

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

- 1) A furniture store produces beds and desks for college students. The production process requires assembly and painting. Each bed requires 6 hours of assembly and 4 hours of painting. Each desk requires 4 hours of assembly and 8 hours of painting. There are 40 hours of assembly time and 45 hours of painting time available each week. Each bed generates \$35 of profit and each desk generates \$45 of profit. As a result of a labour strike, the furniture store is limited to producing at most 8 beds each week. Determine how many beds and desks should be produced each week to maximize weekly profits.

Solve this problem graphically. Then set it up in Excel and solve it using Solver.

- 2) Consider the following linear programming problem.

Maximize: $8R + 8T$

Subject to: $4R + 4T \leq 104$

$6R + 2T \leq 93$

$R \geq 0, T \geq 0$

Solve this problem graphically. Then set it up in Excel and solve it using Solver.

- What are the values of the decision variables?
 - What is the value of the objective function?
 - What are the values of the slack or surplus variables?
- 3) An ice cream shop sells single scoop ice cream cones that come in three flavors: chocolate only, vanilla only, and chocolate-vanilla twist. The cones are prepackaged and sold to a supermarket daily. The ingredients used along with the minimum demand of each flavor are shown as follows:

<u>Ingredient</u>	<u>Ice Cream Flavor</u>		
	<u>Chocolate</u>	<u>Vanilla</u>	<u>Chocolate-Vanilla</u>
Chocolate	120 g	0 g	90 g
Vanilla	0 g	120	60 g
Min daily demand:	20 scoops	15 scoops	10 scoops

Each day, 20 kg of chocolate, and 19 kg of vanilla are supplied to the ice cream shop from an outside vendor. The chocolate, vanilla, and chocolate-vanilla twist each yield a profit of \$2.00, \$2.50, and \$3.00 per cone, respectively. How many chocolate, vanilla, and chocolate-vanilla twist cones must prepackage daily to maximize daily profits?

4) Consider the following linear programming problem.

$$\text{Maximize: } 70P + 40Q$$

$$\begin{aligned} \text{Subject to: } & 9P + 5Q \leq 78 \\ & 3P + 7Q \leq 66 \\ & 9P - 15Q \geq 0 \\ & P \geq 0, Q \geq 0 \end{aligned}$$

Solve this problem graphically. Then set it up in Excel and solve it using Solver.

- What are the values of the decision variables?
- What is the value of the objective function?
- What are the values of the slack or surplus variables?

5) Consider the following linear programming problem.

$$\text{Minimize: } 70M + 40N$$

$$\begin{aligned} \text{Subject to: } & 3M + 7N \geq 233 \\ & 10M + 2N \geq 254 \\ & 2N \geq 54 \\ & 4M \geq 90 \\ & M \geq 0, N \geq 0 \end{aligned}$$

Solve this problem graphically. Then set it up in Excel and solve it using Solver.

- What are the values of the decision variables?
- What is the value of the objective function?
- What are the values of the slack or surplus variables?

6) A small magazine publisher wants to determine the best combination of two possible magazines to print for the month of July. *Backyard* magazine, which he has published for years, is a steady seller. The publisher wants to make sure he prints at least 400 copies to meet his demand from the newsstands. *Porch* is a new venture, and has received the benefit of a great deal of advance publicity. The publisher is hoping that by positioning it near *Backyard*, he will pick up some spillover demand from his regular readers. Also, he is hoping that the advertising campaign will bring in a new type of reader from a potentially very lucrative market. He wants to print at least 300 copies of *Porch*. The cover price for *Backyard* is \$3.50; he is pricing *Porch* at \$4.50, because other magazines in this market seem to be able to command a higher price. The publisher has 50 hours of printing time available for this production run. He also has 30 hours in the collation department, where the magazines are actually assembled. *Backyard* requires 2.5 minutes per copy to print and 1.8 minutes per copy to collate. Because of its larger size, *Porch* will require 3 minutes to print and 2 minutes to collate. How many of each magazine should the publisher print to maximize his revenue?

An architect wishes to design the safety deposit room for a bank safe. He plans to place safety deposit boxes to occupy an area of 2 m by 12 m. The bank has asked him to plan for two sizes of box: large and small. Large boxes (which consume 0.08 m^2) will rent for \$50 per year. Small boxes (which consume 0.05 m^2) will rent for \$30 per year. The bank has asked for at least 80 large boxes and at least 120 small boxes. They hope to maximize their revenue for safety deposit boxes.

7) How many of each size should the architect's design provide?

- 8) The architect has now been informed that the bank's budget will not accommodate such a large space for safety deposit boxes, so the planned area for this use must be made smaller. The bank would like to add a mini size box, which will rent for \$20 per year, and will consume 0.03 m^2 . They will now require at least 30 mini boxes, at least 100 small boxes and at least 40 large boxes. Further, they want the total area of the large boxes to be at least 50% of the available space. How many boxes of each type should the architect include, and how many m^2 will be required?
- 9) A club is ordering pizzas to sell for a fundraiser. They will purchase the pizzas and resell them at a profit. From experience they know that they want to order no more than 12 cheese pizzas, no more than 15 sausage and pepperoni pizzas, and no more than 10 vegetarian pizzas. They also want to make sure that at least 20% of the pizzas are cheese, and at least 50% of the pizzas are sausage and pepperoni. They make a profit of \$1.45 for each cheese pizza they resell, a profit of \$1.75 for every sausage and pepperoni pizza, and \$1.98 for every vegetarian pizza they sell. How many pizzas of each type should they buy?
- 10) The Laser Computer Printer Company decides monthly what to produce during the subsequent month. They produce three types of printers, the Laser Rocket, the Alpha Laser, and the Laser Omega, which bring them profits of \$310, \$365, and \$465, respectively. The Laser Rocket requires 3 hours of assembly time, and the company always produces at least 30 units per month. The Laser Omega requires 5 hours of assembly time, and the company would like to produce at least 25 of these printers. The Alpha Laser requires only 2.5 hours of assembly time. There are 400 hours of labour available for the month. What is the combination of printers Laser should produce to maximize their profits?
- 11) XRP Industries produces high quality aluminum valves for production machinery. The production department is considering the scheduling for the next month. Each valve must go through three CNC machines to be created. After fabrication, each valve is inspected by a robot and then by a human being. The inspection department spends about 15 minutes inspecting each valve for defects. There are 525 inspection hours available for the month. The time required by each CNC machine to work on each valve is shown in the table below. Also shown are the minimum number of valves that must be produced for the month, and the unit profit for each valve.

Valve Number	CNC Production Machines			Minimum Production Level	Unit Profit
	Drill	Mill	Lathe		
X4509	0.40	0.60	1.2	200	\$16
X3125	0.30	0.65	0.6	250	\$12
X4950	0.45	0.52	0.5	600	\$13
X2173	0.35	0.48	0.7	450	\$8
Hours Available	700	890	1 200		

Determine the optimal production mix for XRP Industries to make the best use of their profit potential.

- 12) The Starvu Company is designing a new product to appeal to people who want a very high protein, low carbohydrate instant canned breakfast. The can will contain 325 mL of product. The design specifications are: the drink should have at least 15 grams of protein, no more than 3 grams of fat, no more than 310 mg of sodium, and no more than 38 grams of carbohydrate. To make this, they are mixing the base of two products they already make, Liquid A and Liquid B together with a new product, Liquid Protein. The table below describes the costs and the nutritional make up of the three liquids. Determine the least cost mixture for the new Starvu drink.

	Protein (g)	Fat (g)	Carbohydrate (g)	Sodium (mg)	Cost
Liquid Protein	230	2	24	320	\$28.00
Liquid A	6	8	147	1 770	3.25
Liquid B	9	12	96	720	4.50

A family farm is making plans for the year's planting. They are considering planting corn, tomatoes, potatoes and strawberries. They have 20 hectares to plant. Their method is to determine what it takes to plant a hectare of each crop, compute the yield in bushels, forecast the revenue for a bushel of each crop, and choose the combination of crops which will yield the most profit.

The data they have collected, along with the availability of resources, is shown in the table below.

Crop	yield/ha (bushels)	Revenue/ bushel	Planting Time Required (hours)	Tending Time Required per week	Required m of water per ha/season	Fertilizer Required per ha (kg)	Harvest Time Required (hours)
Corn	125	\$90	25	5	1.875	56.250	15
Tomatoes	95	\$210	38	20	2.250	67.500	50
Potatoes	113	\$50	30	5	1.500	50.625	23
Strawberries	140	\$195	45	30	2.250	39.375	50
Resources Available			770	550	90	900	770

- 13) Determine the best mix of crops to maximize their revenue.
- 14) A family farm has the opportunity to take on a 31.2 hectare farm just adjacent to their land. They would like to narrow their selection of crops to corn, strawberries, or a combination of the two. If they acquire the land, they will be able to increase the amounts of time available to 1800 hours for planting, 825 hours for tending, and 1400 hours for harvesting.

Between the two farms, there are 153 (10 000) m³ of water available for the season. The farmers can obtain as much as 2700 kg of fertilizer. The new farm has not been cultivated in a while, so the farmers believe that each hectare of the new farm will take an additional ten hours of labour to plant, and tending time on the new farm will be increased by five hours per hectare. Because of the condition of the new farm, they expect the yields to be down from 125 to 113 bushels per hectare for corn and from 140 to 125 bushels per hectare for strawberries.

They want to know the best combination of crops to plant at each farm, with the goal of maximizing revenue while planting at least 75% of each farm's hectareage.

- 15) A private freighter operator is selecting which cargo he will carry for his next trip. He has two choices of cargo. He may carry up to 15 tonnes of Cargo A, which takes up 18 m^3 per tonne and earns a revenue of \$80 per tonne, or he may carry up to 54 t of Cargo B, with a volume of 13.5 m^3 and a revenue of \$65 per ton. He may carry any combination of the two cargoes in the same hold without a problem.

The freighter is divided into two holds, right (starboard) and left (port). The right hold has a volume of 420 m^3 and a weight capacity of 26 t. The left hold has a volume of 462 m^3 and a weight capacity of 32 t. For steering reasons it is necessary that the weight is distributed equally between the sides of the freighter, but the freighter engines and captain's bridge, which together weigh 6 t, are actually on the right side of the freighter. This means that the left side is usually loaded with 6 t more cargo to equalize the weight.

How should this freighter be loaded to maximize the revenue?

- 16) A cargo transport plane is to be loaded to maximize the revenue from the load it carries. The plane may carry any combination and any amount of cargoes A, B, and C. The important values for these cargoes are shown in the table below:

Cargo	Tonnes Available	Revenue per Ton	Volume per Tonne
A	10	\$780	60 m^3
B	12	\$570	105 m^3
C	17	\$630	90 m^3

The plane can carry as many as 32 t of cargo. The plane is subdivided into compartments, and there are weight and volume limitations for each compartment. It is critical for safety that the weight ratios are strictly observed. The requirements for cargo distribution are shown in the following table.

Compartment	Volume Max	Compartment Weight/Total Weight Ratio
Right Fore	480 m^3	Must equal .18 of total weight
Right Centre	600 m^3	Must equal .25 of total weight
Right Aft	420 m^3	Must equal .07 of total weight
Left Fore	300 m^3	Must equal .18 of total weight
Left Centre	600 m^3	Must equal .25 of total weight
Left Aft	360 m^3	Must equal .07 of total weight

Write and solve the linear program that will determine which cargoes will be carried, and in which compartments they will be loaded.

- 17) An investor is looking for some stocks to complement his portfolio. He is considering purchasing B & O Railroad, Short Line Railroad, or Reading Railroad. He has consulted his broker, who gave him the following information:

	B & O	Short Line	Reading
The short-term growth potential, per dollar invested	0.39	0.26	0.42
Growth potential over the next three years, per dollar invested	1.59	1.70	1.45
Dividend rate potential	8%	4%	6%

The investor's criteria is as follows:

- (1) He wants his investment to be worth at least \$900 more than he invested after one year,
- (2) He wants his investment to be worth at least \$6000 more than he invested after three years, and,
- (3) He wants his dividends to be at least \$250 per year.

Determine the least amount he can invest, and how that investment should be divided between the three stocks.

- 18) Lizard Loaf, food for pet lizards, is made in 18 kg bags from potentially five ingredients. Ingredient A must constitute at least 20% of the Lizard Loaf by weight. Ingredients B and D must together constitute at least 30% of the weight. Ingredients B, C, and E together must be no more than 50% of the weight. Finally, for labelling purposes, each ingredient must be at least 5% of the total weight. The costs per kg for each ingredient are as follows: A: \$ 2.58; B: \$2.29; C: \$2.08; D: \$ 1.21, and E: \$ 1.01.

How should the Lizard Loaf be made, and what is the cost per bag?

- 19) A car pillow manufacturer has three different models, and is determining his production plan for the next month. He wishes to make at least 300 of each of the three models, and no more than 1200 of any one model. The specifics of each of the car pillows are shown below. Formulate and solve a linear program to maximize the profit the manufacturer can make.

	Sales Price	Cutting time (h)	Sewing time (h)	Finishing time (h)	Packing time (h)
Junior Travel Pillow	\$5.75	0.10	0.05	0.18	0.20
Travel Pillow	\$6.95	0.15	0.12	0.24	0.20
Deluxe Travel Pillow	\$7.50	0.20	0.18	0.20	0.20
Department time/h		\$7.00	\$9.00	\$8.50	\$7.25
Available time		450	550	600	450

20) A manufacturer of fuel cells can hire union, non-union permanent, or temporary help. He has a contract to produce at the rate of 1560 fuel cells per day. He would like to do this at the minimum cost.

Union workers can make 12 fuel cells per hour. Their wages and benefits cost the company \$14.00 and \$6.00 per hour, respectively. Union workers are assured that there will be no more than their number working in non-union permanent positions, and that there will be no more than 25% their number working in temporary positions. They work 7 hours per day.

Non-union permanent workers can also make 12 fuel cells per hour. Their wages are the same as the union employees, but their benefits are worth only \$4.00 per hour. They work 8 hours per day.

Temporary employees make only \$10.00 per hour and do not have any benefits. They work 9 hours per day, and can make 8 fuel cells in each of the hours.

How many union, non-union and temporary employees should be hired to minimize the cost to the firm? What is the average cost of a fuel cell?

Keith McIntosh has a net equity of \$500 000. He wants to invest this money to achieve sustainable income for his retirement. His financial planner is helping him with this plan and found three stocks (A, B, C) that seem to fit Keith's requirements well. Company A's expected annual return is 10%, company B's is 12%, and company C's is 14%. Keith wants to create a diversified portfolio with these 3 stocks to minimize his risk. He figures that in order to achieve that he should not invest more than 40% of his savings in any one stock and 70% in any two choices. In addition, he would like to earn a minimum of 11% annual return.

21) Formulate an LP model to solve Keith's problem.

22) Solve Keith's problem, and highlight what Keith's portfolio return would be at the optimum.

Red Deer Lighting is a private company that manufactures light fixtures, amongst other things. They're evaluating their potential for profits in this market segment and must maximize total profits for the three types of fixtures they build. (Lighting sets profitability targets for its divisions, and this division's target is \$18 000.) The manufacturing process requirements for these products are listed below:

Product \ Resource	Raw Material (m ²)	Labour (h)	Machine Time (h)
High End	1.0	8	1.7
Medium End	1.7	6	2.5
Low End	1.2	9	1.0
Total Resources	400	800	150

Given past demand patterns for these 3 fixtures Lighting wants to keep the same proportion of production at the rate of 1:1.5:1.2, respectively (high, medium, low).

23) If profit levels are \$250, \$200, and \$180, respectively, develop the LP model to solve this problem.

24) If profit levels are \$250, \$200, and \$180, respectively, solve this problem. Does Red Deer Lighting achieve its minimum profitability target?

Belanger & Zimmerman Consulting is involved in three projects requiring 180 hours of work. There are three participants leading the projects, Sylvie, Erroll, and Hans. B&Z needs to minimize costs, especially for these projects because there have been cost overruns with other endeavours and the budget for the month is tight. Sylvie earns \$60 per hour, Erroll \$55, and Hans \$50. B&Z has a policy that none of its workers shall work more than 75 hours on a project. In addition, since Sylvie is also involved with another project she cannot dedicate more than half the time of either of the other two members.

25) Formulate the LP model for this problem.

26) Using the information above, solve B&Z's problem.

Brodeur Home Appliances manufactures 8000 blenders every week. From a quality perspective they're able to produce no less than 93% defect-free units. Since they subscribe to the TQM philosophy (total quality management) they'd like to catch these defects prior to shipping the products to customers. The goal is to improve upon their record above to shipping at most 1% defective units. One way to achieve this goal is to use inspectors. Experienced professionals like these earn \$500 per week, while less experienced ones earn \$350 per week. The rate of success of experienced professionals is 75 defects caught per week, while inexperienced ones cannot do better than 60. Due to the limited number of good professionals in the market Brodeur feels it cannot count on more than 4 experienced professionals. No such limitation exists for inexperienced ones.

27) If Brodeur wants to minimize its cost with this inspection plan, how would you model an LP problem to meet these goals.

28) If Brodeur wants to minimize its cost with this inspection plan, solve Brodeur's problem.

LASER is a forgery operating from Alix, Alberta. It entered into a contract with a major customer to deliver sophisticated engine caps for tractors according to the following weekly schedule:

On week 1 deliver 50 caps, on week 2 deliver 40, on week 3 deliver 60, and on week 4 deliver 80. LASER can produce a regular batch of 60 caps per week at a cost of \$600 per part. During overtime hours they could produce an extra 20 at a 50% higher cost due to government regulations. The carrying cost of inventory for this large item is \$15 per week. Due to space limitations LASER can never stock more than 30 caps at any point in time. LASER is starting its scheduling from scratch, so there are no caps in inventory yet. Since this is a one-time deal LASER would like to end its 4-week contract with this customer with no caps in inventory.

29) Formulate an LP model to solve this minimization problem.

30) Solve LASER's problem.

Answer Key

Testname: UNTITLED1

- 1) Beds = 4.375, Desks = 3.438; Z = \$307.81
(see spreadsheet 2.1)
- 2) a. R = 10.25, T = 15.75; b. Z = 208, c. S1 = 0, S2 = 0
(see spreadsheet 2.2)
- 3) 20 chocolate cones, 61 vanilla cones, and 161 chocolate-vanilla twist cones; Z = \$778.06
(see spreadsheet 2.3)
- 4) a. P = 6.5, Q = 3.9; b. Z = 611, c. S1 = 0, S2 = 19.2, S3 = 0
(see spreadsheet 2.4)
- 5) a. M = 22.5, N = 27.0; b. Z = 2655, c. S1 = 23.5, S2 = 25, S3 = 0, S4 = 0
(see spreadsheet 2.5)
- 6) Print 540 copies of *Porch* and 400 copies of *Backyard*. Z = \$3830.
(see spreadsheet 2.6)
- 7) Provide for 225 large boxes and 120 small boxes for an annual revenue of \$14 850.
(see spreadsheet 2.7)
- 8) Provide for 73.8 large, 100.0 small and 30.0 mini sized boxes. The total area required is 11.80 m² (the architect will probably round up to 74, 100 and 30 for 11.82 m²).
(see spreadsheet 2.8)
- 9) Buy 6 Cheese, 15 Sausage and Pepperoni, and 9 Vegetarian pizzas. Profit = \$52.77.
(see spreadsheet 2.9)
- 10) 30 Laser Rockets, 74 Alpha Lasers, and 25 Laser Omegas, for a profit of \$47 935.
(see spreadsheet 2.10)
- 11) Make 332.5 X4509, 250.0 X3125, 600.0 X4950, and 450.0 X2173 for a profit of \$19 720.
(see spreadsheet 2.11)
- 12) Each can should contain 0.0559 litres of Liquid Protein, 0.0937 litres of Liquid A and 0.1754 litres of Liquid B. The cost per can is \$2.66.
(see spreadsheet 2.12)
- 13) Plant only corn (6.6 ha) and strawberries (13.4 ha) for a total revenue of \$440 529.
(see spreadsheet 2.13)
- 14) On Farm 1, plant 1.7 ha in corn and 18.3 ha in strawberries.
On Farm 2, plant 26.7 ha in corn and no strawberries.
Total revenue = \$789 250.
(see spreadsheet 2.14)
- 15) On the right side, carry 15 t of Cargo A and 11 t of Cargo B.
On the left side, carry 32 t of Cargo B.
Total Revenue = \$3995.
(see spreadsheet 2.15)
- 16)

	Right	Left		Total A	Total B	Total C
Fore	5.00 t of C	5.00 t of A		10.00 t	0.78 t	17.00 t
Centre	4.17 t of A 2.78 t of C	0.83 t of A 6.11 t of C		Revenue = \$18 953.33		
Aft	0.78 t of B 1.17 t of C	1.94 t of C				

(see spreadsheet 2.16)
- 17) Invest \$2555.25 in B & O, \$1139.50 in Short Line and nothing in Reading.
Total investment = \$3694.75
(see spreadsheet 2.17)
- 18) Lizard Loaf should contain 3.6 kg of A, 0.9 kg of B, 0.9 kg of C, 5.4 kg of D, and 7.2 kg of E, for a total cost of \$27.03 per bag.
(see spreadsheet 2.18)

Answer Key

Testname: UNTITLED1

19) Produce 1200 Junior Travel Pillows, 750 Travel Pillows, and 300 Deluxe Travel Pillows for a profit of \$3340.50.

(see spreadsheet 2.19)

20) The firm needs 7.88 (8) union workers, 7.88 (8) non-union workers, and 1.97 (2) temporary workers.

The real number of worker values yields 1560 fuel cells at a cost of \$2417.05 or \$1.55 per unit. The integer values yield 1584 fuel cells at a cost of \$2454.24, or \$1.55 per unit.

(see spreadsheet 2.20)

21) Let: A be the amount invested in company A
B be the amount invested in company B
C be the amount invested in company C

Maximize $0.10A + 0.12B + 0.14C$

Subject to

$$\begin{aligned} A + B + C &= 500\,000 \\ A &\leq 200\,000 \\ B &\leq 200\,000 \\ C &\leq 200\,000 \\ A + B &\leq 350\,000 \\ B + C &\leq 350\,000 \\ A + C &\leq 350\,000 \\ 0.10A + 0.12B + 0.14C &\geq 55\,000 \\ A, B, C &\geq 0 \end{aligned}$$

(see spreadsheet 2.21)

22) Invest \$150 000 in A, \$150 000 in B, and \$200 000 in C, for a total profit of \$61 000 per year or an annual return of 12.2%.

(see spreadsheet 2.22)

23) Let: H be number of high-end fixtures
M be number of medium-end fixtures
L be number of low-end fixtures

Maximize $250H + 200M + 180L$

Subject to

$$\begin{aligned} 1.0H + 1.7M + 1.2L &\leq 400 \\ 8H + 6M + 9L &\leq 800 \\ 1.7H + 2.5M + 1.0L &\leq 150 \\ 1.0H - 1.5M &= 0 \\ 1.0H - 1.2L &= 0 \\ H, M, L &\geq 0 \end{aligned}$$

(see spreadsheet 2.23)

24) The production mix should be 35.7 H, 23.8 M, and 29.8 L, for a total profit of \$19 048. Yes, this actually exceeds the target by \$1048.

(see spreadsheet 2.24)

Answer Key

Testname: UNTITLED1

- 25) Let: S be # h Sylvie works
 E be # h Erroll works
 H be # h Hans works

Minimize $60S + 55E + 50H$

Subject to

$$\begin{aligned} S + E + H &\geq 180 \\ S &\leq 75 \\ E &\leq 75 \\ H &\leq 75 \\ S - 0.5E &= 0 \\ S - 0.5H &= 0 \\ S, E, H &\geq 0 \end{aligned}$$

(see spreadsheet 2.25)

- 26) Sylvie should work 37.5 h, Erroll 75.0, and Hans 75.0, for a total cost of \$10 125.
 (see spreadsheet 2.26)

- 27) Let: E be # experienced inspectors
 I be # inexperienced inspectors

Minimize $500E + 350I$

Subject to

$$\begin{aligned} 75E + 60I &\geq 480 \\ E &\leq 4 \\ E, I &\geq 0 \end{aligned}$$

(see spreadsheet 2.27)

- 28) Brodeur should hire only inexperienced inspectors, 8 of them, at a total cost of \$2800.
 (see spreadsheet 2.28)

- 29) Let: ECR₁ be the quantity of caps produced during regular hours in week 1
 ECR₂ be the quantity of caps produced during regular hours in week 2
 ECR₃ be the quantity of caps produced during regular hours in week 3
 ECR₄ be the quantity of caps produced during regular hours in week 4
 ECO₁ be the quantity of caps produced in overtime hours in week 1
 ECO₂ be the quantity of caps produced in overtime hours in week 2
 ECO₃ be the quantity of caps produced in overtime hours in week 3
 ECO₄ be the quantity of caps produced in overtime hours in week 4
 EIEC₁ be the ending inventory of caps for week 1
 EIEC₂ be the ending inventory of caps for week 2
 EIEC₃ be the ending inventory of caps for week 3

Minimize $600(ECR_1 + ECR_2 + ECR_3 + ECR_4) + 900(ECO_1 + ECO_2 + ECO_3 + ECO_4) + 15(EIEC_1 + EIEC_2 + EIEC_3)$

Subject to

$$\begin{aligned} ECR_1 + ECO_1 - EIEC_1 &= 50 \end{aligned}$$

Answer Key

Testname: UNTITLED1

$$\begin{array}{rcl}
 & \text{ECR}_2 + & \text{ECO}_2 + & \\
 + \text{EIEC}_1 - \text{EIEC}_2 & & & = 40 \\
 & \text{ECR}_3 + & \text{ECO}_3 + & \\
 + \text{EIEC}_2 - \text{EIEC}_3 & & & = 60 \\
 & \text{ECR}_4 + & \text{ECO}_4 + & \\
 + \text{EIEC}_3 & & & = 80 \\
 \text{ECR}_1 & & & \leq 60 \\
 \text{ECR}_2 & & & \leq 60 \\
 \text{ECR}_3 & & & \leq 60 \\
 \text{ECR}_4 & & & \leq 60 \\
 & \text{ECO}_1 & & \leq 20 \\
 & \text{ECO}_2 & & \leq 20 \\
 & \text{ECO}_3 & & \leq 20 \\
 & \text{ECO}_4 & & \leq 20 \\
 \text{EIEC}_1 & & & \leq 30 \\
 \text{EIEC}_2 & & & \leq 30 \\
 \text{EIEC}_3 & & & \leq 30 \\
 \text{ECR}_1, \text{ECR}_2, \text{ECR}_3, \text{ECR}_4, \text{ECO}_1, \text{ECO}_2, \text{ECO}_3, \text{ECO}_4, \text{EIEC}_1, \text{EIEC}_2, \text{EIEC}_3 \geq 0
 \end{array}$$

(see spreadsheet 2.29)

30) LASER should produce 30, 50, 10, and 60 caps during regular hours for weeks 1 through 4, respectively, and 20 caps each week during overtime hours. The total cost of this plan will be \$54 000.

(see spreadsheet 2.30)