

Yesterday

When finished... Friday

HOMEWORK...

HOMEWORK: p. 225: #2
p. 235: #2, 4 & 6

p. 236: #7 - 10 (7)

NOTE: Each question requires a graph to get possible solutions!

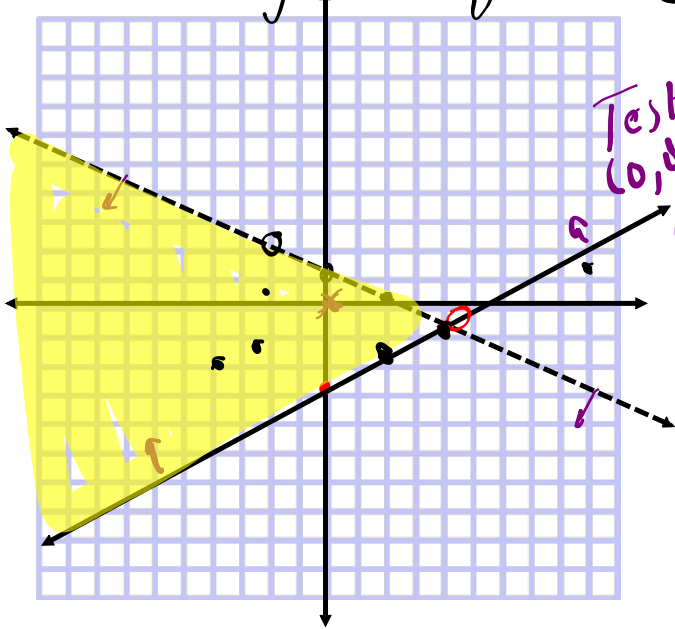
- 7. a) Graph the solution set for the following system of inequalities. Determine a solution. Check its validity.

$$9x + 18y < 18$$

$$3x - 6y \leq 18$$

- b) Is each point below a possible solution to the system? How do you know?

- | | | |
|-----------------------|----------------------------|--------------------------|
| i) (4, -1) yes | ii) (-2, 2) No | iii) (-4, -2) yes |
| iv) (9, 1) No | v) (-2.5, -1.5) yes | vi) (2, -2) yes |



$$9x + 18y = 18$$

$$18y = -9x + 18$$

$$y = \frac{-9x + 18}{18}$$

$$y = \frac{-1}{2}x + 1$$

$$3x - 6y = 18$$

$$-6y = -3x + 18$$

$$y = \frac{-3x + 18}{-6}$$

$$y = \frac{1}{2}x - 3$$

$$y = \frac{-1}{2}x + 1$$

$$y = \frac{1}{2}x - 3$$

Test (0,0) → LS < RS

$$9(0) + 18(0) < 18$$

$$0 < 18$$

yes

$$3x - 6y \leq 18$$

$$LS \leq RS$$

$$3(0) - 6(0) \leq 18$$

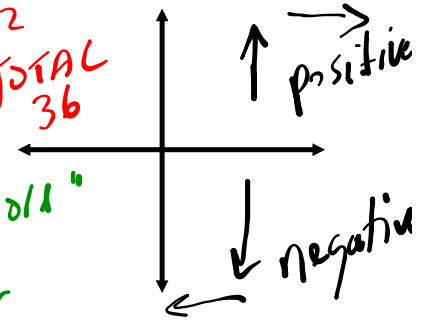
$$0 \leq 18$$

yes

10. Spence, a disc jockey, is often hired to play weddings.

- * His contract states that he will play no longer than 3 h, with no more than 12 songs each hour.
- He likes to play two or more songs for younger listeners for every one song he plays for older listeners. "young depends on old"

3x12
TOTAL
36



Determine three possible combinations of numbers of songs he could play.

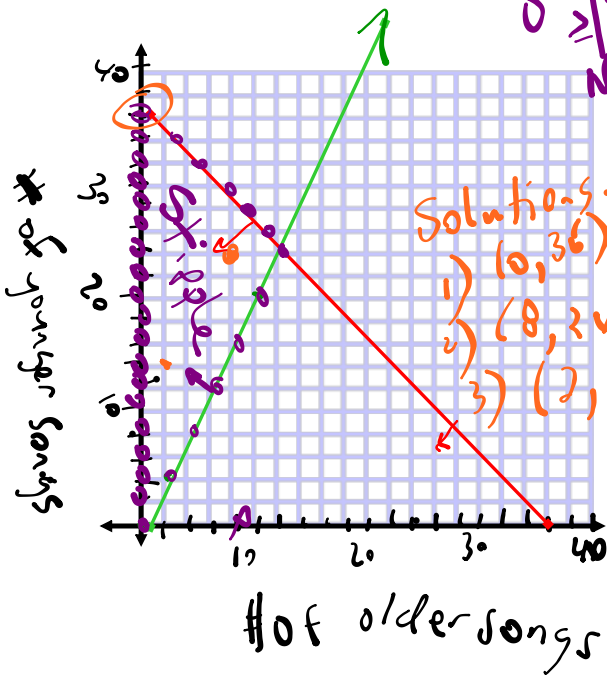
Variables → x → # of songs for older
 y → # of songs for younger

Restrictions → $x \in \mathbb{W}$
 $y \in \mathbb{W}$

Inequalities → $x + y \leq 36$
 $y \geq 2x$
 Test (10,0) $CS \geq 12S$
 $0 \geq 2(10)$
 $0 \geq 20$
 No

$y = 2x$

x	y
0	0
10	20
20	40



$x + y = 36$

x -int $\Rightarrow x + 0 = 36$
 $(36, 0)$

y -int $\Rightarrow 0 + y = 36$
 $(0, 36)$

5.4

Notes - Optimization Problems.pdf

Optimization Problems I: Creating the Model

Word Problem Inequation

optimization problem
A problem where a quantity must be maximized or minimized following a set of guidelines or conditions.

constraint
A limiting condition of the optimization problem being modelled, represented by a linear inequality.

* Equation

objective function
In an optimization problem, the equation that represents the relationship between the two variables in the system of linear inequalities and the quantity to be optimized.

Overlap

feasible region
The solution region for a system of linear inequalities that is modelling an optimization problem.

GRAPH

Need to Know

- You can create a model for an optimization problem by following these steps:
 - Step 1.** Identify the quantity that must be optimized. Look for key words, such as *maximize* or *minimize*, *largest* or *smallest*, and *greatest* or *least*.
 - Step 2.** Define the variables that affect the quantity to be optimized. Identify any restrictions on these variables.
 - Step 3.** Write a system of linear inequalities to describe all the constraints of the problem. Graph the system.
 - Step 4.** Write an objective function to represent the relationship between the variables and the quantity to be optimized.

Ex #1

Three teams are travelling to a basketball tournament in cars and minivans.

TOTAL 48

- Each team has no more than 2 coaches and 14 athletes.
- Each car can take 4 team members, and each minivan can take 6 team members.
- No more than 4 minivans and 12 cars are available.



The school wants to know the combination of cars and minivans that will require the minimum and maximum number of vehicles. Create a model to represent this situation.

Variables ⇒

$x \rightarrow$ # of minivans

$y \rightarrow$ # of cars

Restrictions

$x \leq 4$

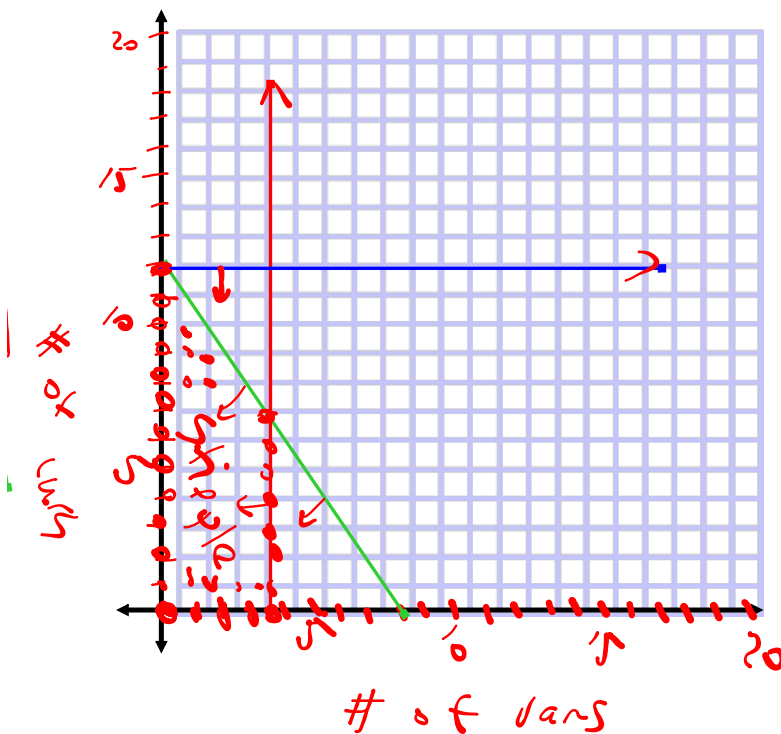
$y \leq 12$

Constraints

$6x + 4y \leq 48$

$x \leq 4$
 $y \leq 12$

$x = 4$ (vertical),
 $y = 12$ (horizontal),
Graph



$6x + 4y = 48$

x-int $\frac{6x + 4(0) = 48}{6}$
 $x = 8$
 $(8, 0)$

y-int $\frac{6(0) + 4y = 48}{4}$
 $y = 12$
 $(0, 12)$

APPLY the Math

p. 243

EXAMPLE 1

Creating a model for an optimization problem with whole-number variables

Three teams are travelling to a basketball tournament in cars and minivans.

- Each team has no more than 2 coaches and 14 athletes.
- Each car can take 4 team members, and each minivan can take 6 team members.
- No more than 4 minivans and 12 cars are available.

The school wants to know the combination of cars and minivans that will require the minimum and maximum number of vehicles. Create a model to represent this situation.



Juanita's Solution



Let m represent the number of minivans.
Let c represent the number of cars.

The two variables in the problem are the number of cars and the number of minivans. The values of these variables are whole numbers.

$m \in \mathbb{W}$ and $c \in \mathbb{W}$

Constraints:

Number of cars available:

$c \leq 12$

Number of minivans available:

$m \leq 4$

Number of team members:

$4c + 6m \leq 48$

I knew that this is an **optimization problem** because the number of vehicles has to be minimized and maximized.

optimization problem

A problem where a quantity must be maximized or minimized following a set of guidelines or conditions.

I wrote three linear inequalities to represent the three limiting conditions, or **constraints**.

constraint

A limiting condition of the optimization problem being modelled, represented by a linear inequality.

The maximum number of team members is the number of teams multiplied by the maximum number of coaches and athletes:
 $3(14) + 3(2) = 48$

Objective function:

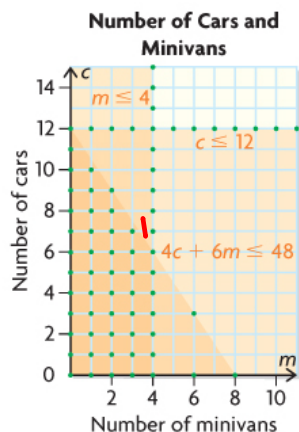
Let V represent the total number of vehicles.

$V = c + m$

I created an equation, called the **objective function**, to represent the relationship between the two variables (number of minivans and number of cars) and the quantity to be minimized and maximized (number of vehicles).

objective function

In an optimization problem, the equation that represents the relationship between the two variables in the system of linear inequalities and the quantity to be optimized.



I graphed the system of three inequalities.

One of the solutions in the **feasible region** represents the combination of cars and minivans that results in the minimum total number of vehicles and another solution represents the maximum. I think I could use the objective function to determine each point, but I am not certain how yet.

feasible region

The solution region for a system of linear inequalities that is modelling an optimization problem.

Your Turn

Suppose that the greatest number of athletes changed from 14 to 12 per team. How would Juanita's model change?



Answer

If the greatest number of athletes changed to 12, then the greatest number of passengers would be reduced to 42 (12 athletes + 2 coaches per team). All the other parts of the model would remain the same. The model would change as follows:

Restrictions: $c \in \mathbb{W}, m \in \mathbb{W}$

Constraints:

$$c \geq 0$$

$$m \geq 0$$

$$c \leq 12$$

$$m \leq 4$$

$$4c + 6m \leq 42$$

Objective function to optimize:

$$V = c + m$$

EXAMPLE 2

Creating a model for a maximization problem with positive real-number variables

Note: At least \geq

A refinery produces oil and gas.

- At least 2 L of gasoline is produced for each litre of heating oil.
 - The refinery can produce up to 9 million litres of heating oil and 6 million litres of gasoline each day.
 - Gasoline is projected to sell for \$1.10 per litre. Heating oil is projected to sell for \$1.75 per litre.
- The company needs to determine the daily combination of gas and heating oil that must be produced to maximize revenue. Create a model to represent this situation.

$y > 2x$
 $x \leq 9000000$
 $y \leq 6000000$



Umberto's Solution



Let h represent the number of litres of heating oil.
 Let g represent the number of litres of gasoline.

Restrictions:
 $h \geq 0$ and $g \geq 0$, where $h \in \mathbb{R}$ and $g \in \mathbb{R}$

Quad 1

- Constraints:
- Ratio of gasoline produced to oil produced:
 $g \geq 2h$
 - Amount of gasoline that can be produced:
 $g \leq 6\,000\,000$
 - Amount of oil that can be produced:
 $h \leq 9\,000\,000$

Let R represent total revenue from sales of gasoline and heating oil.

Objective function to maximize:
 $R = 1.10g + 1.75h$

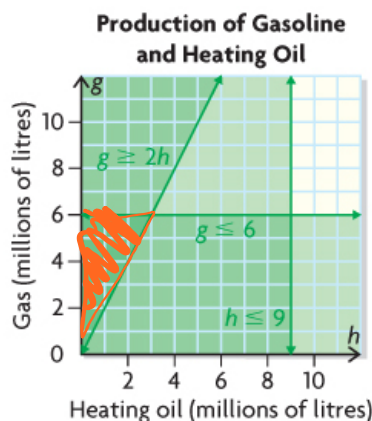
I knew that this is an optimization problem because the total revenue has to be maximized.
 The two variables in the problem are the volume of heating oil and the volume of gasoline, both in litres. Litres are measured using positive real numbers.

I created inequalities to represent the five constraints of the problem.
 I treated the restrictions on each variable as a constraint.

I wrote an objective function to represent the relationship between the two variables (volume of heating oil and volume of gasoline) and the quantity to be maximized (total revenue).

I graphed the system of inequalities in the 1st quadrant because of the restrictions on the variables. The feasible region is a right triangle and includes all points on its boundaries.

I think I can use the objective function to determine which point in the feasible region represents the combination of oil and gas that will result in the maximum revenue, but I am not sure how yet.



In Summary

Key Ideas

- To solve an optimization problem, you need to determine which combination of values of two variables results in a maximum or minimum value of a related quantity.
- When creating a model, the first step is to represent the situation algebraically. An algebraic model includes these parts:
 - a defining statement of the variables used in your model
 - a statement describing the restrictions on the variables
 - a system of linear inequalities that describes the constraints
 - an objective function that shows how the variables are related to the quantity to be optimized
- The second step is to represent the system of linear inequalities graphically.
- In optimization problems, any restrictions on the variables are considered constraints. For example, if you are working with positive real numbers, $x \geq 0$ and $y \geq 0$ are constraints and should be included in the system of linear inequalities.

Need to Know

- You can create a model for an optimization problem by following these steps:
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 - Step 2.** Define the variables that affect the quantity to be optimized. Identify any restrictions on these variables.
 - Step 3.** Write a system of linear inequalities to describe all the constraints of the problem. Graph the system.
 - Step 4.** Write an objective function to represent the relationship between the variables and the quantity to be optimized.

HOMEWORK...

Page 248: #1, #2, #3, #5



NOTE:

Create a model means graph the solution region

Attachments

Notes - Optimization Problems.pdf

6Ws4e1.mp4