*	*Crop 3*	*Crop 4*
Dry	20	22.5	30	20
Moderate	35	30	25	20
Damp	40	45	25	20
Net income per bushel	$1	$1	$1	$1

After referring to historical meteorological records, Dwight also estimated the following prior probabilities for the weather during the growing season:

Dry	0.3
Moderate	0.5
Damp	0.2

a. Develop a decision analysis formulation of this problem by identifying the decision alternatives, the states of nature, and the payoff table.

b. Construct a decision tree for this problem.

c. Use Bayes' Decision Rule to Determine which crop to grow.

d) Calculate the MAXIMAX, MAXIMIN, and Equally Likely

e) Calculate EVPI

13) Using the data found in the table, aswer the questions below.

Activity	Prede-cessors	Opti-mistic time	Most likely time	Pessi istic time	Crash cost/day ($)
A) Bonding, insurance, tax structuring	---	20	30	40	1500
B) Foundation, concrete footings for boxes	A	20	65	80	3500
C) Upgrading skyboxes, stadium seating	A	50	60	100	4000
D) Upgrading walkways, stairwells, elevators	C	30	50	100	1900
E) Interior wiring, lathes	B	25	30	35	9500
F) Inspection approvals	E	1	1	1	0
G) Plumbing	D, E	25	30	35	2500
H) Painting	G	10	20	30	2000
I) Hardware/air conditioning/metal workings	H	20	25	60	2000
J) Tile/carpeting/windows	H	8	10	12	6000
K) Inspection	J	1	1	1	0
L) Final detail work/cleanup	I, K	20	25	60	4500

a) Draw the workflow diagram.

b) Calculate the expected time and standard deviation of each activity.

c) Calculate the ES,EF,LS,LF, and Slack for each activity.

d) Determine the Critical Path(s).

e) Without crashing the project, what are the chances of meeting a 270 day deadline?

f) Without crashing the project, what are the chances of meeting a 240 day deadline?

g) Each activity can be crashed for up to 10 days at the costs shown in the table. You would like to crash the project to 249 days in the cheapest way possible, how would you do it? What would the total crashing cost be?