THE UNIVERSITY OF BRITISH COLUMBIA
Sauder School of Business

COMMERCE 290 – INTRODUCTION TO QUANTITATIVE DECISION MAKING

SAMPLE MIDTERM EXAMINATION

PLEASE READ THE FOLLOWING:

1. This examination consists of 13 pages including this cover page. Please check to ensure this paper is complete.

2. No candidate shall be permitted to enter the examination room after the expiration of ½ hour, or to leave during the first ½ hour of the examination. **Candidates are not permitted to ask questions of interpretation.** ie: "What does this mean?"

3. **Cell phones** must be turned off and are **not permitted to be in view** or be used as a watch during this exam.

4. **Detailed work** must be shown to receive credit. Show all work for non-multiple choice questions on this exam paper in the space provided. **No credit for answers only!**

5. **Time: 90 minutes**

6. CLOSED BOOK EXAM; Non-graphing, non-programmable calculators permitted **(graphing calculators like the TI 83 etc are not permitted).**

LAST NAME:_____ FIRST NAME:_____

STUDENT NUMBER:_____

EXCEL LAB SECTION:_____SIGNATURE:_____

Problem	Maximum Possible	Marks Awarded
1	31	
2	9	
3	30	
4	15	
Total	85	

Problem 1 *(31 marks)*

Bob's farm in Saskatoon has 680 acres of land available for crops this season. He is planning to grow two crops, Beans and Wheat in the next season. He was experimenting with the beans production for last few years and planted a minimum of 80 acres of Beans. This year also he wants to continue with his experiment and will plant a minimum of 80 acres of Beans. It takes 1 hour to plant each acre of Beans and 2 hours to plant each acre of Wheat. Harvesting times are 2 hours per acre for Beans and 1.5 hours per acre for Wheat. Bob estimates that he has 615 hours available for planting and 900 hours available for harvesting. Each acre of Beans is expected to bring $200 in revenue whereas each acre of Wheat is expected to bring $300 in revenue.

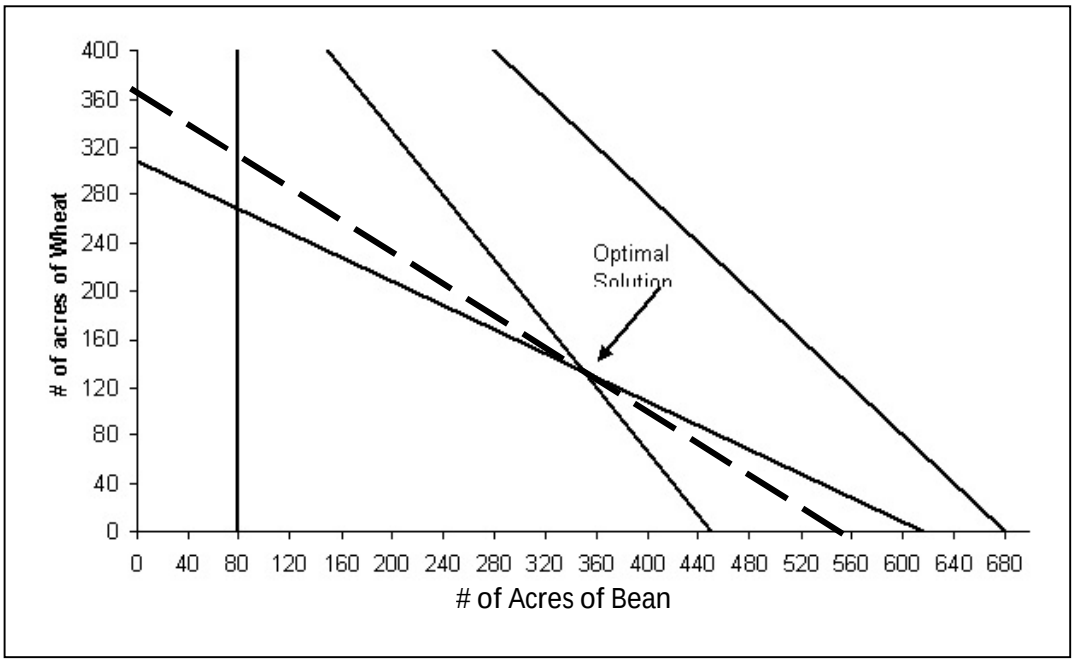
Bob is interested in maximizing revenue over the next growing season. To help accomplish this, he has hired a consulting firm to help solve this problem. The consulting firm has provided the correct linear programming model below in algebraic form.

Let B = number of acres to plant in Beans
W = number of acres to plant in Wheat

Maximize 200B + 300W

(HARVESTING)	2B + 1.5W	≤	900	*hours*
(PLANTING)	1B + 2W	≤	615	*hours*
(ACRES)	B + W	≤	680	*acres*
(MINIMUM DEMAND)	B	≥	80	*acres*
NONNEG)	B, W	≥	0	

(a) The **completed graph** below (**drawn to scale**) correctly identifies the Optimal Solution
   i. **Label** all the constraints (except non-neg) by name.
   ii. **Shade and identify the feasible region.**



(b) With respect to the primary decisions facing Bob, if you were the consultant, what recommendation would you provide to Bob?

(c) How much revenue will Bob realize if they operate at the optimal solution?

Your Answer: _____

(d) If Bob wanted to increase the amount indicated in part (c) above, which of the following activities would increase revenues? ***(Choose the best answer)***

i. increase just Planting time
ii. increase just Harvest time
iii. increase both Planting and Harvest times
iv. increase either Planting or Harvest times
v. increase prices received for Beans and Wheat
vi. all of the above
vii. none of the above

Your Answer: _____

(e) Over what ***range*** for the unit profit on Beans would the optimal solution remain unchanged?

Your Answer: _____

(f) How much would revenue increase if Bob could increase his HARVEST time by 1 extra hour?

Your Answer: _____

(g) Determine the **allowable increase** and **allowable decrease** for the HARVEST constraint.

Your Answer: _____

(h) What is the **allowable increase** for the ACRES constraint?

Your Answer: _____

(i) In an effort to increase revenue, should Bob try and get more land on which to grow crops? ***Circle the correct response*** and explain.

Yes No Cannot tell

Explain:

(j) Bob knows from the consultant's report that one extra hour of Planting time is worth $120, and that this value is valid up to 1,066.67 total Planting hours. If Bob could add 100 extra hours of Planting time **OR** 300 extra hours of Harvest time, which option should he choose? Provide convincing evidence.

Problem 2 *(9 marks)*

Refer to the previous "Bob Farms" problem to answer these additional questions.

Bob has noted from the consultant's report that he has large parts of his farm that are not being used to plant and harvest Beans and Wheat. Bob knows that, because good farming land is in high demand, he could rent any amount of land to other farmers in the surrounding area for $175 per acre.

(a) According to the optimal solution, how many acres should be left unplanted?

Your Answer:_____

(b) ***FOR THIS QUESTION ONLY***, suppose Bob rents out 100 acres of his land so that the ***maximum*** available land for planting is now only 580 acres. ***Circle the correct responses.***

i.	Would the feasible region change?	Yes	No
ii.	Would the optimal solution change?	Yes	No
iii.	Would the set of binding constraints change?	Yes	No

(c) Bob's wife has observed that if other farmers are willing to pay $175 per acre, Bob's Farms would be financially better off growing no crops of their own and instead renting out ALL their land.

Is she correct? Provide evidence to support your answer.

Is there a solution that is better than both the consultant's and the wife's solutions? If yes, what is the revenue from this solution?

Problem 3 (30 marks)

Frandec Company manufactures and assembles material handling equipment used in warehouses and distribution. One product, called a Liftmaster, is assembled from four components: a frame, a motor, three supports and a metal strap. Frandec's production schedule calls for at least 5,000 Liftmasters to be made next month. Frandec purchases the motors from an outside supplier, but Frandec can either Make (manufacture) the frames, supports and straps or Buy (purchase) from an outside supplier. Manufacturing and purchase costs per unit are as follows:

Component	Manufacturing Cost	Purchase Cost
Frame	$40.00	$53.00
Support	$12	$16.00
Strap	$7	$9

Three departments are involved in the manufacture of these components. The time (in minutes per unit) required to make each component in each department and the available capacity (in hours) for the three departments are as follows:

Department	Production Time per unit (minutes)			Time Available
	Frame	Support	Strap	Hours
Cutting	3.6	1.75	0.9	300
Milling	2.6	1.9	0	300
Shaping	3.2	2.8	1.5	350

This problem was correctly formulated as a linear programming problem in Excel and solved using Solver. The solved model with an optimal solution and Sensitivity Report are attached. Use these printouts to answer the questions on the following pages. You may assume that Frandec will use this solution.

To receive full marks, be sure to **include your units** when answering the following questions.

QUESTIONS ARE INDEPENDENT.

Question 3

Frandec

Input Data

	Prod Time (minutes)per unit			Time		Time		Time	
	Frame	Support	Strap	Used		Available		Available	
Cutting	3.6	1.75	0.9	16961.5385	<=	18000	*minutes*	300	*hours*
Milling	2.6	1.9	0	9000	<=	9000	*minutes*	150	*hours*
shaping	3.2	2.8	1.5	18576.9231	<=	21000	*minutes*	350	*hours*

	Frame	Support	Strap
Manufac.Cost	$40.00	$12.00	$7.00
Purchasing Cost	$53.00	$16.00	$9.00

Action Plan

	Frame	Support	Strap	
Make	3,462	0	5,000	Units
Buy	1,538	15,000	0	Units
Supply	5,000	15,000	5,000	Units
	>=	>=	>=	
Demand	5,000	15,000	5,000	

Cost Issues

	Frame	Support	Strap	Total
Make	138,461.54	0.00	35,000.00	173,461.54
Buy	81,538.46	240,000.00	0.00	321,538.46
Total	220,000.00	240,000.00	35,000.00	495,000.00

Sensitivity Report

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C18	Make Frame	3,462	0	40	7.52632	1E+30
D18	Make Support	0	5	12	1E+30	5.5
E18	Make Strap	5,000	0	7	2	7
C19	Buy Frame	1,538	0	53	1E+30	7.52631579
D19	Buy Support	15,000	0	16	5.5	16
E19	Buy Strap	0	2	9	1E+30	2

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F7	Cutting Used	16961.538	0	18000	1E+30	1038.46154
F8	Milling Used	9000	-5	9000	750	9000
F9	shaping Used	18576.923	0	21000	1E+30	2423.07692
C20	Supply Frame	5,000	53	5000	1E+30	1538.46154
D20	Supply Support	15,000	16	15000	1E+30	15000
E20	Supply Strap	5,000	7	5000	1153.85	5000

(a) How many Liftmasters should be assembled next month?

Your Answer:_____

(b) How many Frames are manufactured next month?

Your Answer:_____

(c) What is the total manufacturing cost for the Liftmasters?

Your Answer:_____

(d) How many Liftmasters can be assembled using only parts that were purchased?

Your Answer:_____

(e) Which manufacturing department(s) are limiting the manufacturing volume?

Your Answer:_____

(f) Of all the Straps manufactured, how many will be attached to the frames that are manufactured?

Your Answer:_____

(g) Suppose the manufacturing cost for Frames increased by $4.00. Would this change encourage Frandec to buy more Frames? ***Circle the best response*** and explain.

Yes No Cannot tell with information provided

Explain:

(h) Read the following statement and then ***circle the correct response***.
Frandec management is not manufacturing any Supports because Frames and Straps are more profitable when internally manufactured:

True False

What does the reduced cost number mean in this context?

(i) Is there any evidence of multiple optima in this problem? ***Circle the correct response***.

Yes No

(j) Suppose Frandec could get an additional 5 hours (300 minutes) of Milling Time at the regular cost. What can you say about the effect this change will have on:

i. the Target Cell?

ii. Optimal solution. Explain

(k) Suppose the cost of the extra Milling Time in the question directly $2.00 above the regular cost. What specific effect would this have on the value of the Target Cell?

(l) If the amount of Milling time reduced by 10 hours (600 minutes), would the optimal solution change? ***Circle the correct response*** and explain.

Yes No Don't know

Explain:

(m) Suppose Frandec can obtain 1,200 extra minutes (or nothing) of Milling time for $1,000. Should they do this? Provide convincing evidence.

Problem 4 *(15 marks)*

Refer to the previous "Frandec" problem to answer these additional questions.

(a) What is the **best** Excel formula in cell F7?

Your Answer: _____

(b)) What is the Excel formula in H7?

Your Answer: _____

(c) In cell D22, the 15,000 was entered as a number. A better choice would have been if it had been entered as a formula. What should this formula be?

Your Answer: _____

(d) Is the cost of the motors a relevant or sunk cost in this problem?

Your Answer: _____

(e) Management has noticed that at the optimal solution, all the available milling time has been used. Does this mean that to improve their costs they would need to acquire more time in milling department? ***Circle the correct response*** and explain.

Yes No

Explain:

If we formulated this problem algebraically, one correct version for the decision variables would be:

Let,

FM = number of Frames to Make
SM = number of Supports to Make
STM = number of STraps to Make
FB = number of Frames to Buy
SB = number of Supports to Buy
STB = number of STraps to Buy

(f) Write all the algebraic Supply/Demand constraints for this problem.

(g) Frandec has just been notified that its Liftmaster customers require that **all** Frames, Supports and Straps must be Painted before they are assembled. It takes 2 minutes to paint one Frame, 1 minute to paint 1 Support and 0.8 minute to paint 1 Strap. Frandec has 500 hours available for this task.,

Set up the algebraic constraint for Painting.

Would the introduction of this Painting constraint affect the optimal solution? ***Circle the correct response*** and explain.

Yes No Don't know

Explain:

Solution

Problem 1 *(31 marks)*

Bob's farm in Saskatoon has 680 acres of land available for crops this season. He is planning to grow two crops, Beans and Wheat in the next season. He was experimenting with the beans production for last few years and planted a minimum of 80 acres of Beans. This year also he wants to continue with his experiment and will plant a minimum of 80 acres of Beans. It takes 1 hour to plant each acre of Beans and 2 hours to plant each acre of Wheat. Harvesting times are 2 hours per acre for Beans and 1.5 hours per acre for Wheat. Bob estimates that he has 615 hours available for planting and 900 hours available for harvesting. Each acre of Beans is expected to bring $200 in revenue whereas each acre of Wheat is expected to bring $300 in revenue.

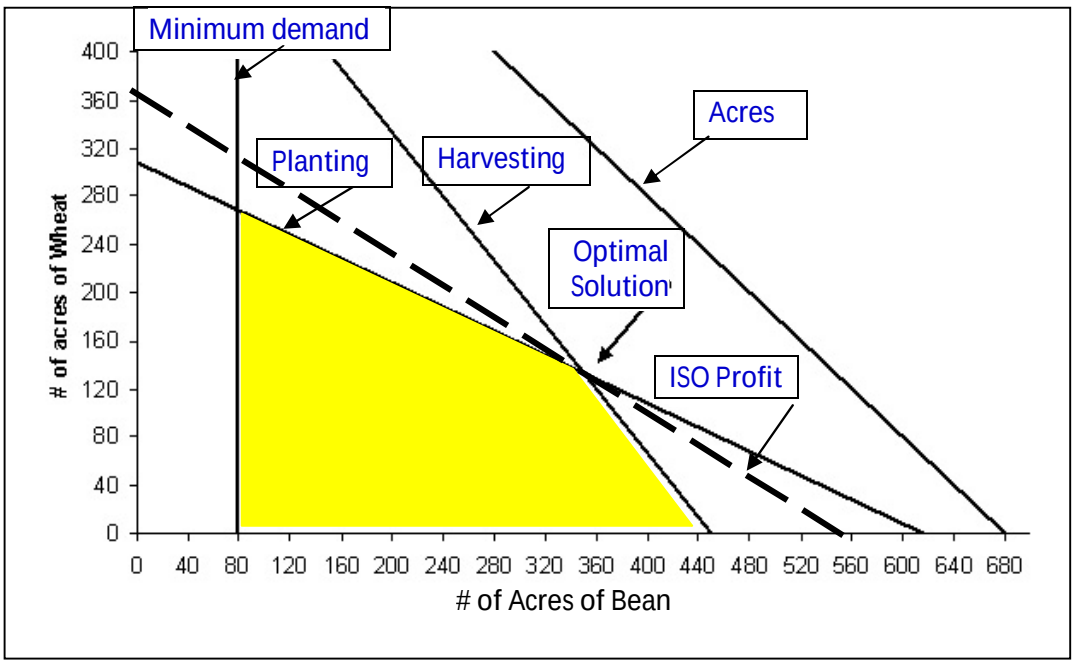
Bob is interested in maximizing revenue over the next growing season. To help accomplish this, he has hired a consulting firm to help solve this problem. The consulting firm has provided the correct linear programming model below in algebraic form.

Let B = number of acres to plant in Beans
W = number of acres to plant in Wheat

Maximize 200B + 300W

(HARVESTING)	2B + 1.5W	≤	900	*hours*
(PLANTING)	1B + 2W	≤	615	*hours*
(ACRES)	B + W	≤	680	*acres*
(MINIMUM DEMAND)	B	≥	80	*acres*
NONNEG)	B, W	≥	0	

(k) The **completed graph** below (**drawn to scale**) correctly identifies the Optimal Solution
iii. **Label** all the constraints (except non-neg) by name.
iv. **Shade and identify the feasible region.**



(l) With respect to the primary decisions facing Bob, if you were the consultant, what recommendation would you provide to Bob?

Bob should used
351 acres for producing Beans
132 acres for producing Wheat

(m) How much revenue will Bob realize if they operate at the optimal solution?

Your Answer: **$109,800**

(n) If Bob wanted to increase the amount indicated in part (c) above, which of the following activities would increase revenues? ***(Choose the best answer)***

viii. increase just Planting time
ix. increase just Harvest time
x. increase both Planting and Harvest times
xi. increase either Planting or Harvest times
xii. increase prices received for Beans and Wheat
xiii. all of the above
xiv. none of the above

Your Answer: **vi**

(o) Over what ***range*** for the unit profit on Beans would the optimal solution remain unchanged?

$$-\frac{1}{2} \geq -\frac{B}{300} \geq -\frac{2}{1.5}$$

$$-\frac{1}{2} \geq -\frac{B}{300} \qquad -\frac{B}{300} \geq -\frac{2}{1.5}$$

$$\frac{B}{300} \geq \frac{1}{2} \qquad \frac{B}{300} \leq \frac{2}{1.5}$$

$$B \geq 150 \qquad B \leq 400$$

$$150 \leq B \leq 400$$

Your Answer: **Revenue of $150 to $400 per acre of Beans**

(p) How much would revenue increase if Bob could increase his HARVEST time by 1 extra hour?

New optimal revenue can be calculated by getting the value of B and W from:

(HARVESTING) 2B + 1.5W ≤ 901 *hours*

(PLANTING) 1B + 2W ≤ 615 *hours*

By solving the above equation we will get B = 351.8 acre and W = 131.6 acre

So new revenue will be (351.8*200 + 131.6*300) =		$109,840
Old revenue	=	$109,800
Increase	**=**	**$40**

Your Answer: **$40**

(q) Determine the **allowable increase** and **allowable decrease** for the HARVEST constraint.

Move to the intersection of planting and minimum demand

Planting	1B + 2W	=	615
	B	=	80
So,	W	=	267.5

We know,

Harvesting	2B + 1.5W	=	900
	2(80) + 1.5(267.5)	=	561.25
Allowable decrease		=	**338.75**

Move to the intersection of planting line and Bean axis

Planting	1B + 2W	=	615
	W	=	0
So,	B	=	615

	2B + 1.5W	=	900
	2(615) + 1.5(0)	=	1,230
Allowable Increase		=	**330**

Your Answer: ⇩**338.5,** ⇧**330**

(r) What is the **allowable increase** for the ACRES constraint?

Your Answer: **infinity**

(s) In an effort to increase revenue, should Bob try and get more land on which to grow crops? ***Circle the correct response*** and explain.

Yes **No** Cannot tell

Explain: Land is redundant constraint and the land constraint line is above the feasible region.

(t) Bob knows from the consultant's report that one extra hour of Planting time is worth $120, and that this value is valid up to 1,066.67 total Planting hours. If Bob could add 100 extra hours of Planting time **OR** 300 extra hours of Harvest time, which option should he choose? Provide convincing evidence.

Total improvement to profit for each constraint:

Harvesting	$40 * 300	= $12,000
Planting	$120 * 100	= $12,000

Both options will give the same amount of extra profit. However, 100 planting labor hours may be less costly than the 300 harvesting hours. So select 100 Planting time.

Problem 2 *(9 marks)*

Refer to the previous "Bob Farms" problem to answer these additional questions.

Bob has noted from the consultant's report that he has large parts of his farm that are not being used to plant and harvest Beans and Wheat. Bob knows that, because good farming land is in high demand, he could rent any amount of land to other farmers in the surrounding area for $175 per acre.

(d) According to the optimal solution, how many acres should be left unplanted?

680 – (351+132) = 197

Your Answer: **197 acres**

(e) ***FOR THIS QUESTION ONLY***, suppose Bob rents out 100 acres of his land so that the ***maximum*** available land for planting is now only 580 acres. ***Circle the correct responses.***

iv.	Would the feasible region change?	Yes	**No**
v.	Would the optimal solution change?	Yes	**No**
vi.	Would the set of binding constraints change?	Yes	**No**

(f) Bob's wife has observed that if other farmers are willing to pay $175 per acre, Bob's Farms would be financially better off growing no crops of their own and instead renting out ALL their land.

Is she correct? Provide evidence to support your answer.

Total revenue by renting all land (175 * 680) = $119,000
Total revenue by growing crops = $109,800
Extra profit = $ 9,200

Yes, Bob can make $ 9,200 more by renting all land instead of growing crops.

Is there a solution that is better than both the consultant's and the wife's solutions? If yes, what is the revenue from this solution?

Bob can grow 483 acres of land and rent the rest

Revenue from growing 483 acre of land = $109,800
Revenue from renting 197 acres of land = $ 34,475
Total revenue from 680 acres = $144,275

Problem 3 (30 marks)

Frandec Company manufactures and assembles material handling equipment used in warehouses and distribution. One product, called a Liftmaster, is assembled from four components: a frame, a motor, three supports and a metal strap. Frandec's production schedule calls for at least 5,000 Liftmasters to be made next month. Frandec purchases the motors from an outside supplier, but Frandec can either Make (manufacture) the frames, supports and straps or Buy (purchase) from an outside supplier. Manufacturing and purchase costs per unit are as follows:

Component	Manufacturing Cost	Purchase Cost
Frame	$40.00	$53.00
Support	$12	$16.00
Strap	$7	$9

Three departments are involved in the manufacture of these components. The time (in minutes per unit) required to make each component in each department and the available capacity (in hours) for the three departments are as follows:

Department	Production Time per unit (minutes)			Time Available
	Frame	Support	Strap	Hours
Cutting	3.6	1.75	0.9	300
Milling	2.6	1.9	0	300
Shaping	3.2	2.8	1.5	350

This problem was correctly formulated as a linear programming problem in Excel and solved using Solver. The solved model with an optimal solution and Sensitivity Report are attached. Use these printouts to answer the questions on the following pages. You may assume that Frandec will use this solution.

To receive full marks, be sure to **include your units** when answering the following questions.

QUESTIONS ARE INDEPENDENT.

Question 3

Frandec

Input Data

	Prod Time (minutes)per unit			Time		Time		Time	
	Frame	Support	Strap	Used		Available		Available	
Cutting	3.6	1.75	0.9	16961.5385	<=	18000	*minutes*	300	*hours*
Milling	2.6	1.9	0	9000	<=	9000	*minutes*	150	*hours*
shaping	3.2	2.8	1.5	18576.9231	<=	21000	*minutes*	350	*hours*

	Frame	Support	Strap
Manufac.Cost	$40.00	$12.00	$7.00
Purchasing Cost	$53.00	$16.00	$9.00

Action Plan

	Frame	Support	Strap	
Make	3,462	0	5,000	Units
Buy	1,538	15,000	0	Units
Supply	5,000	15,000	5,000	Units
	>=	>=	>=	
Demand	5,000	15,000	5,000	

Cost Issues

	Frame	Support	Strap	Total
Make	138,461.54	0.00	35,000.00	173,461.54
Buy	81,538.46	240,000.00	0.00	321,538.46
Total	220,000.00	240,000.00	35,000.00	495,000.00

Sensitivity Report

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C18	Make Frame	3,462	0	40	7.52632	1E+30
D18	Make Support	0	5	12	1E+30	5.5
E18	Make Strap	5,000	0	7	2	7
C19	Buy Frame	1,538	0	53	1E+30	7.52631579
D19	Buy Support	15,000	0	16	5.5	16
E19	Buy Strap	0	2	9	1E+30	2

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F7	Cutting Used	16961.538	0	18000	1E+30	1038.46154
F8	Milling Used	9000	-5	9000	750	9000
F9	shaping Used	18576.923	0	21000	1E+30	2423.07692
C20	Supply Frame	5,000	53	5000	1E+30	1538.46154
D20	Supply Support	15,000	16	15000	1E+30	15000
E20	Supply Strap	5,000	7	5000	1153.85	5000

(n) How many Liftmasters should be assembled next month?

Your Answer: **5,000 liftmasters**

(o) How many Frames are manufactured next month?

Your Answer: **3,462 frames**

(p) What is the total manufacturing cost for the Liftmasters?

Your Answer: **$173,461.54**

(q) How many Liftmasters can be assembled using only parts that were purchased?

Your Answer: **0 liftmasters**

(r) Which manufacturing department(s) are limiting the manufacturing volume?

Your Answer: **Milling department**

(s) Of all the Straps manufactured, how many will be attached to the frames that are manufactured?

Your Answer: **3,462 Straps**

(t) Suppose the manufacturing cost for Frames increased by $4.00. Would this change encourage Frandec to buy more Frames? ***Circle the best response*** and explain.

Yes **No** Cannot tell with information provided

Explain: Because the allowable increase cost for frame is $7.53, so $4 increase will not change the optimal solution.

(u) Read the following statement and then ***circle the correct response***.
Frandec management is not manufacturing any Supports because Frames and Straps are more profitable when internally manufactured:

True False

What does the reduced cost number mean in this context?

The reduced cost number 5 means that the manufacturing cost of frames should be reduced by more than $5 to be considered to manufacture.

(v) Is there any evidence of multiple optima in this problem? ***Circle the correct response***.

Yes **No**

(w) Suppose Frandec could get an additional 5 hours (300 minutes) of Milling Time at the regular cost. What can you say about the effect this change will have on:

iii. the Target Cell?

The target cell will be reduced by (5*300) = $1,500, as the shadow price for milling department is -$5 and allowable increase is 750 minutes.

iv. Optimal solution. Explain

Optimal solution would change because the milling constraint is binding.

(x) Suppose the cost of the extra Milling Time in the question directly $2.00 above the regular cost. What specific effect would this have on the value of the Target Cell?

The target will be reduced by ($5-$2) = $3 as the shadow price for milling department is -$5 and it is a binding constraint.

(y) If the amount of Milling time reduced by 10 hours (600 minutes), would the optimal solution change? ***Circle the correct response*** and explain.

Yes No Don't know

Explain: Yes, as Milling time is binding constraint.

(z) Suppose Frandec can obtain 1,200 extra minutes (or nothing) of Milling time for $1,000. Should they do this? Provide convincing evidence.

Yes, as the shadow price of Milling is -$5 and allowable increase is 750 minutes the minimum savings will be $5*750 -$1,000 = $2,750.

Problem 4 *(15 marks)*

Refer to the previous "Frandec" problem to answer these additional questions.

(h) What is the **best** Excel formula in cell F7?

Your Answer: **=SUMPRODUCT(C7:E7,C18:E18)**

(i)) What is the Excel formula in H7?

Your Answer: **=J7*60**

(j) In cell D22, the 15,000 was entered as a number. A better choice would have been if it had been entered as a formula. What should this formula be?

Use separate cells for # of liftmaster to be produced and in some other cells # of each part required for each lift master.

Your Answer: **# to be produced * # required**

(k) Is the cost of the motors a relevant or sunk cost in this problem?

Your Answer: **sunk cost**

(l) Management has noticed that at the optimal solution, all the available milling time has been used. Does this mean that to improve their costs they would need to acquire more time in milling department? ***Circle the correct response*** and explain.

Yes No

Explain: Yes, as milling time is a binding constraint. The shadow price of Milling is -$5 per minute and allowable increase is 750 minutes.

If we formulated this problem algebraically, one correct version for the decision variables would be:

Let,

FM = number of Frames to Make
SM = number of Supports to Make
STM = number of STraps to Make
FB = number of Frames to Buy
SB = number of Supports to Buy
STB = number of STraps to Buy

(m) Write all the algebraic Supply/Demand constraints for this problem.

FM + FB >= 5,000
SM + SB >= 15,000
STM+STB >= 5,000

(n) Frandec has just been notified that its Liftmaster customers require that **all** Frames, Supports and Straps must be Painted before they are assembled. It takes 2 minutes to paint one Frame, 1 minute to paint 1 Support and 0.8 minute to paint 1 Strap. Frandec has 500 hours available for this task.,

Set up the algebraic constraint for Painting.

2(FM+FB) + 1(3SM+3SB) + 0.8(STM+STB) <= 500*60

Would the introduction of this Painting constraint affect the optimal solution? ***Circle the correct response*** and explain.

Yes **No** Don't know

Explain:

Total # of Frames, Supports and Straps used are 5,000, 15,000 and 5,000 respectively. So We can calculate total Painting time by using the above formula:

2(FM+FB) + 1(3SM+3SB) + 0.8(STM+STB) <= 500*60
2*5,000 + 1 * 15,000 + 0.8 (5,000) <= 30,000
10,000 + 15,000 + 4,000 <= 30,000
29,000 minutes <= 30,000