TI-nspire™

Linear Programming
by – Christine Czapleski

Activity overview
This activity adds a twist to a traditional linear programming problem by using the features of the TI-Nspire calculator.

Concepts
Converting verbal problems into equations and inequalities.
Graphing inequalities
Finding points of intersection of linear equations
Finding the overlapping regions for linear inequalities
Distinguishing between the graphs of functions and relations

Teacher preparation
This would probably not be the first linear programming problem attempted by the students. It would be a great summary exercise.

Classroom management tips
Students should work with a partner or a group so that they can discuss the problem as they go along.

TI-Nspire Applications
Graphing Inequalities
Finding Intersection points
Moving the graph of an equation
Using a spread sheet

Step-by-step directions
Teacher Pages
The manufacture of sleeping bags makes a standard model and a sub-zero model. Each standard sleeping bag requires 1 labor-hour from the cutting department and 3 labor-hours from the assembly department. Each sub-zero sleeping bag requires 2 labor hours from the cutting department and 4 labor-hours from the assembly department. The maximum labor-hours available per week in the cutting department and the assembly department are 32 and 84, respectively. In addition, the distributor, because of demand, will not take more than 12 sub-zero sleeping bags per week. If the company makes a profit of $50 on each standard sleeping bag and $80 on each sub-zero sleeping bag, how many sleeping bags of each type should be manufactured each week to maximize the total weekly profit?

Linear Programming with the TI-Nspire

by: Chris Czapleski
Grade level: 9-12
Subject: Algebra II
Time required: 90 minutes
Materials: TI-Nspire

Organize the manufacturing requirements, objectives and restrictions in the table below.

	Labor-hours per sleeping bag Standard Model	Labor-hours per sleeping bag Sub-Zero Model	Maximum Labor-Hours Available per week
Cutting Department	1	2	32
Assembly Department	3	4	84
Profit per sleeping bag	$50	$80	

The objective of management is to decide how many of each model of sleeping bag should be produced to maximize the profit.

Choose variable to represent each of the **decision** quantities.

x = _____the number of standard models___

y = _____the number of sub-zero models___

Write an equation to represent the total profit assuming all sleeping bags manufactured are sold.

Profit: $P = 50x + 80y$_____ (This is the **Objective function**)

Mathematically, the management needs to decide the values for the **decision variables** (x, y) that achieve its objective, that is maximizing the **objective function**.

Any manufacturing company has manufacturing limits imposed by available resources, plant capacity, demand, and so froth. These limits are referred to as **constraints**.

Use the contents of the above table to write two inequalities which represents the manufacturing constraints.

X+2y ≤ 32   Cutting department

$3x + 4y ≤ 84$ Assembly department

Use the information in the problem to write an inequality which represents the demand constraint.

y≤ 12

It is not possible to manufacture a negative number of sleeping bags; thus there are two inequalities which represent the **nonnegative constraints**.

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X ≥ 0

y ≥ 0

Use your TI *n*spire to graph the constraints. The overlapping region is called the **feasible region.**

Begin with a new TI-Nspire document, and create a Graphs and Geometry page.
Move the curser to the entry line and press ENTER to activate it. Clear to remove the = sign and replace it with <= followed by your expression.

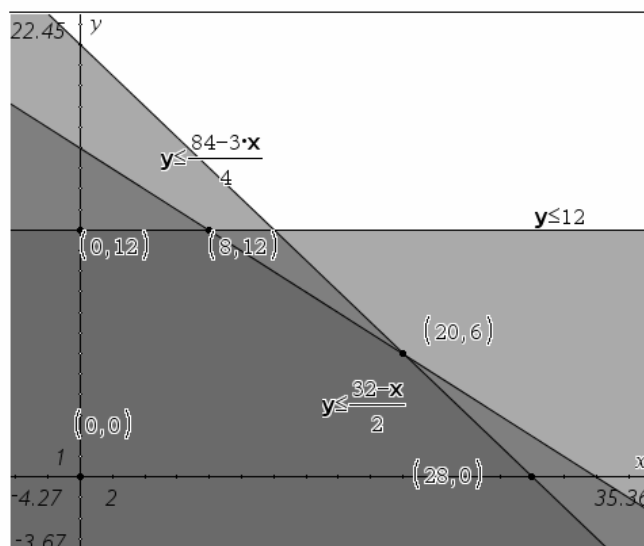The *f*1(x) changes to *y* when an inequality is graphed, what is the significance of this change?

_____*The region is a relation and not a function; therefore functional notation cannot be used.___*

Continue to enter the next two constraints and then adjust the window to show the first quadrant to accommodate the nonnegative constraints. The window is found MENU-4:WINDOW-1:WINDOW SETTINGS.

Find the corner points of the feasibility region using

Two of the intersection points can be found using: MENU-6:POINTS&LINES-3:INTERSECTION POINTS.

The other three points can be found using: MENU-6:POINTS&LINES-2: POINT ON.

Linear Programming with the TI-Nspire

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Time required: 90 minutes
Materials: TI-Nspire

To estimate which point will provide the maximum profit do the following:

Move the curser to the entry line and enter the object function without the y-intercept.
Move the curser back to the graph screen and move the line vertically until it intersects the feasibility region in just one point.
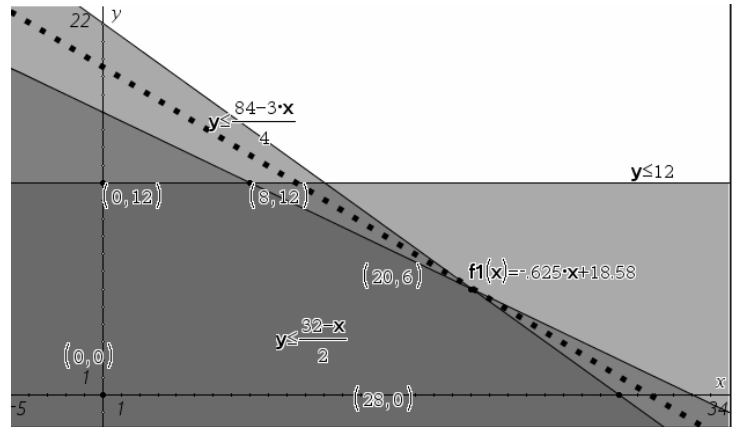
$$P = 50x + 80y$$

$$P - 50x = 80y$$

$$\frac{P}{80} - \frac{50}{80}x = y$$

Graph: $f_1(x) = -0.625X$

(Select MENU-1.Tools-3.Atributes. Move the curser to the line and press ENTER.
This will allow you to change the appearance of the line.)

It is necessary to use the decimal form of the fraction in order to be able to move the line.

What is your estimate of the point that will maximize the profit? ____(20,6)_____

Calculate the maximum profit at this point. _____$1480_____

To check your estimate, add a new page: MENU-3:Lists and Spreadsheets.

Enter the coordinates of the five corner points into the A and B columns of the spreadsheet.

In the white box next to the A, enter the word "standard". In the white box next to the B, enter the word "subzero".

In column C, go to the gray formula box and enter the object function in the following manner.
= 50 *VAR-3LINK TO-standard + 80*VAR-3LINK TO-subzero.

Now look at the generated values and verify that the ordered pair that produces the maximum profit is the same ordered pair as you observed on the graph.

Linear Programming with the TI-Nspire

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Grade level: 9-12
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Time required: 90 minutes
Materials: TI-Nspire

	A standard	B subzero	C	D
◆			=50*'standard+80	
1	0	0	0	
2	0	12	960	
3	8	12	1360	
4	20	6	1480	
5	28	0	1400	
6				
7				
8				
9				
10				

Answer the following.

How many standard sleeping bags should the company produce to maximize the profit?
They should make 20 standard sleeping bags.

How many sub-zero sleeping bags should the company produce to maximize the profit?
They should make 6 subzero sleeping bags.

What is the maximum profit for the company?
The maximum profit for the company is $1480.

Assessment and evaluation

Answers are provided in the teacher document. Teachers can determine success of the activity if students successfully complete the exercise

Activity extensions

To determine if the students understand both the mathematics and the calculator procedure repeat the activity with any linear programming problem from an Algebra II text.

Linear Programming
by: Christine Czapleski
Grade level: secondary
Subject: mathematics
Time required: 45 to 90 minutes
Materials: TI- *n*spire

Student TI-Nspire Document

The manufacture of sleeping bags makes a standard model and a sub-zero model. Each standard sleeping bag requires 1 labor-hour from the cutting department and 3 labor-hours from the assembly department. Each sub-zero sleeping bag requires 2 labor hours from the cutting department and 4 labor-hours from the assembly department. The maximum labor-hours available per week in the cutting department and the assembly department are 32 and 84, respectively. In addition, the distributor, because of demand, will not take more than 12 sub-zero sleeping bags per week. If the company makes a profit of $50 on each standard sleeping bag and $80 on each sub-zero sleeping bag, how many sleeping bags of each type should be manufactured each week to maximize the total weekly profit?

Organize the manufacturing requirements, objectives and restrictions in the table below.

	Labor-hours per sleeping bag Standard Model	Labor-hours per sleeping bag Sub-Zero Model	Maximum Labor-Hours Available per week
Cutting Department			
Assembly Department			
Profit per sleeping bag			

The objective of management is to decide how many of each model of sleeping bag should be produced to maximize the profit.

Choose variable to represent each of the decision quantities.

x = **_____**

y = _____

Write an equation to represent the total profit assuming all sleeping bags manufactured are sold.

Profit: *P* = _____ (This is the Objective function)

Mathematically, the management needs to decide on values for the **decision variables** (x, y) that achieve its objective, that is maximizing the **objective functions**.

Any manufacturing company has manufacturing limits imposed by available resources, plant capacity, demand, and so froth. These limits are referred to as **constraints**.

Linear Programming
by: Christine Czapleski
Grade level: secondary
Subject: mathematics
Time required: 45 to 90 minutes
Materials: TI- *n*spire

Use the contents of the above table to write two inequalities which represents the manufacturing constraints.

_____

_____

Use the information in the problem to write an inequality which represents the demand constraint.

_____

It is not possible to manufacture a negative number of sleeping bags; thus there are two inequalities which represent the **nonnegative constraints**.

_____

_____

Use your TI *n*spire to graph the constraints. The overlapping region is called the **feasible region.**

Begin with a new TI-Nspire document, and create a Graphs and Geometry page.
Move the curser to the entry line and press ENTER to activate it. Clear to remove the = sign and replace it with <= followed by your expression.

The $f1(x)$ changes to y when an inequality is graphed, what is the significance of this change?

_____

Continue to enter the next two constraints and then adjust the window to show the first quadrant to accommodate the nonnegative constraints. The window is found MENU-4:WINDOW-1:WINDOW SETTINGS.

Find the corner points of the feasibility region using

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The other three points can be found using: MENU-6:POINTS&LINES-2: POINT ON.

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Grade level: secondary
Subject: mathematics
Time required: 45 to 90 minutes
Materials: TI- *n*spire

Move the curser to the entry line and enter the object function without the y-intercept. (The slope must be in decimal form.)

Move the curser back to the graph screen, grab and move the line vertically until it intersects the feasibility region in just one point.

What is your estimate of the point that will maximize the profit? _____

Calculate the maximum profit at this point. _____

To check your estimate, add a new page: MENU-3:Lists and Spreadsheets.

Enter the coordinates of the five corner points into the A and B columns of the spreadsheet.

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Now look at the generated values and verify that the ordered pair that produces the maximum profit is the same ordered pair as you observed on the graph.

Answer the following.

How many standard sleeping bags should the company produce to maximize the profit?

How many sub-zero sleeping bags should the company produce to maximize the profit?

What is the maximum profit for the company?