

# Optimizing an Advertising Campaign

Math 1010 Intermediate Algebra Group Project

## Background Information:

Linear Programming is a technique used for optimization of a real-world situation. Examples of optimization include maximizing the number of items that can be manufactured or minimizing the cost of production. The equation that represents the quantity to be optimized is called the objective function, since the objective of the process is to optimize the value. In this project the objective is to maximize the number of people who will be reached by an advertising campaign.

The objective is subject to limitations or constraints that are represented by inequalities. Limitations on the number of items that can be produced, the number of hours that workers are available, and the amount of land a farmer has for crops are examples of constraints that can be represented using inequalities. Broadcasting an infinite number of advertisements is not a realistic goal. In this project one of the constraints will be based on an advertising budget.

Graphing the system of inequalities based on the constraints provides a visual representation of the possible solutions to the problem. If the graph is a closed region, it can be shown that the values that optimize the objective function will occur at one of the "corners" of the region.

## The Problem:

In this project your group will solve the following situation:

A local business plans on advertising their new product by purchasing advertisements on the radio and on TV. The business plans to purchase at least 60 total ads and they want to have at least twice as many TV ads as radio ads. Radio ads cost \$20 each and TV ads cost \$80 each. The advertising budget is \$4320. It is estimated that each radio ad will be heard by 2000 listeners and each TV ad will be seen by 1500 people. How many of each type of ad should be purchased to maximize the number of people who will be reached by the advertisements?

## Modeling the Problem:

Let X be the number of radio ads that are purchased and Y be the number of TV ads.

1. Write down a linear inequality for the total number of desired ads.

$$60 \leq \begin{matrix} r & + & t \\ x & & y \end{matrix} \qquad 60 \leq x + y$$

2. Write down a linear inequality for the cost of the ads.

$$20r + 80t \leq 4320 \\ x \qquad y$$

3. Recall that the business wants at least twice as many TV ads as radio ads. Write down a linear inequality that expresses this fact.

~~2t < r~~

~~2t < r~~

less than or = to

r cannot be greater

$r \leq 2t$

4. There are two more constraints that must be met. These relate to the fact that there cannot be negative numbers of advertisements. Write the two inequalities that model these constraints:

~~r > 0~~

~~t > 0~~

$r \geq 0$

$t \geq 0$

Zero right?

has to be gr than zero  
b/c cannot be neg

5. Next, write down the function for the number of people that will be exposed to the advertisements. This is the Objective Function for the problem. **Figure this out.**

# of people in the problem idiot

$P = 2000r + 1500t$

You now have four linear inequalities and an objective function. These together describe the situation. This combined set of inequalities and objective function make up what is known mathematically as a **linear programming** problem. Write all of the inequalities and the objective function together below. This is typically written as a list of constraints, with the objective function last.

$r \geq 0$

$t \geq 0$

$60 \leq r + t$

$20r + 80t \leq 4320$

$P = 2000r + 1500t$

$r \leq 2t$

$x \leq y$

$x \leq 2y$

$x = 2y + 0$

$r \geq 0$

$t \geq 0$

$r \leq 2t$

$60 \leq r + t$

$20r + 80t \leq 4320$

$P = 2000r + 1500t$   
x y

$x \geq 0$

$y \geq 0$

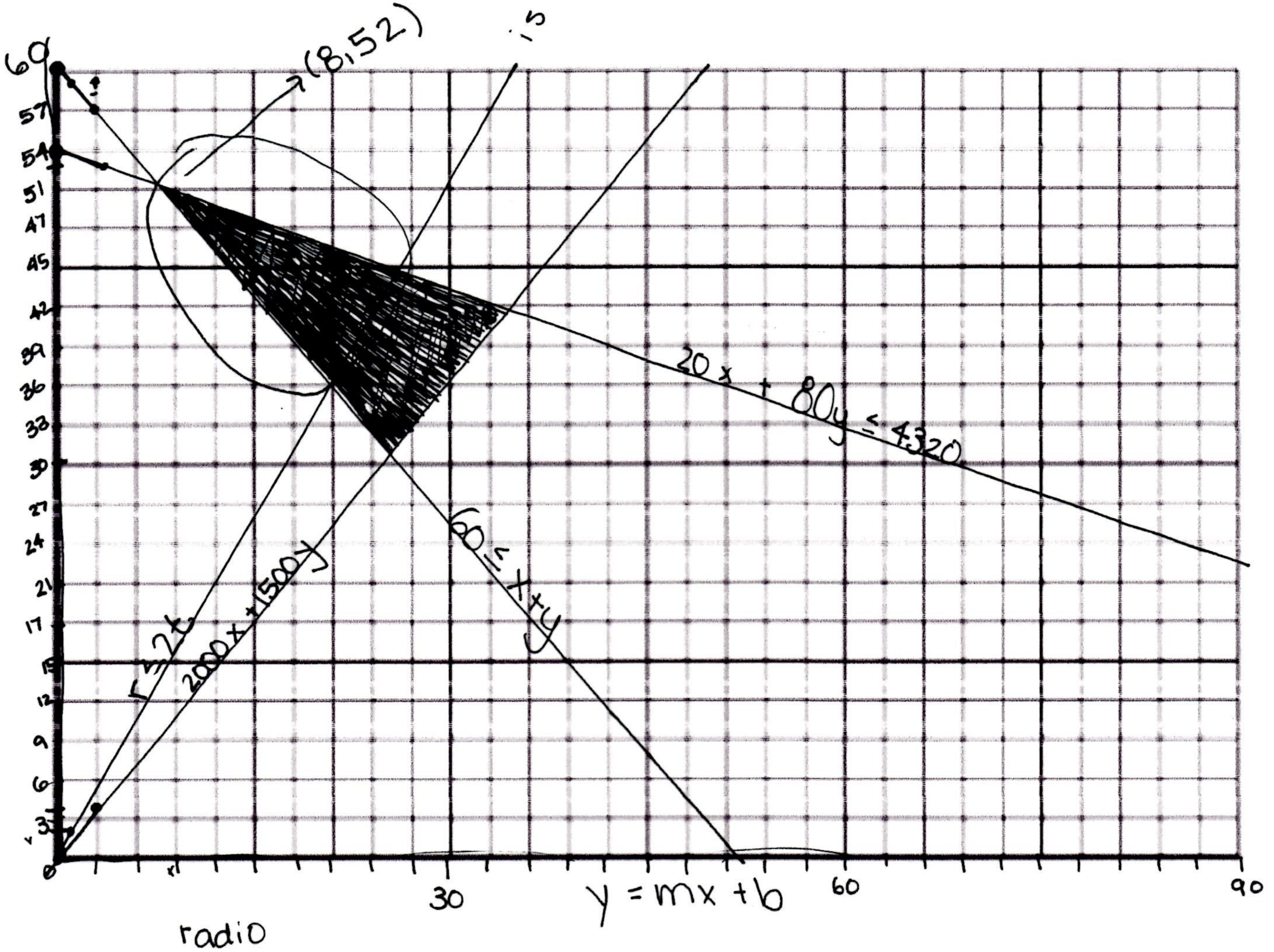
$y = mx + b$

$\frac{-1500y}{-1500} = \frac{2000x}{-1500}$

6. To solve this problem, you will need to graph the intersection of all five inequalities on one common XY plane. Do this on the grid below. Have the bottom left be the origin, with the horizontal axis representing X and the vertical axis representing Y. Label the axes with what they represent and label your lines as you graph them.

$$y = mx + b$$

is this wrong?



$$\frac{80y}{80} = \frac{-20x}{80} + \frac{4320}{80}$$

$$y = -\frac{1}{4}x + 54$$

7. The shaded region in the above graph is called the feasible region. Any  $(x, y)$  point in the region corresponds to a possible number of radio and TV ads that will meet all the requirements of the problem. However, the values that will maximize the number of people exposed to the ads will occur at one of the vertices or corners of the region. Your region should have three corners. Find the coordinates of these corners by solving the appropriate system of linear equations. Be sure to *show your work* and *label* the  $(x, y)$  coordinates of the corners in your graph.

$$20x + 80y \leq 4320$$

$$x \leq 2y$$

$$60 \leq y + x$$

$$\begin{array}{r} 60 \leq 36 + x \\ -36 \quad -36 \\ \hline \end{array}$$

$$20(2y) + 80y \leq 4320$$

$$40y + 80y \leq 4320$$

$$y \leq 36$$

$$72 \leq 2(36)$$

$$72 \leq 72 \checkmark$$

$$24 \leq x$$

See separate pages

$$20x + 80(36) \leq 4320$$

$$\begin{array}{r} 20x + 2880 \leq 4320 \\ -2880 \quad -2880 \\ \hline \end{array}$$

$$20x \leq 1440$$

$$x \leq 72$$

$$60 \leq 36 + 72$$

$$(8, 52) \quad (72, 36) \quad (40, 20)$$

$$20(72) + 80(36)$$

$$1440 + 2880$$

$$4320 \leq 4320 \checkmark$$

8. To find which number of radio and TV ads will maximize the number of people who are exposed to the business advertisements, evaluate the objective function  $P$  for each of the vertices you found. Show your work.

~~$$(8, 52)$$~~

$$(72, 36)$$

$$40, 20$$

in order

$$8, 52$$

$$60 \leq x + y$$

$$\textcircled{7} \quad 20x + 80y \leq 4320$$

$$60 \leq x + y$$

$$x + y \geq 60$$

$$20x + 80y \leq 4320$$

$$x + y \geq 60 \quad (0, 60)$$

~~$$20(0) + 80(60)$$~~

~~$$4800 \neq 4320$$~~

$$20x + 80y \leq 4320$$

$$60 \leq x + y$$

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(6)  $x \geq 0$

$y \geq 0$

$60 \leq x+y$

$-y =$

$-x \quad 60 \leq x+y$   
 $-x \quad -x$

$y \geq 60-x$

$y \geq -x+60$   
(0, +60)

$20x + 80y \leq 4320$

$\frac{80y}{80} \leq \frac{-20x}{80} + \frac{4320}{80}$

$y \leq -\frac{1}{4}x + 54$

~~$x \leq 2y$~~   $x \leq 2y$

$\frac{-2y}{-2} \leq \frac{-x}{-2}$

$y \geq 2x$

$P = 2000x + 15000y$

2000

$P = 2000r + 15000$

$y = mx + b$

$y = \frac{4}{3}x$

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⑦

$$r \leq 2t$$

$$x \leq 2y$$

$$60 \leq x+y$$

$$x - 2y \leq 0 \quad (1)$$

$$x + y \geq 60 \quad (-1)$$

~~(+2)~~  
~~(-2)~~

$$\cancel{x} - 2y \leq 0$$

$$-\cancel{x} - y \leq 60$$

$$\frac{-3y \leq 60}{-3} \quad \frac{-60}{-3}$$

$$y \geq -20$$

how can it be  
a neg. #?

$$\cancel{x \leq 2(-20)}$$

$$\cancel{x \leq -40}$$

$60 \leq -60$  WTF?

False

Something went wrong

$$\cancel{x} - 2y \leq 0$$

$$-\cancel{x} - y \leq 60$$

$$-3y \leq 60$$

$$\cancel{x} - 2y \leq 0$$

$$-\cancel{x} - y \leq -60$$

$$\frac{-3y \leq -60}{-3} \quad \frac{-60}{-3}$$

$$y \leq 20$$

$$y \geq 20$$

$$x \leq 40$$

$$20(20)$$

$$x \leq 40$$

40, 20

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$$\textcircled{7} \begin{cases} 20x + 80y \leq 4320 & | \\ x + y \leq 60 & \cdot -20 \end{cases}$$

~~$20x + 80y$~~   
cant do that

$$\begin{array}{r} \cancel{20x} + 80y \leq 4320 \\ -\cancel{20x} - 20y \leq -60(20) \quad -1200 \end{array}$$

$$\frac{60y}{60} \leq \frac{3120}{60}$$

$$y \leq 52$$

$$80(52) \leq 4320$$

$$20x + 4160 \leq 4320$$

$$20x \leq 160$$

$$x \leq 8$$

$$(8, 52)$$

⑦

$$r \leq 2t$$

$$x \leq 2y$$

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$$20x + 80y \leq 4320$$

$$x - 2y \leq 0 \quad (80)$$

$$20x + 80y \leq 4320 \quad (2)$$

$$\begin{array}{r} 80x - 160y \leq 0 \\ 40x + 160y \leq 8640 \end{array}$$

$$120x \leq 8640$$

$$x \leq 72$$

$$\frac{72}{2} \leq \frac{2y}{2}$$

$$36 \leq y$$

$$20(72) + 80(36) \leq 4320$$

$$1440 + 2880$$

$$4320 \leq 4320 \checkmark$$

⑧  $P = 2000x + 1500y$

$$2000(8) + 1500(52) = 94000$$

$$2000(72) + 1500(36) = 198,000$$

$$2000(40) + 1500(20) = 110,000$$

9. Write a sentence describing how many of each type of advertisement should be purchased and what is the maximum number of people who will be exposed to the ad.

72 ~~television~~ radio ads and 36 television ads should be purchased in order to reach a maximum of 198,000 people.

10. Reflective Writing..

- a) Following are seven learning outcomes that we focus on in our general education classes here at Salt Lake Community College. Pick at least two of these that you feel this assignment addresses and describe how the assignment helped you achieve this outcome.
- b) Did this project change the way you think about how math can be applied to the real world? What ideas changed and why? If this project did not change the way you think, write how this project gave further evidence to support your existing opinion about applying math. Be specific.

**SLCC's General Education Learning Outcomes**

**Students communicate effectively.** This includes developing critical literacies—reading, writing, speaking, listening, visual understanding—that they can apply in various contexts; Organizing and presenting ideas and information visually, orally, and in writing according to standard usage; Understanding and using the elements of effective communication in interpersonal, small group, and mass settings.

**Students develop quantitative literacies necessary for their chosen field of study.** This includes approaching practical problems by choosing and applying appropriate mathematical techniques; Using information represented as data, graphs, tables, and schematics in a variety of disciplines; Applying mathematical theory, concepts, and methods of inquiry appropriate to program-specific problems.

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This assignment really put a lot of my thinking skills to the test. It took a while for me to figure out what the equations/inequalities were in the problem and I really had a hard time applying them to the actual graph. I think the thing I struggled with the most was translating the work from a wordy math problem into an actual workable problem. Constantly switching between linear problems and words was my biggest struggle because I continuously overlooked the words in each question. Communication in here goes about remembering to view the problem for what it is while still effectively applying math skills with language skills.

Students think critically and creatively. This includes reasoning effectively from available evidence; demonstrating effective problem solving; engaging in creative thinking, expression, and application; Engaging in reflective thinking and expression; Demonstrating higher-order skills such as analysis, synthesis, and evaluation; Making connections across disciplines; Applying scientific methods to the inquiry process.

I think that this assignment challenged my problem solving skills and put them to the test. Being able to think critically about the problem while still applying knowledge of what I've learned and actually using that knowledge proved to be my biggest challenge. Translating from words to numbers so many times got to be confusing and even frustrating at times. I think this was a very challenging thing to do because I already struggle with word problems, so taking it a step further and working on something as elaborate as this, it reminded me of what I need to work on. I was able to make some easy connections when it came to figuring out what the inequalities were, but when it came to applying them to the solution, that is where my biggest problem came in. It seems like I struggle a lot with this. I am hoping to figure out some more ways that will help me not get stuck in the future on application of the problems.

Did this project change the way you think about how math can be applied to the real world? What changed and why? If this project did not change the way you think, write how this project gave further evidence to support your existing opinion about applying math. Be specific.

I do not feel that this changed my perspective of how math applies to the working world. I already believe that math is a firm root in everything, including language itself. I think that the only thing this assignment really deepened as far as my understanding is concerned, is just reinforcing that solutions to math can be many rather than just a couple. The graph formulated has multiple different points on it that could be plugged into the equation, and can be applied to many different questions. It's all in what is asked. So no, I don't feel this assignment changed my views or gave me some deep moving insight because it really didn't go that deep into anything other than just giving a few sentences and asking the viewer to solve. On the other hand, I do think that this helped me start to get a more firm grasp on linear equations and their graphs. It was interesting to see the graph form, right or wrong, it matched what I had in my head regarding it. It was very exciting to see this come to life. My only question that remains at this point is what other students interpreted and got in their graphs.