

Custom Question Builder Tutorial

Advanced Topics



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ABOUT THE ADVANCED TUTORIAL LESSONS

In the advanced tutorial lessons, you will explore additional methods for creating custom questions, including how to use symbol codes, templates, and functions, and how to insert graphs, images, number lines, pie charts, and bar charts into your questions.

You should already know how to copy and edit a custom question, create static and algorithmic questions, and insert short answer, multiple-choice, true-false, or essay answer options into your question. Please refer to the lessons in the *Custom Question Builder – Introduction* tutorial if you need to learn or review these techniques.

In each lesson in the advanced tutorial, you will create two or more custom questions. Each question will illustrate the use of the tools or techniques for that lesson. The directions and explanations in the lesson will focus on the new information covered in that lesson. If you need more detailed directions on the basic techniques, please refer to the lessons in the *Custom Question Builder – Introduction* tutorial.

Here are the steps you will follow when creating each custom question in this tutorial.

- Design the question
- Create a new question
- Enter the algorithms
- Enter the question
- Test the question
- Save the question

Please note that you:

- Cannot change the layout of a problem once you started.
- Can change the answer rules.
- Should be cautious with double versus single quote marks in your notation.
- Must write one algorithmic value per line.

LESSON 1 – MODIFY THE DISPLAY OF MATHEMATICAL EXPRESSIONS

Learn about the IFTHEN function

The IFTHEN function is one of the built-in functions in the Custom Question Builder. Refer to Appendix A for a full list of the available functions. In Lesson 4, you will learn how to use more of these functions in a question.

Here is the syntax for the IFTHEN function: IFTHEN(X, Y, Z)

X is the Boolean statement

If X is true, then Y is the output

If X is false, then Z is the output

For example, the function IFTHEN($\sim B=1$, "red", "blue") will result in the output "red" when the algorithmic value $\sim B$ is equal to 1. When $\sim B$ is not equal to 1, the output will be "blue". Note that since Y and Z are text values, you must enter these values using quotes. *Notice these are double quotes.*

The IFTHEN function is used whenever you need to make a choice between two possible output values. You will need to create a new algorithmic value and enter the IFTHEN function in the constraint value box, as shown in the example below. Since the output of the IFTHEN function is a text value, you have to select Text or Symbol as the type.

Edit Algorithmic Values

Constraints | **Options**

Algorithmic Value Name:

Select Type of Algorithmic Value

Select the type of algorithmic value you wish to create

☐ Integer ☒ Text or Symbol

☐ Decimal ☐ Algebraic or Numeric Expression

List Values or Set Up Constraints

To define a constraint, select a relational operator and enter a constraint value, using multiple rows for multiple values. Use the context menu to insert functions, symbols, or other algorithmic values.

Relational Operator	Constraint Value (One Constraint per row. Use quotes around text.)
=	IFTHEN($\sim B=1$, "red", "blue")
<select>	

You would then enter $\sim Bcolor$ in the question at the location where you want to make the choice between the two output values. You will learn how to do this in the examples in this lesson.

IFTHEN functions can be nested, and you will learn how to do this in Example 1B.

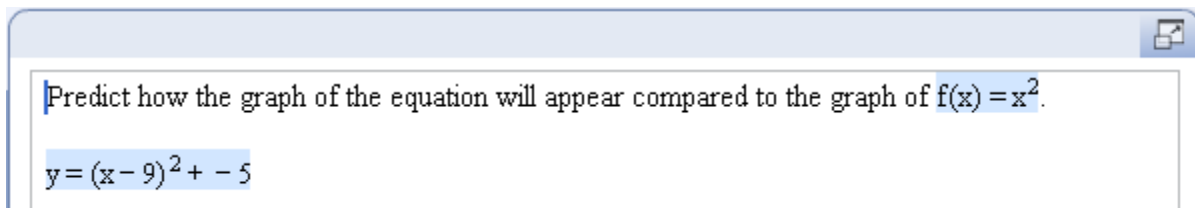
Note: Remember to save your work frequently!

Example 1A – Display negative terms correctly

In Example 9A of the Custom Question Builder – Introduction tutorial, you created an essay answer, algorithmic, conceptual question that asked students to describe the transformation of a graph. In that question, you restricted the horizontal and vertical shifts to positive integers. This is how you wrote the equation:

$$y = (x - \sim\text{horiz})^2 + \sim\text{vert}$$

If you allowed negative integers for the vertical shift, $\sim\text{vert}$, the equation could then look like this:



You would like the equation to be displayed so that there is no plus sign in front of the vertical shift when the vertical shift is negative. To accomplish this, you will need to use the built-in IFTHEN function.

1. Design the question.

You will model part (c) of the question shown on the right. You will define algorithmic values for the horizontal shift and the vertical shift, as follows:

1. Predict how the graph of each equation will appear compared to the graph of $f(x) = x^2$.

(a) $y = (x + 4)^2$ (b) $y = x^2 - 3$

(c) $y = (x - 5)^2 + 3$

Name	Definition	Constraints
$\sim\text{vert}$	vertical shift	integer between (and including) -9 and 9, not equal to 0 and not equal to the horizontal shift or the opposite of the horizontal shift
$\sim\text{horiz}$	horizontal shift	integer between (and including) -9 and 9, not equal to 0

Note: For pedagogical reasons, you do not want either the vertical shift or the horizontal shift to equal 0. You also do not want the shifts to equal each other or the opposite of each other as this may not completely test students' understanding of transformations.

Next, you will define the algorithmic value, $\sim\text{vsign}$, to replace the + sign in front of $\sim\text{vert}$ in the equation. You will use the IFTHEN function to display the + sign when $\sim\text{vert}$ is positive and hide the + sign when $\sim\text{vert}$ is negative. In addition, since the graph will be shifted up when $\sim\text{vert}$ is positive and shifted down when $\sim\text{vert}$ is negative, you need to define an algorithmic value to display the word "up" or "down" depending on the sign of $\sim\text{vert}$. Lastly, you need an algorithmic value to represent the amount of vertical shift. You will use the built-in function ABS to calculate the amount of vertical shift. Here are the three new algorithmic values needed to display the vertical shift correctly:

Name	Definition	Constraints
$\sim\text{vsign}$	sign of the vertical shift	text value, displays the + sign only when the vertical shift is positive IFTHEN($\sim\text{vert} > 0$, "+", "")
$\sim\text{vshift}$	direction of vertical shift	text value, will be either "up" or "down" depending on the sign of the vertical shift IFTHEN($\sim\text{vert} > 0$, "up", "down")

~vamt	amount of vertical shift	integer, equal to the absolute value of the vertical shift
-------	--------------------------	------------------------------------------------------------

You have to create a similar set of algorithmic values for the horizontal shift. However, since you use $(x - \sim\text{horiz})$ in the equation, you have to display the negative sign when $\sim\text{horiz}$ is positive and display the positive sign when $\sim\text{horiz}$ is negative. You also have to use the absolute value of $\sim\text{horiz}$ in the equation instead of $\sim\text{horiz}$ so that the signs will display correctly. Here are the algorithmic values you need to display the horizontal shift correctly:






Name	Definition	Constraints
~hsign	sign of the horizontal shift	text value, displays the – sign when the horizontal shift is positive and the + sign when the horizontal shift is negative $\text{IFTHEN}(\sim\text{horiz}>0, "-", "+")$
~hshift	direction of horizontal shift	text value, will be either "right" or "left" depending on the sign of the horizontal shift $\text{IFTHEN}(\sim\text{horiz}>0, "right", "left")$
~hamt	amount of horizontal shift	integer, equal to the absolute value of the horizontal shift

2. Create a new question.

If you completed Example 9A in the Custom Question Builder – Introduction tutorial, you can copy that question to create the question for this example. Otherwise, start with a new template and choose the Full Screen layout.

3. Enter the algorithms.

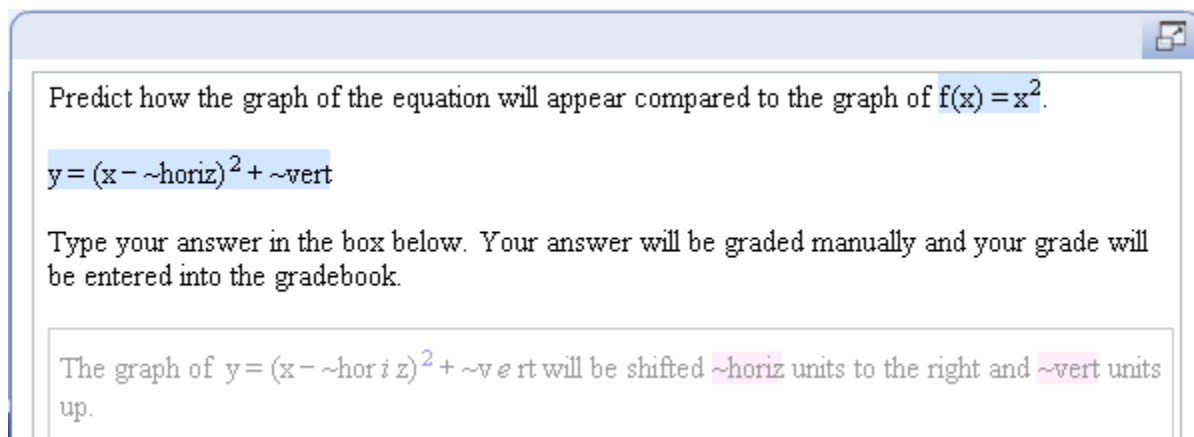
Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
 Edit  Add  Duplicate  Delete  Regenerate algorithmic values							
	Name	Type	Form	Constraints	Link ID	Value	Authoring Notes
Edit	hamt	Integer	-	=ABS(~horiz)		3	amount of horizontal shift
Edit	horiz	Integer	-	>=-9, <=9, <>0		3	horizontal shift
Edit	hshift	Text	-	=IFTHEN(~horiz>0,"right","le..		right	direction of horizontal shift
Edit	hsign	Text	-	=IFTHEN(~horiz>0,"-", "+")		-	sign of horizontal shift term
Edit	vamt	Integer	-	=ABS(~vert)		6	amount of vertical shift
Edit	vert	Integer	-	>=-9, <=9, <>[~horiz,0]		-6	vertical shift
Edit	vshift	Text	-	=IFTHEN(~vert>0,"up","dow..		down	direction of vertical shift
Edit	vsign	Text	-	=IFTHEN(~vert>0,"+", "-")			sign of vertical shift term

Note: Adjust the width of each column in the Algorithmic Values List, if desired, to display each cell on one line.

4. Enter the question.

Here is how the question was entered in Example 9A of the Custom Question Builder – Introduction tutorial.



Predict how the graph of the equation will appear compared to the graph of $f(x) = x^2$.

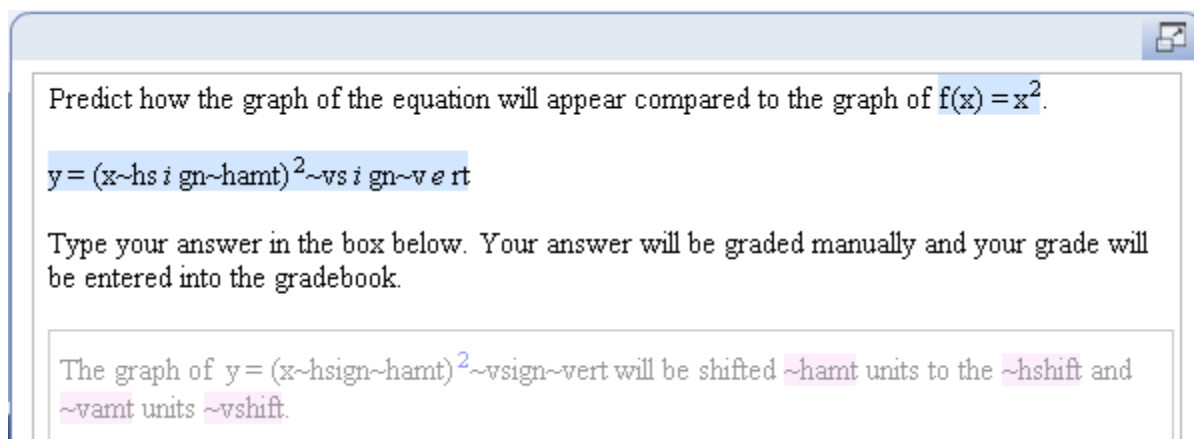
$y = (x - \sim\text{horiz})^2 + \sim\text{vert}$

Type your answer in the box below. Your answer will be graded manually and your grade will be entered into the gradebook.

The graph of $y = (x - \sim\text{horiz})^2 + \sim\text{vert}$ will be shifted $\sim\text{horiz}$ units to the right and $\sim\text{vert}$ units up.

To display the equation correctly when $\sim\text{horiz}$ is negative, you must replace the minus sign in the parentheses of the equation by $\sim\text{hsign}$ and $\sim\text{horiz}$ by $\sim\text{hamt}$. You also have to replace the positive sign in front of the vertical shift by $\sim\text{vsign}$. Similar replacements are needed in the sample essay answer to implement the algorithms that will modify the display of the expressions.

Use the Equation Editor and Essay Answer option to enter the question. When done, your question should look like this:



Predict how the graph of the equation will appear compared to the graph of $f(x) = x^2$.


$y = (x \sim\text{hsign} \sim\text{hamt})^2 \sim\text{vsign} \sim\text{vert}$

Type your answer in the box below. Your answer will be graded manually and your grade will be entered into the gradebook.

The graph of $y = (x \sim\text{hsign} \sim\text{hamt})^2 \sim\text{vsign} \sim\text{vert}$ will be shifted $\sim\text{hamt}$ units to the $\sim\text{hshift}$ and $\sim\text{vamt}$ units $\sim\text{vshift}$.

5. Test the question.


Here's how the preview looks with the sample essay answer displayed. When testing your question, be sure to check that the wording in the sample answer is mathematically correct for the equation displayed.



Predict how the graph of the equation will appear compared to the graph of $f(x) = x^2$.


$y = (x + 3)^2 - 8$

Type your answer in the box below. Your answer will be graded manually and your grade will be entered into the gradebook.

Essay Sample Answer

The graph of $y = (x + 3)^2 - 8$ will be shifted 3 units to the left and 8 units down.

Done

Enter your answer in the form of an essay.

Show Sample AnswerCheck AnswerClose

6. Save the question.

Example 1B – Display coefficients of 1 or -1 correctly

Now that you know how to use the IFTHEN function to display signs correctly, you will learn how to nest the IFTHEN functions whenever you have more than one Boolean statement to test. Example 1B illustrates this technique.

Solve the equation and check your solutions.

$$y^2 + 13y + 40 = 0$$

The solution is **-5, -8**
(Type your answers as integers separated by a comma.)

In Example 8B of the Custom Question Builder – Introduction tutorial, the two solutions to the equation were constrained to be negative integers only. If you removed this constraint and allowed the solutions to be positive or negative integers, the equation could then have coefficients of 1 or -1, as shown in the example below.

Solve the equation and check your solutions.

$$y^2 + -1y + -12 = 0$$

The solution is **-3, 4**
(Type your answers as integers separated by a comma.)

You would like the equation to be displayed without the coefficient of 1 or -1. In addition, you want negative constants to be displayed without the + sign in front of the term.

1. Design the question.

The question that you will use as the model is shown on the right. You will define algorithmic values for the coefficient of y and the constant term in the equation, and the two solutions to the equation, as follows:

Solve each equation, and check your solutions.

15. $y^2 + 3y + 2 = 0$

Name	Definition	Constraints
~ans1	one solution to the quadratic equation	integer between (and including) -9 and 9, not equal to 0
~ans2	the other solution to the quadratic equation	integer between (and including) -9 and 9, but not equal to 0, ~ans1, or --ans1
~coeff	coefficient of y in the quadratic equation	equal to the opposite of the sum of the two solutions
~const	constant term in the quadratic equation	equal to the product of the two solutions.

Note: You constrain the two solutions to be distinct and not opposites of each other so that the polynomial in the equation will be a trinomial that is not a perfect square trinomial.

Since both answers are allowed to be positive or negative, both the coefficient of y and the constant term could be positive or negative. You will use the IFTHEN function to display the sign of the coefficient and the constant term correctly, like you did in Example 1A for the vertical shift. In addition, you need to define an algorithmic value to display the y -term correctly when the coefficient is 1 or -1. Since there are two values to test, you will use two nested IFTHEN functions.

Name	Definition	Constraints
~constsign	sign of the constant term	text value, displays the + sign only when the constant term is positive IFTHEN(~const>0,"+", "")
~coeffsign	sign of the coefficient	text value, displays the + sign only when the coefficient is positive IFTHEN(~coeff>0,"+", "")
~coeffdisp	display of the coefficient	text value, hides the coefficient of 1 and displays only the minus sign for the coefficient of -1 IFTHEN(~coeff=1,"", IFTHEN(~coeff=-1,"- ", "~coeff"))

Note: You have to enclose ~coeff in quotes in the IFTHEN function for ~coeffdisp. This is because the IFTHEN function has to be defined as a text algorithmic type so as to display the minus sign correctly, and text values must be enclosed in quotes even if the output is a numerical algorithmic value.

2. Create a new question.

If you completed Example 8B of the Custom Question Builder – Introduction tutorial, you can copy that question to create the question for this example. Otherwise, start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
	Name	Type	Forma	Constraints	Link ID	Value	Authoring Notes
Edit	ans1	Integer	-	>=-9, <=9, <>0		-5	one solution to the equation
Edit	ans2	Integer	-	>=-9, <=9, <>[~ans1,0,~ans1]		-4	other solution to the equation
Edit	coeff	Integer	-	=[~ans1+~ans2]		9	coefficient of y in the equation
Edit	coeffdisp	Text	-	=IFTHEN(~coeff=1,"",IFTHEN(~...		9	displays the coefficient of y correctly when equal to 1 or -1
Edit	coeffsign	Text	-	=IFTHEN(~coeff>0,"+", "")		+	sign of the coefficient of y
Edit	const	Integer	-	=~ans1**ans2		20	constant term in the equation
Edit	constsign	Text	-	=IFTHEN(~const>0,"+", "")		+	sign of the constant term

4. Enter the question.

Here's how the question was entered in Example 8B of the Custom Question Builder – Introduction tutorial.

Solve the equation and check your solutions.

$$y^2 + \sim\text{coeffy} + \sim\text{const} = 0$$

The solution is $\sim\text{ans1}, \sim\text{ans2}$

To modify the display of the equation, you will need to replace the two plus signs by $\sim\text{coeffsign}$ and $\sim\text{constsign}$ respectively. In addition, you will replace $\sim\text{coeff}$ by $\sim\text{coeffdisp}$ so that coefficients of 1 or -1 are displayed correctly. Here's how the completed question should look.

Solve the equation and check your solutions.

$$y^2 \sim\text{coeffsign} \sim\text{coeffdisp} \sim\text{constsign} \sim\text{const} = 0$$

The solution is $\sim\text{ans1}, \sim\text{ans2}$

When entering the short answer, don't forget to check the "All solutions listed above are required for the correct answer." box in Step 2 of the Edit Answer Definition window.


5. Test the question.

Here's how the preview looks with the correct answer entered.

Solve the equation and check your solutions.

$$y^2 - 3y - 10 = 0$$

The solution is $5, -2$
(Type your answers as integers separated by a comma.)

 **Good job!**

6. Save the question.

LESSON 2 – USE THE CUSTOM QUESTION BUILDER SYMBOL CODES

Learn about the CQB symbol codes

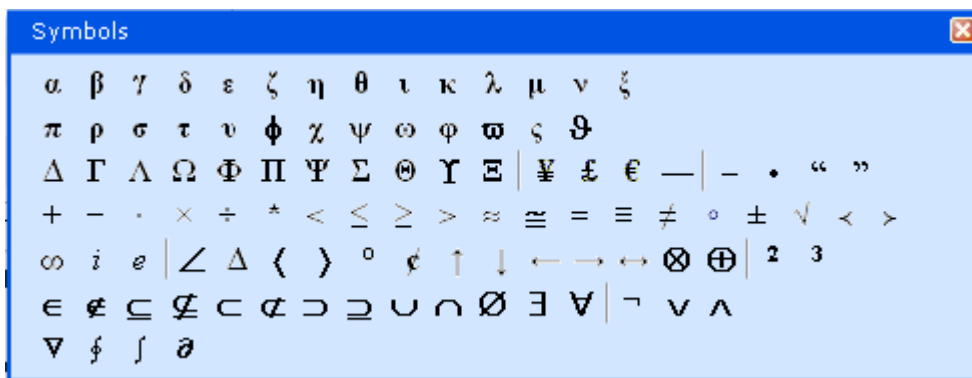
In the Custom Question Builder – Introduction tutorial, you learned how to enter a symbol into the question area using the Insert Symbol menu. You also learned how to enter a mathematical expression using the Equation Editor. Both techniques allow you to select the symbol you want from a palette, and this approach works when you want to enter a symbol directly in the question or answer area of the question. When you want to enter the symbol in the constraints for an algorithmic value or in a short answer definition, you can enter some symbols by using the right-click menu. For symbols not on the menu, you will need to enter the code for the symbol. Refer to Appendix B for a list of available symbol codes.

The algorithmic value type you select determines how the symbol will be displayed, as detailed in the table below.

Integer and Decimal types	<p>If you use the multiplication and division operators, these operations will be performed.</p> <p>For example, $12 \div 3$ will display as 4.</p> <p>If you use any other symbols, your algorithmic value displays as !ERROR.</p>
Text or symbol type	<p>If you use the multiplication and division operators, these operations will not be performed.</p> <p>For example, "$12 \div 3$" displays as $12 \div 3$ and has no mathematical significance.</p>
Algebraic or Numeric Expression type	<p>If you use the multiplication and division operators, these operations will not be performed.</p> <p>For example, "$12 \div 3$" displays as $12 \div 3$, but in this case, the expression has mathematical significance.</p>

To enter a symbol when defining an algorithmic value or short answer, use the right-click menu to select the symbol from a palette, shown on the right.

Alternatively, if the symbol you want is not in the palette, you can type in the symbol code.



Note: Be careful when using these symbol codes in a short answer definition, as students can only enter the symbols that are available in the symbol palette. If you want to enter a symbol in a short answer definition, be sure to preview your answer to check whether the symbol can be entered by students.

The examples in this lesson will illustrate the use of symbol codes when defining algorithmic values and short answers.

Example 2A – Find the period of a trigonometric function

This example shows you how to enter a symbol in a short answer box.

1. Design the question.

You want students to find the period of a sine function defined as $y = \sin(\sim Bx)$. You will define $\sim B$ to be 2, 3, 4, or 5. The period would then be π , $2\pi/3$, $\pi/2$, or $2\pi/5$ respectively. For this example, you will create an algorithmic value for each of these answers and then use nested IFTHEN functions to choose the correct answer to correspond to the value of $\sim B$. Here is the list of algorithmic values you need to define.

Name	Definition	Constraints
$\sim B$	coefficient of x in the function	can be 2, 3, 4, or 5
$\sim \text{ans2}$	period for $\sim B=2$	algebraic expression equal to π
$\sim \text{ans3}$	period for $\sim B=3$	algebraic expression equal to $2\pi/3$
$\sim \text{ans4}$	period for $\sim B=4$	algebraic expression equal to $\pi/2$
$\sim \text{ans5}$	period for $\sim B=5$	algebraic expression equal to $2\pi/5$
$\sim \text{ans}$	period of the function	will equal one of the 4 answers, depending on the coefficient of x






You will use the symbol code $\&\pi$; to enter the pi symbol for each of the 4 answers. For the final answer, $\sim \text{ans}$, you will use 3 nested IFTHEN functions to choose the correct period for each possible value of $\sim B$.

2. Create a new question.

Start with a new template; you might want to consider the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
					Regenerate algorithmic values		
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	ANS	Text	-	=IFTHEN($\sim B=2$, " $\sim \text{ANS2}$ ", I...		$\&\pi/2$	period of the function
Edit	ANS2	Symbolic	-	= $\&\pi$;		$\&\pi$;	answer when B=2
Edit	ANS3	Symbolic	-	= $2\&\pi/3$		$2\&\pi/3$	answer when B=3
Edit	ANS4	Symbolic	-	= $\&\pi/2$		$\&\pi/2$	answer when B=4
Edit	ANS5	Symbolic	-	= $2\&\pi/5$		$2\&\pi/5$	answer when B=5
Edit	B	Integer	-	$>=2, <=5$		4	coefficient of x in function

Note: The output of the IFTHEN function is an algebraic expression, but you have to select Text or Symbol type otherwise the player will display the IFTHEN function instead of the output. Don't forget to use quotes when entering each of the 4 possible answers into the IFTHEN function for $\sim \text{ans}$.

4. Enter the question.

Here's how your question should look with algorithmic values shown.



Find the period of the function.

$y = \sin(\sim Bx)$

The period is $\sim \text{ANS}$

Use the Equation Editor to enter the function; notice that the editor automatically puts the sin function in bold. This is called "Math style", which automatically converts math functions to special notation.

When entering the short answer, use the answer rule "Accept similar answer or algebraic function." This will display the period as a built-up fraction, as shown below.



Find the period of the function.

$y = \sin(4x)$

The period is $\frac{\pi}{2}$

If you chose the "Answer is text or contains a symbol" rule, the period will be displayed as a horizontal fraction:



Find the period of the function.

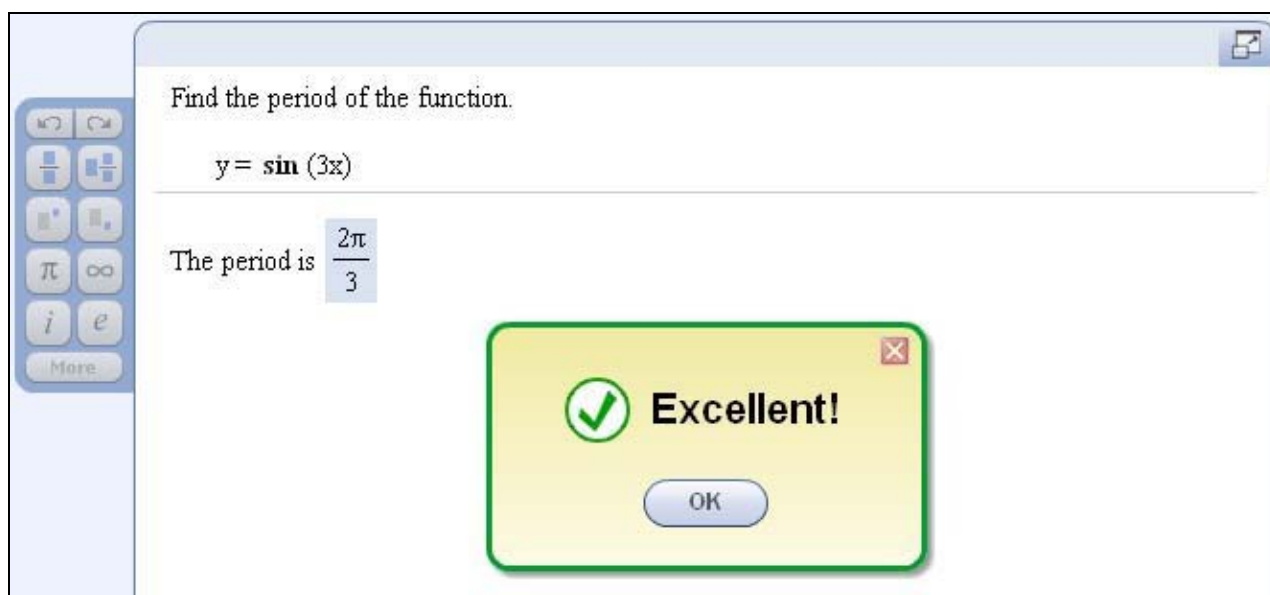
$y = \sin(4x)$

The period is $\pi/2$

Since students will need to type the pi symbol in their answer, customize the symbol palette so that the pi button is active. You should also leave the fraction button active as well as other buttons that can serve as distracters.

5. Test the question.

Here's how the preview looks with the correct answer entered. When testing your question, enter a non-simplified fraction to see what feedback is given by the program.



6. Save the question.

Example 2B – Write an answer using interval notation

In this example, students are asked to solve an inequality and enter their solution using interval notation. If the solution is an open interval with finite endpoints, you could use the "ordered pair" answer rule and enter the interval in the same way you would enter an ordered pair. However, if the solution is a closed or half-open interval or if at least one of the endpoints was infinity, then you have to use the "text" answer rule. In the case of infinite endpoints, you will need to enter the symbol code for infinity, &inf;. You will also learn how to enter a short answer as an inequality.

1. Design the question.

You will use the inequality: $x + \sim a \leq 3x + \sim b$. The solution is to be written in two ways, as an inequality, and in interval notation. Solving the inequality, you see that $x \geq (\sim a - \sim b)/2$. For this lesson, you want the left endpoint of the interval to be an integer, defined as $\sim c$. Since $\sim c = (\sim a - \sim b)/2$, you solve this formula for $\sim a$ to get $\sim a = \sim b + 2 \cdot \sim c$. Therefore, if you define $\sim b$ and $\sim c$ to both be integers, you will get $\sim a$ to be an integer as well.

Lastly, since both $\sim a$ and $\sim b$ can be negative integers, you need to use the IFTHEN function to ensure that the sign of each term is displayed correctly.

Here are the algorithmic values you need to define.

Name	Definition	Constraints
$\sim b$	constant term on right side of inequality	integer between (and including) -9 and 9, not equal to 0
$\sim c$	left endpoint of solution	integer between (and including) -9 and 9, but not equal to 0
$\sim a$	constant term on left side of inequality	integer equal to $\sim b + 2 \cdot \sim c$
$\sim \text{assign}$	sign of the constant term on the left	text value, displays the + sign only when the $\sim a$ is positive IFTHEN($\sim a > 0$, "+", "")
$\sim \text{bsign}$	sign of the constant term on the right	text value, displays the + sign only when the $\sim b$ is positive IFTHEN($\sim b > 0$, "+", "")

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	a	Integer	-	=~b+2*~c		-5	constant term on left of inequality
Edit	asign	Text	-	=IFTHEN(~a>0,"+", "")			sign of ~a
Edit	b	Integer	-	>=9, <=9, <>0		7	constant term on right of inequality
Edit	bsign	Text	-	=IFTHEN(~b>0,"+", "")		+	sign of ~b
Edit	c	Integer	-	>=9, <=9, <>0		-6	left endpoint of solution

4. Enter the question.

Here's how your question should look with algorithmic values shown.

Solve the inequality. Write your answer a) as an inequality and b) in interval notation.

$$x - \text{asign} \sim a \leq 3x - \text{bsign} \sim b$$

In the answer area, enter the answer prompts as shown below.

a) The solution written as an inequality is

b) The solution in interval notation is

For answer a), enter a short answer box and select the "Answer is text or contains a symbol." answer rule. In Step 2 of the Edit Answer Definition window, enter the value "[~c,&inf;)". Be sure to enclose the interval in quotes. In Step 3, make sure the "Ignore Spaces" and "Ignore Case" boxes are checked. This will ensure that the program will accept answers that are entered with varying amount of space and that both upper and lower case entries are accepted.

In the same way, enter the short answer for answer b). Use the value "x ≥ ~c" for the answer value, $x \geq \sim c$. If you want the program to accept the answer $\sim c \leq x$, you will need to enter it as an alternate solution in Step 2 of the Edit Answer Definition window.

Here's how the answer area should look with algorithmic values shown.

a) The solution written as an inequality is $x \geq \sim c$

b) The solution in interval notation is $[\sim c, \infty)$

Lastly, customize the symbol palette so that the inequality and infinity symbols are active.

5. Test the question.

Here's how the preview looks with the correct answer entered.

Solve the inequality. Write your answer a) as an inequality and b) in interval notation.

$x + 9 \leq 3x + 5$

a) The solution written as an inequality is $x \geq 2$

b) The solution in interval notation is $[2, \infty)$

Excellent!

OK

6. Save the question.

LESSON 3 – USE THE CUSTOM QUESTION BUILDER TEMPLATE CODES

Learn about the CQB template codes

In Lesson 2, you learned how to enter symbol codes in the constraints for an algorithmic value and in a short answer. In this lesson, you will learn how to enter template codes when defining an algorithmic value or short answer.

If you are entering a mathematical expression directly in the question area or answer area of the question, you can use the templates in the Equation Editor to enter the expression. However, when you need to format a mathematical expression (such as a fraction) in the definition of an algorithmic value, you will need to use the template codes. Similarly, when you are entering a short answer defined as a text value, you have to use template codes to ensure that the answer is displayed using correct mathematical notation. Refer to Appendix C for a list of available template codes.

The examples in this lesson will illustrate the use of template codes when defining algorithmic values and short answers.

Example 3A – Solve an inequality with a fractional endpoint

In this example, students will need to enter the solution in interval notation where one of the endpoints is a fraction.

1. Design the question.

The question asks students to solve an inequality written in the form $\sim Ax + \sim B > \sim C$. You will use the IFTHEN function to correctly display the B term in the inequality. The solution will be the interval $(\sim \text{num}/\sim \text{den}, \infty)$, where $\sim \text{num} = \sim C - \sim B$, and $\sim \text{den} = \sim A$. To avoid having to simplify the fraction, you will constrain $\sim \text{num}$ and $\sim \text{den}$ to be relatively prime to each other.

Name	Definition	Constraints
$\sim A$	coefficient of x	integer between (and including) 2 and 9
$\sim B$	constant term on left	integer between (and including) -10 and 10, not equal to 0
$\sim B_{\text{sign}}$	sign of $\sim B$	IFTHEN($\sim B > 0$, "+", "")
$\sim C$	constant term on right	integer between (and including) -10 and 10, not equal to 0 or $\sim B$
$\sim \text{num}$	numerator of solution	equal to $\sim C - \sim B$
$\sim \text{den}$	denominator of solution	equal to $\sim A$, relatively prime to $\sim \text{num}$

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms

Enter the algorithms as defined in the design step above. When entering $\sim \text{den}$, use the Prime Number Constraint section to force $\sim \text{den}$ to be relatively prime to $\sim \text{num}$, as shown below.

Prime Number Constraint

☐ Final value must be a prime number

Must be relatively prime to:

When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit Add Duplicate Delete Regenerate algorithmic values							
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	A	Integer	-	$\geq 2, \leq 9$		3	coefficient of x
Edit	B	Integer	-	$\geq -10, \leq 10, < 0$		6	constant term on left
Edit	Bsign	Text	-	$= \text{IFTHEN}(\sim B > 0, "+", "-")$		+	sign of $\sim B$
Edit	C	Integer	-	$\geq -10, \leq 10, < [0, \sim B]$		4	constant term on right
Edit	den	Integer	-	$= \sim A, \text{RPrime}[\sim \text{num}]$		3	denominator of left endpoint
Edit	num	Integer	-	$= \sim C \cdot \sim B$		-2	numerator of left endpoint

4. Enter the question.

Here's how your problem statement and answer prompt should look with algorithmic values shown.

Solve the inequality. Write your answer in interval notation.

$\sim A x \sim B \text{sign} \sim B > \sim C$

The solution in interval notation is

Enter a short answer box at the end of the answer prompt. In the Edit Answer Definition window, select the answer rule "Answer is text or contains a symbol." In Example 2B, you entered the interval as " $[\sim c, \infty)$ " to denote the solution $x \geq \sim c$. For this example, the left endpoint is a fraction, and you have to use the @DIV template to display the fraction. Here is the value you will enter in Step 2 of the Edit Answer Definition window: " $(\text{@DIV}\{\sim \text{num}; \sim \text{den}\}, \infty)$ ".

Here's how your question should look when you are done.

Solve the inequality. Write your answer in interval notation.

$\sim A x \sim B \text{sign} \sim B > \sim C$

The solution in interval notation is $\left(\frac{\sim \text{num}}{\sim \text{den}}, \infty \right)$

Note: The program automatically expands the size of the parentheses to accommodate the fraction. If the interval is half-open, with a bracket on the left endpoint instead of a parenthesis, the program will not expand the size of the bracket to accommodate the fraction.

5. Test the question.

When testing the question, if the numerator is negative, notice that the negative sign is displayed in the numerator of the fraction in the interval. If you enter the negative sign in front of the fraction, the program will not recognize the solution. You can fix this by entering an alternate answer with the negative sign in front of the fraction. First, you need to define a new algorithmic value to calculate the absolute value of the numerator:




$$\sim\text{numabs} = \text{ABS}(\sim\text{num})$$

When the numerator is negative, you want the program to accept either " $(-\text{@DIV}\{\sim\text{numabs}; \sim\text{den}\}, \&\text{inf};)$ " or " $(\text{@DIV}\{-\sim\text{numabs}; \sim\text{den}\}, \&\text{inf};)$ ". When the numerator is positive, the answer you entered in step 4 above will work: " $(\text{@DIV}\{\sim\text{num}; \sim\text{den}\}, \&\text{inf};)$ ". Since you need to make a choice about the form of the interval displayed, you have to define two algorithmic values for each form.

$$\sim\text{ans1} = \text{IFTHEN}(\sim\text{num} > 0, "(\text{@DIV}\{\sim\text{num}; \sim\text{den}\}, \&\text{inf};)", "(-\text{@DIV}\{\sim\text{numabs}; \sim\text{den}\}, \&\text{inf};)")$$

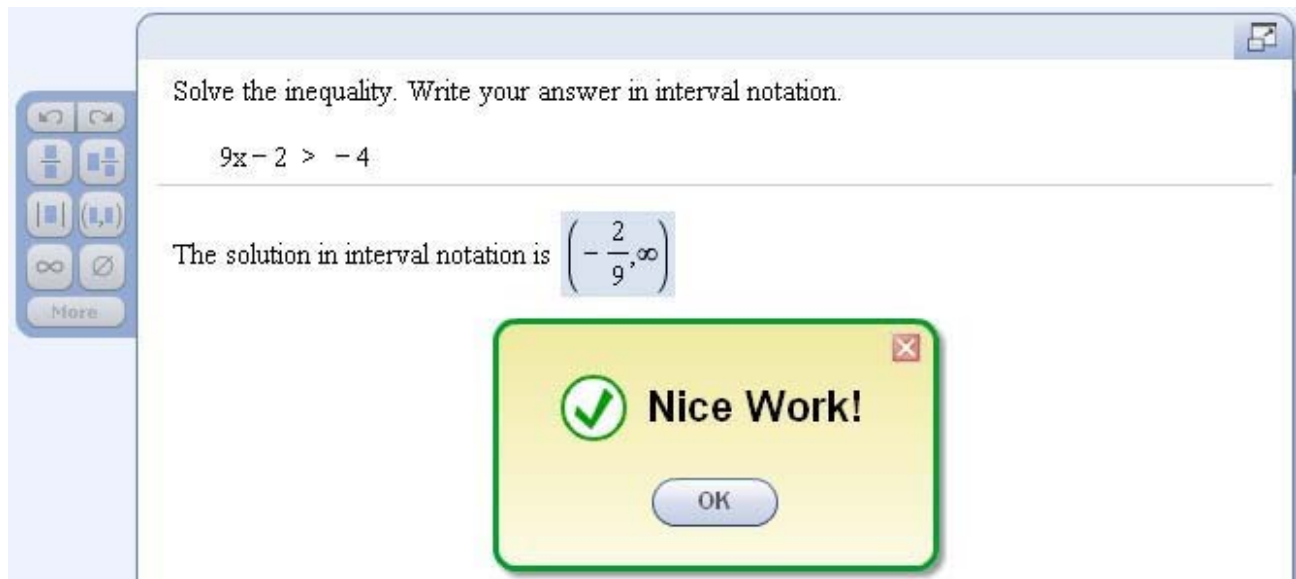
$$\sim\text{ans2} = \text{IFTHEN}(\sim\text{num} > 0, "(\text{@DIV}\{\sim\text{num}; \sim\text{den}\}, \&\text{inf};)", "(\text{@DIV}\{-\sim\text{numabs}; \sim\text{den}\}, \&\text{inf};)")$$

You would then enter $\sim\text{ans1}$ and $\sim\text{ans2}$ in step 2 when defining the answer.

	Value	
	$\sim\text{ans1}$	
	$\sim\text{ans2}$	

Note: When you enter two possible answers in the Edit Answer Definition window, only the first answer is displayed to students. Therefore, if you want students to see the answer with the negative sign in front of the fraction, you need to enter that answer on the first line.


Here's how the preview looks like with the correct answer entered; notice that the symbol palette is customized to show the infinity symbol.



Solve the inequality. Write your answer in interval notation.

$$9x - 2 > -4$$

The solution in interval notation is $\left(-\frac{2}{9}, \infty\right)$

 **Nice Work!**

OK

6. Save the question.

Example 3B – Multiply radical expressions

This example will illustrate the use of the template for displaying radical expressions.

1. Design the question.

The question asks students to multiply two radical expressions, $\sqrt{\sim A}$ and $\sqrt{\sim B}$, where the radicands can be any positive integer from 2 to 20, but not equal to a perfect square. For this lesson, students will not be required to simplify the resulting radical. In Lesson 4, you will simplify a radical expression by using the GCS and GCSR functions.






Name	Definition	Constraints
$\sim A$	radicand of first radical	integer between (and including) 2 and 20, not equal to a perfect square
$\sim B$	radicand of second radical	integer between (and including) 2 and 20, not equal to a perfect square, and not equal to $\sim A$
$\sim C$	product of two radicands	equal to $\sim A * \sim B$

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
				 Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	A	Integer	-	$\geq 2, \leq 20, \neq [4, 9, 16]$		8	first radicand
Edit	B	Integer	-	$\geq 2, \leq 20, \neq [4, 9, 16, \sim A]$		11	second radicand
Edit	C	Integer	-	$= \sim A * \sim B$		88	product of two radicands

4. Enter the question.

Here's how your problem statement and answer prompt should look with algorithmic values shown.

Multiply the radical expressions.

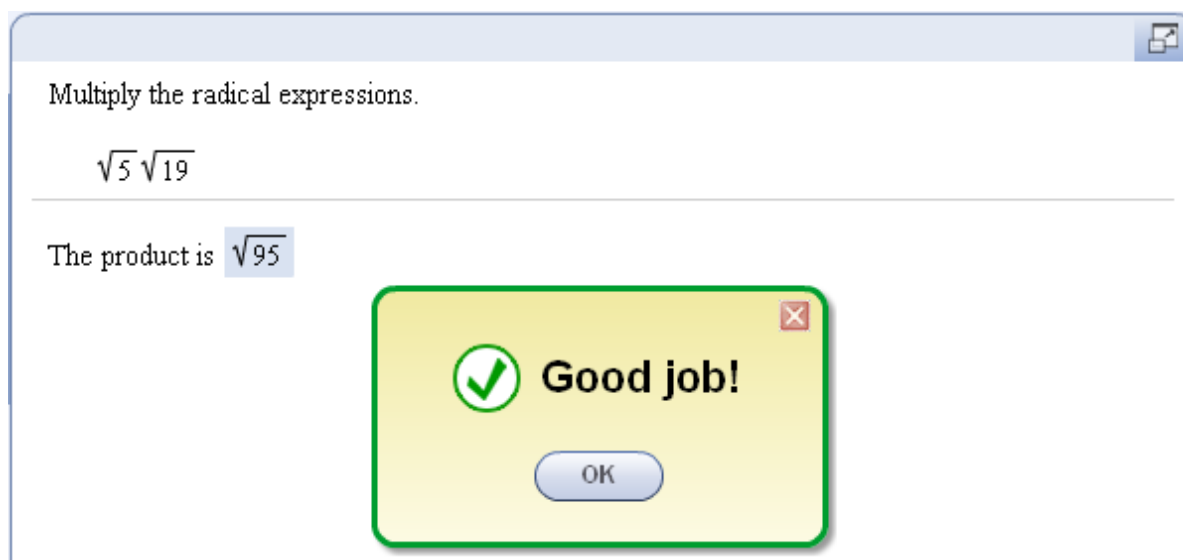
$$\sqrt{\sim A} \sqrt{\sim B}$$

The product is

Enter a short answer box at the end of the answer prompt. In the Edit Answer Definition window, select the answer rule "Accept similar answer or algebraic function." Define the answer as $\text{@RT}\{\sim C\}$. Notice that you do not need quotes around this answer since the answer rule is not defined as text.

5. Test the question.

Here's how the preview looks with the correct answer entered.



Note: In Lesson 4, you will revise this question to simplify the final radical.

6. Save the question.

Example 3C – Simplify a complex fraction

The third example in this lesson will illustrate the use of the superscript template in conjunction with the fraction template, so that you can see how to nest templates in an expression.

1. Design the question.

The question asks students to simplify the complex fraction that has $\sim a/x$ in the numerator and $x/\sim b$ in the denominator. The result will be $\sim c/x^2$, and you will need to use the @DIV template to format the built-up fraction and the @SUP template to format the superscript in the denominator.

Name	Definition	Constraints
$\sim A$	numerator of first fraction	integer between (and including) 1 and 9
$\sim B$	denominator of second fraction	integer between (and including) 2 and 9
$\sim C$	numerator of answer	equal to $\sim A * \sim B$

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
					Regenerate algorithmic values		
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	A	Integer	-	>=1, <=9		2	numerator of first fraction
Edit	B	Integer	-	>=2, <=9		3	denominator of second fraction
Edit	C	Integer	-	=~A*~B		6	numerator of answer

4. Enter the question.

Here's how your problem statement and answer prompt should look with algorithmic values shown.



Simplify the complex fraction.

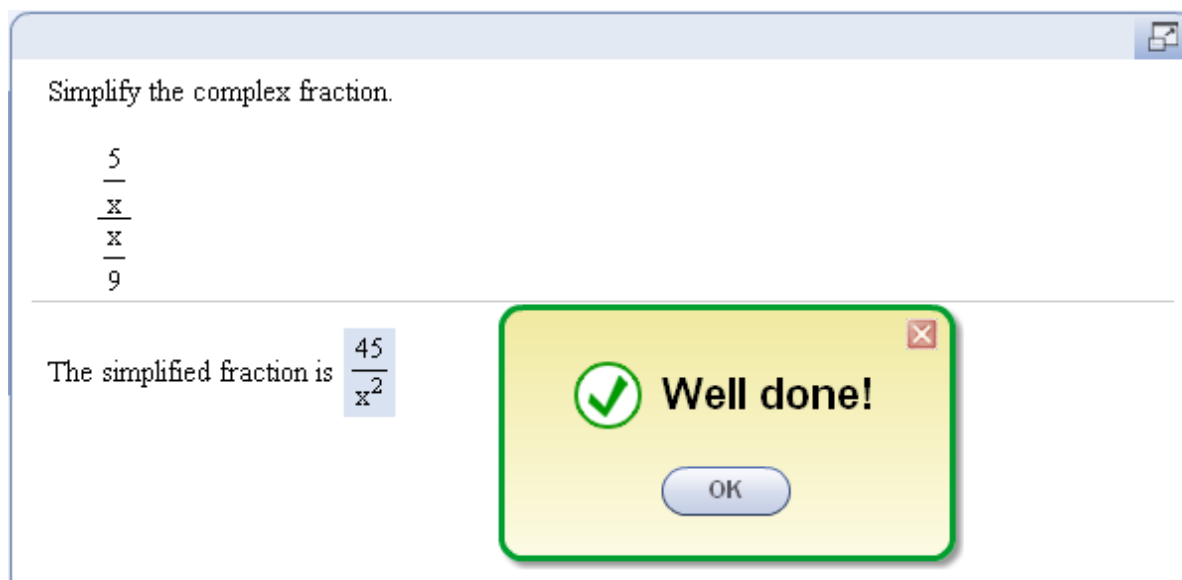
$$\frac{\frac{\sim a}{x}}{\frac{x}{\sim b}}$$

The simplified fraction is

Enter a short answer box at the end of the answer prompt. In the Edit Answer Definition window, select the answer rule "Accept similar answer or algebraic function." Define the answer as @DIV{ ~c; x@SUP{2} }. As with the previous example, you do not need quotes around this answer since the answer rule is not "text".

5. Test the question.


Here's how the preview looks with the correct answer entered.



Simplify the complex fraction.

$$\frac{\frac{5}{x}}{\frac{x}{9}}$$

The simplified fraction is $\frac{45}{x^2}$

 **Well done!**
OK

6. Save the question.

LESSON 4 – USE THE CUSTOM QUESTION BUILDER FUNCTIONS

In Lesson 1, you learned how to use the IFTHEN and ABS functions when defining an algorithmic value. Many more functions are available in the Custom Question Builder, and in this lesson you will use several of these functions. Refer to Appendix A for a full list of the available functions.

Learn about the CQB functions

The CQB functions (such as ABS) perform calculations or other special functions on static and algorithmic values. To use a function, type the function name into the appropriate definition box and enter the function arguments following the syntax for that function.

If the algorithmic value is defined as the "Text or symbol" or "Algebraic or Numeric Expression" type, the calculations will not be performed. Instead, the algorithmic value will display the text of the expression exactly as you defined it.

For example, suppose you want to define an algorithmic value to calculate the value of the expression, $|-3|+5$. If you define ~ans as an algebraic expression, $ABS(-3)+5$, the program will display this expression as written. However, if you define ~ans as an integer, then the output will equal 8.

To use the result of a calculation in an algorithmic value, you have to use another algorithmic value to perform the calculation and then use that value in the algorithmic value you are defining.

For example, suppose the numerator of a fraction is calculated as $ABS(\sim A) + \sim B$, and the denominator is $\sim C$. If you enter the fraction as

$$\sim \text{frac} = (ABS(\sim A) + \sim B) / \sim C$$

the program will display the numerator as written. You have to define an intermediate value, ~num, to equal $ABS(\sim A) + \sim B$, and then define the fraction as $\sim \text{num} / \sim \text{den}$.

Note: Do not confuse functions with templates. Templates are for typesetting only and do not perform any calculations.

Example 4A - Find the period of a trigonometric function

This example is a follow-up of Example 2A, where you created a question to find the period of the sine function, $y = \sin(Bx)$. In that example, you restricted the values of B so that the resulting period would be a simplified fraction. In this example, you will remove the restriction and see how to use the SIMPAB and SIMPBA functions to simplify the period.

1. Design the question.

You want students to find the period of a sine function defined as $y = \sin(\sim Bx)$. You will define ~B to be any integer from 2 to 9. The period would then be $2\pi/\sim B$. Since B can be even or odd, you will need to simplify the fraction when B is even.

You use the SIMPAB(A,B) function to find the simplified numerator of the fraction. The SIMPAB function finds the greatest common factor of A and B and divides this value into A. The output will be $A/\text{GCF}(A,B)$. Similarly, you use SIMPBA(A,B) to find the simplified denominator of the fraction. The output of SIMPBA(A,B) will be $B/\text{GCF}(A,B)$.

Here is the list of algorithmic values you need to define.

Name	Definition	Constraints
~B	coefficient of x in the function	integer between (and including) 2 and 9, not equal to 0
~num	simplified coefficient of the numerator of the period of the function	integer equal to SIMPAB(2,~B)
~den	simplified denominator of the period of the function	integer equal to SIMPBA(2,~B)

In addition, since the display of the period will vary depending on whether B is odd, even, or equal to 2, you will use nested IFTHEN functions to correctly display the period.






Name	Definition	Constraints
~ans1	period when B is odd	algebraic expression equal to $\sim\text{num}\pi/\sim\text{den}$
~ans2	period when B is even, or $\sim\text{num}=1$	algebraic expression equal to $\pi/\sim\text{den}$
~ans3	period when B=2 or $\sim\text{den}=1$	algebraic expression equal to π ;
~ans	final answer	equal to either ~ans1, ~ans2, or ~ans3 depending on the value of B

2. Create a new question.

If you completed Example 2A, you can copy that question to create the question for this example. Otherwise, start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
 Edit  Add  Duplicate  Delete  Regenerate algorithmic values							
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	ans	Text	-	=IFTHEN(~den=1,"~ans3",...		$2\pi/7$	period of the function
Edit	ans1	Symbolic	-	=~num π /~den		$2\pi/7$	period when B is odd
Edit	ans2	Symbolic	-	= π /~den		$\pi/7$	period when B is even
Edit	ans3	Symbolic	-	= π ;		π ;	period when B=2
Edit	B	Integer	-	>=2, <=9, <>0		7	coefficient of x
Edit	den	Integer	-	=SIMPBA(2,~B)		7	simplified denominator of period
Edit	num	Integer	-	=SIMPAB(2,~B)		2	simplified coefficient of numerator of period

4. Enter the question.

Here's how your question should look with algorithmic values shown.

Find the period of the function.

$y = \sin(\sim Bx)$

The period is $\sim ans$

When entering the short answer, use the answer rule "Accept similar answer or algebraic function." This rule will display the period as a built-up fraction, as shown below. Lastly, customize the math palette so that the pi symbol is visible.

Find the period of the function.

$y = \sin(7x)$

The period is $\frac{2\pi}{7}$

5. Test the question.

When testing your question, try entering an unsimplified fraction for the period. The program should tell you that your answer is incorrect and you should see the standard feedback informing you that the answer is equal to the correct answer but not in the correct form.

Find the period of the function.

$y = \sin(4x)$

The period is $\frac{2\pi}{4}$

⊗ Sorry, that's not correct.

Although your answer is equal to the correct answer, it is not in the correct form. Be sure to read any instructions given in the problem. If there are no special instructions, make sure your answer is simplified and entered in a fully-reduced form.

Done

6. Save the question.

Example 4B – Multiply and simplify radical expressions

This example is a follow-up of Example 3B, where you created a question to multiply two radical expressions. In that example, you did not require students to simplify the resulting radical. In this example, you will use the GCS and GCSR functions to simplify the radical.

1. Design the question.

The question asks students to multiply two radical expressions, $\sqrt{\sim A}$ and $\sqrt{\sim B}$.

Name	Definition	Constraints
$\sim A$	radicand of first radical	integer between (and including) 2 and 20, not equal to a perfect square
$\sim B$	radicand of second radical	integer between (and including) 2 and 20, not equal to a perfect square, and not equal to $\sim A$
$\sim C$	product of two radicands	equal to $\sim A * \sim B$

To simplify the radical answer, you need to find the greatest perfect square factor of the radicand, $\sim C$. Then, you need to find the square root of this factor. The GCS(X) function accomplishes both of these tasks. For example, GCS(20) will find the greatest perfect factor, 4, and give the square root of this number as the output. Similarly, GCS(72) will equal 6. You also need to find the remaining factor in the radicand after the greatest perfect factor is taken out. The GCSR(X) function will do this. For example, GCSR(20) will equal 5, and GCSR(72) will equal 2.

Therefore, if you want to simplify $\sqrt{20}$, you will use both the GCS and GCSR functions to write the expression as $\text{GCS}(20)\sqrt{\text{GCSR}(20)}$. The output will be $2\sqrt{5}$. You will add two new algorithmic values, one for the factor in front of the radical answer and one for the radicand.

Name	Definition	Constraints
$\sim \text{fact}$	factor in front of the radical answer	integer, equal to $\text{GCS}(\sim C)$
$\sim \text{rad}$	radicand of answer	integer, equal to $\text{GCSR}(\sim C)$

Lastly, you need to correctly display the answer when the radical cannot be simplified. In this case, $\sim \text{fact}$ will equal 1, and you can use an IFTHEN function to display the answer without the factor in front. In Example 3B, you entered the answer directly into the Short Answer definition window. In this example, you will define a new algorithmic value to represent the answer and then enter this algorithmic value in the Short Answer definition window.

2. Create a new question.

If you completed Example 3B, you can copy that question to create the question for this example. Otherwise, start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	A	Integer	-	>=2, <=20, <>[4,9,16]		13	first radicand
Edit	ans	Text	-	=IFTHEN(~fact=1,"@RT{~..		@RT{26}	final answer
Edit	B	Integer	-	>=2, <=20, <>[4,9,16,~A]		2	second radicand
Edit	C	Integer	-	=~A*~B		26	product of two radicands
Edit	fact	Integer	-	=GCS(~C)		1	factor in front of radical answer
Edit	rad	Integer	-	=GCSR(~C)		26	radicand of answer

4. Enter the question.

Here's how your question should look with algorithmic values shown.

Multiply the radical expressions.

$$\sqrt{\sim A} \sqrt{\sim B}$$

The product is $\sim ans$

When entering the short answer, use the answer rule "Accept similar answer or algebraic function." This rule will allow the program to recognize unsimplified answers and provide the appropriate feedback to the student.

5. Test the question.

When testing your question, try entering an unsimplified radical for the answer. The program should tell you that your answer is incorrect and you should see the standard feedback informing you that the answer is equal to the correct answer but not in the correct form (see below).

Multiply the radical expressions.

$$\sqrt{20} \sqrt{10}$$

The product is $\sqrt{200}$

Sorry, that's not correct.

Although your answer is equal to the correct answer, it is not in the correct form. Be sure to read any instructions given in the problem. If there are no special instructions, make sure your answer is fully simplified.

Done

6. Save the question.

LESSON 5 – USE SYNCHRONIZED LISTS

Learn about synchronized lists

Thus far, you have been defining algorithmic values by specifying a range of numbers or a formula. In this lesson you will learn how to specify a list of values for an algorithmic value. In addition, you will learn how to synchronize two or more lists so that there is a one-to-one correspondence between the elements in the list. For example, suppose you define the following algorithmic values by specifying a list of 5 numbers each:

$\sim A = \{1, 2, 3, 4, 5\}$

$\sim B = \{2, 5, 7, 3, 9\}$

$\sim C = \{1, 1, 3, 9, 5\}$

If you then synchronize the three lists, the program will always choose the values from the same position in each list. For example, if the program picks 3 from $\sim A$ (the 3rd value in the list), the program will then pick 7 from $\sim B$ and 3 from $\sim C$.

Synchronized lists are useful whenever you need to match up two algorithmic values and cannot use a formula to do so. Each list must have the same number of elements, and must be entered in the exact order you want for the synchronization.

Example 5A – List the digit in the nth decimal place of pi

In this example, students are asked to state the digit in the nth decimal place of the irrational number pi. Since there is no pattern to the digits, it is not possible to use a formula to determine the digit. Instead, you have to create a list for the digits and another list for the place value. The two lists will then be synchronized so that the correct digit is selected for the given place value.

1. Design the question.

The value of pi to 10 decimal places is 3.1415926535. The first list will consist of each of the digits in the decimal part of pi, entered in order from largest to smallest. The second list will consist of the decimal place names, again entered in order from left to right.

Name	Definition	List of values
\sim digit	decimal digits for pi	1, 4, 1, 5, 9, 2, 6, 5, 3, 5
\sim place	decimal place value	tenth, hundredth, thousandth, ten-thousandth, hundred-thousandth, 6th decimal, 7th decimal, 8th decimal, 9th decimal, 10th decimal

2. Create a new question.

Start with a new template and choose the Full Screen layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. Make sure you enter the lists of values in the exact order specified. Enter the same number, such as 1, in the link ID column for both algorithmic values. The value you enter for the link ID is immaterial; what is important is that the link IDs are the same for each list you want to synchronize. When you are done, your Algorithmic Values List should look like this (screen shot has typo for values in the decimal places....should be 3.1415926...)

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	digig	Integer	-	=["1,4,1,5,9,1,6,5,3,5"]	1	3	decimal digit for pi
Edit	place	Text	-	=["tenth","hundredth","tho...	1	9th decimal	decimal place value

4. Enter the question.

Here's how your problem statement and answer prompt should look like with algorithmic values shown.

The digit in the ~place place of the irrational number π is ~digit.

When entering the short answer, use the answer rule "Accept integer or decimal equivalents only." Note that this means an answer of 2.0 will be accepted in place of 2. If you want only the whole number 2 to be accepted, you need to define ~digit as a text value and enclose each number in quotes, as shown below.

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	digit	Text	-	=["1","4","1","5","9","1","6","5","3","5"]	1	1	decimal digit for pi
Edit	place	Text	-	=["tenth","hundredth","tho...	1	6th decimal	decimal place value

You then need to change the answer rule for ~digit to "Answer is text or contains a symbol."

5. Test the question.

When testing the question, try entering the digit as a decimal. Notice that the program will not accept this answer and you will have to enter only the whole number.

The digit in the tenth place of the irrational number π is 1.0.

Sorry, that's not correct.

Please try again.

[Done](#)

6. Save the question.

Example 5B – Find the phase shift of a sine function

In Examples 2A and 4A, you learned how to find the period of a sine function, $y = \sin(Bx)$ and display the result as a simplified fraction. In this example, you will expand on Example 4A by asking students to also find the phase shift of the function, $y = \sin(Bx + C)$.

1. Design the question.

You want students to find the period and phase shift of a sine function defined as $y = \sin(\sim Bx + \sim C)$. You will use the same algorithmic values that were defined in Example 4A for the period.

Name	Definition	Constraints
$\sim B$	coefficient of x in the function	integer between (and including) 2 and 9
$\sim \text{num}$	simplified coefficient of the numerator of the period of the function	integer equal to $\text{SIMPAB}(2, \sim B)$
$\sim \text{den}$	simplified denominator of the period of the function	integer equal to $\text{SIMPBA}(2, \sim B)$
$\sim \text{ans1}$	period when $\sim \text{den}$ is odd	algebraic expression equal to $\sim \text{num}\pi / \sim \text{den}$
$\sim \text{ans2}$	period when $\sim \text{den}$ is even	algebraic expression equal to $\pi / \sim \text{den}$
$\sim \text{ans3}$	period when $\sim \text{den} = 2$	algebraic expression equal to π
$\sim \text{ans}$	final answer	equal to either $\sim \text{ans1}$, $\sim \text{ans2}$, or $\sim \text{ans3}$ depending on the value of $\sim \text{den}$

You will list each value for $\sim C$ since these values are not easily specified using a range of values or a formula. The phase shift is then calculated as $\sim C / \sim B$. Since $\sim B$ is defined using a range of values, it is not possible to define the phase shift using a list of values. Instead, you have to calculate the denominator of the phase shift and then define the phase shift as a fraction using the values of the numerator and denominator.

Lastly, you need to specify the direction of the phase shift and you can use an IFTHEN function to do this. Here is the list of algorithmic values related to the phase shift.

Name	Definition	Constraints
$\sim C$	constant term in the function	list of algebraic expressions, π , $-\pi$, $\pi/2$, $-\pi/2$, $\pi/4$, $-\pi/4$
$\sim \text{Csign}$	sign of constant term	$\text{IFTHEN}(\sim C > 0, "+", "-")$
$\sim \text{Cden}$	denominator of $\sim C$	list of integers, 1, 1, 2, 2, 4, 4
$\sim \text{Pden}$	denominator of phase shift	integer, equal to $\sim \text{Cden} * \sim B$
$\sim \text{Pshift}$	value of phase shift	algebraic expression, equal to $\pi / \sim \text{Pden}$
$\sim \text{Pdir}$	direction of phase shift	text value, will be either "right" or "left" depending on the sign of the $\sim C$ term $\text{IFTHEN}(\sim C > 0, "right", "left")$

2. Create a new question.

If you completed Example 4A, you can copy that question to create the question for this example. Otherwise, start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit Add Duplicate Delete Regenerate algorithmic values							
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	ans	Text	-	=IFTHEN(~den=1,"~ans3"...		$2\pi/3$	period of the function
Edit	ans1	Symbolic	-	=~numπ/~den		$2\pi/3$	period when B is odd
Edit	ans2	Symbolic	-	=π/~den		$\pi/3$	period when B is even
Edit	ans3	Symbolic	-	=π		π	period when B=2
Edit	B	Integer	-	>=2, <=9, <>0		3	coefficient of x in function
Edit	C	Symbolic	-	=[π,-π,π/2,-π/2,&pi...	1	$-\pi/2$	constant term in function
Edit	Cden	Integer	-	=[1,1,2,2,4,4]	1	2	denominator of constant term
Edit	Csign	Text	-	=IFTHEN(~C>0,"+", "")			sign of constant term
Edit	den	Integer	-	=SIMPBA(2,~B)		3	simplified denominator of period
Edit	num	Integer	-	=SIMPAB(2,~B)		2	simplified coefficient of numerator of period
Edit	Pden	Integer	-	=~Cden*~B		6	denominator of phase shift
Edit	Pdir	Text	-	=IFTHEN(~C>0,"right","left")		left	direction of phase shift
Edit	Pshift	Symbolic	-	=π/~Pden		$\pi/6$	value of phase shift

4. Enter the question.

Here's how your question should look with algorithmic values shown.

Find the period and phase shift of the function.

$$y = \sin(\sim Bx \sim C \sin \sim C)$$

The period is $\sim ans$.

The phase shift is $\sim Pshift$ to the $\sim Pdir$.

When entering the short answer for $\sim Pshift$, use the answer rule "Accept similar answer or algebraic function." This will display the period as a built-up fraction, as shown in the next screenshot. For the direction of the phase shift, use the answer rule "Answer is text or contains a symbol."

Find the period and phase shift of the function.

$$y = \sin\left(3x - \frac{\pi}{2}\right)$$

The period is $\frac{2\pi}{3}$.

The phase shift is $\frac{\pi}{6}$ to the left.

5. Test the question.


Here's how the preview looks with the correct answers entered. If the phase shift does not display as a built-up fraction, you will need to edit the definition of ~C and use the @DIV template to define the fractions.

Find the period and phase shift of the function.

$$y = \sin\left(3x + \frac{\pi}{2}\right)$$

The period is $\frac{2\pi}{3}$.

The phase shift is $\frac{\pi}{6}$ to the right.

 **Excellent!**

6. Save the question.

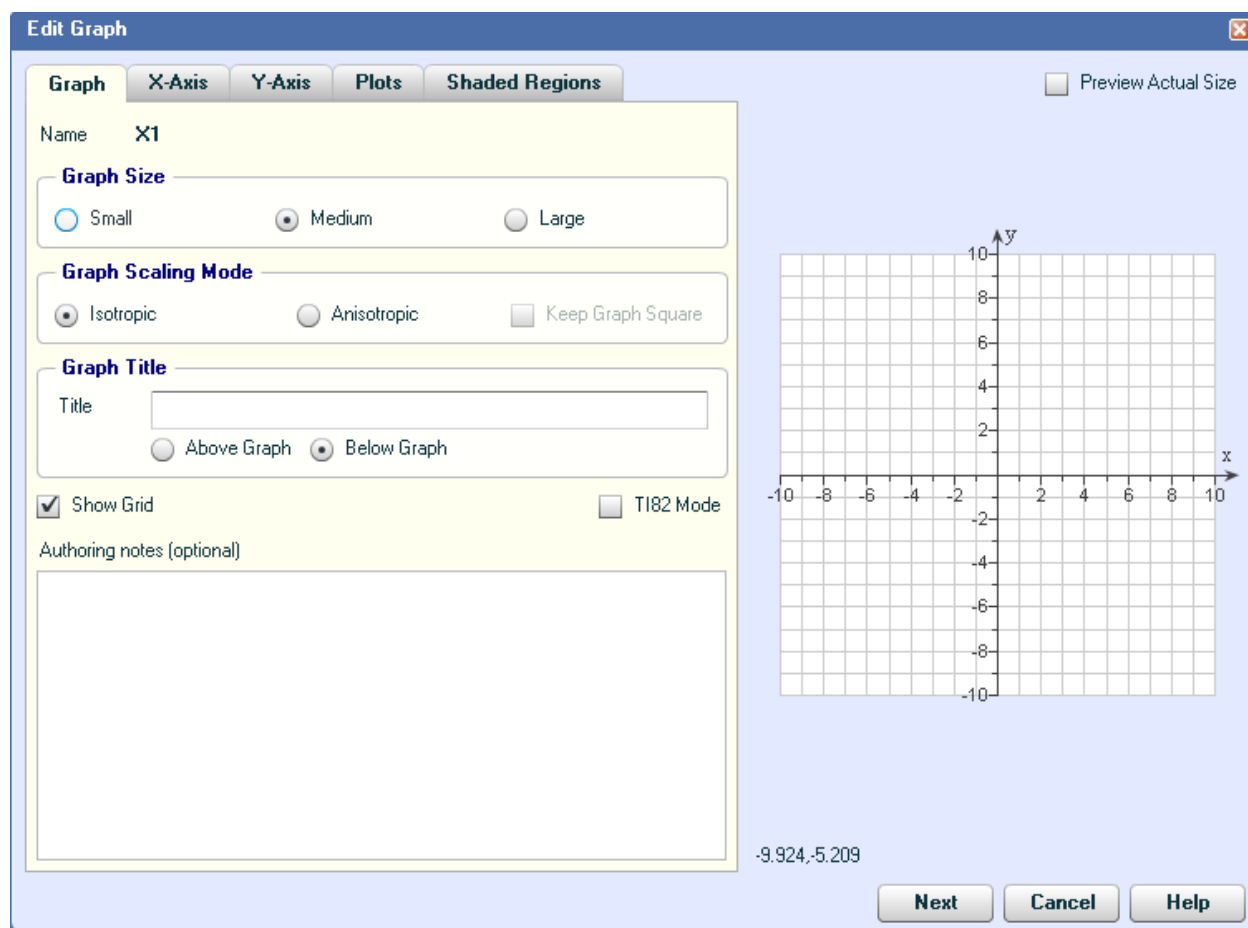
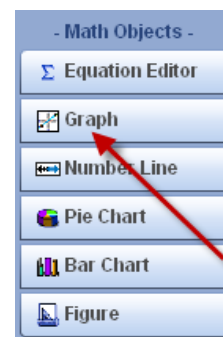
LESSON 6 – ADD A GRAPH TO A QUESTION

The next four lessons will focus on the different math objects you can add to your custom question. These objects include graphs, number lines, figures, pie charts, and bar charts.

Learn about the Graph tool

In this lesson, you will learn how to add a Cartesian graph to your question. When creating a graph, you can use any combination of four types of plots: functions, parametric equations, linear equations, and points. You can also shade one or more regions on the graph. In addition, you can fully customize each graph's title, size, axis limits and labels, and tick-mark scaling. You can add a graph to either the question area or answer area.

To add a graph to your question, click the Graph button in the Math Objects toolbar, as shown on the right. The Edit Graph window will be displayed, and you will customize the graph from the window.



There are five tabbed pages in this window, and the table below gives you a brief description of the customization you can do in each tab. The right side of the Edit Graph window shows you a preview of your graph. Uncheck the Preview Actual Size box for a larger view of the preview (as shown in the screenshot above).

Tab	Item	Description	Default Value
Graph	Graph Size	Specify the size of the graph.	Medium
	Graph Scaling Mode	Specify the proportion of the graph. Isotropic keeps the same scale in both axes. Anisotropic creates an almost proportional grid.	Isotropic
	Graph Title	Enter the title of the graph. The title can be displayed either above or below the graph. (optional)	None
	Authoring notes	Enter your annotations for the graph. (optional)	None
X-Axis Y-Axis	Axis Label	Enter an alternative name for the axis.	x or y
	Minimum*	Specify the minimum limit of the axis.	-10
	Maximum*	Specify the maximum limit of the axis.	10
	Tick Spacing*	Specify the increments of the tick marks.	1
	Tick Mark Labels	Choose the values to label along the axis.	Every 2 tick marks
	Axis Location	Specify the placement of each axis.	Zero
Plots	Add	Choose the type of plot (function, parametric, linear, points) to create. Once the plot has been selected, you will see additional options for defining the parameters of the plot.*	N/A
	Remove	Allows you to remove a plot from the graph.	N/A
Shaded Regions	Add	Add a shaded region to the graph. You can shade an area under a curve or an area bounded by two or more curves. Once a shaded region has been added, you will see additional options for defining the parameters of the region.*	N/A
	Remove	Allows you to remove a shaded region from the graph.	N/A

*You can include algorithmic values when defining these items.

Once you save the graph, it will be displayed in your question. Note that you can only display a graph in your question; students will not be able to draw graphs or otherwise interact with the displayed graph. Therefore, for questions requiring a graphical answer, you will need to create a multiple-choice answer and ask students to select the correct graph from a list of possible graphs.

Example 6A – Graph a quadratic function

In this example, you will learn how to use the Graph tool to draw a quadratic function.

1. Design the question.

You want students to select the correct graph for the function $f(x)=a(x-h)^2+k$. You will define the function in a similar way to what you did in Example 1A, except that you are adding a stretching factor of $\sim a$, and limiting the amount of the shifts. As you did in Example 1A, you will define $\sim h$ sign, $\sim h$ abs, and $\sim v$ sign so you can display the signs in the function correctly. Here are the algorithmic values needed for this question.

Name	Definition	Constraints
$\sim a$	stretching factor	integer, either 2 or 3
$\sim h$	horizontal shift	integer between (and including) -5 and 5, not equal to 0
$\sim k$	vertical shift	integer between (and including) -5 and 5, not equal to 0 and not equal to the horizontal shift or the opposite of the horizontal shift
$\sim h$ sign	sign of horizontal shift	IFTHEN($\sim h > 0$, "-", "+")

~habs	amount of horizontal shift	integer, equal to the absolute value of the horizontal shift
~vsign	sign of vertical shift	IFTHEN(~k>0,"+", "-")

Note: For pedagogical reasons, you do not want either the vertical shift or the horizontal shift to equal 0. You also do not want the shifts to equal each other or the opposite of each other as this may not completely test students' understanding of transformations.

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	a	Integer	-	=[2,3]		3	stretching factor
Edit	h	Integer	-	>=-5, <=5, <>0		-4	horizontal shift
Edit	habs	Integer	-	=ABS(~h)		4	amount of horizontal shift
Edit	hsign	Text	-	=IFTHEN(~h>0,"+", "-")		+	sign of horizontal shift
Edit	k	Integer	-	>=-5, <=5, <>[0,~h,~h]		2	vertical shift
Edit	ksign	Text	-	=IFTHEN(~k>0,"+", "-")		-	sign of vertical shift

4. Enter the question.

Here's how your problem statement and answer prompt should look with algorithmic values shown.

Graph the quadratic function.

$$f(x) = \sim a(x \sim hsign \sim habs)^2 \sim ksign \sim k$$

Choose the correct graph.

Add a multiple-choice answer below the answer prompt. Place your cursor in the box to the right of answer choice A, and click the Graph button in the Math Objects toolbar. Customize the Graph tab as follows:

Tab	Item	Value
Graph	Graph Size	Small
	Graph Scaling Mode	Anisotropic

Do not change any of the settings in the X-Axis or Y-Axis tabs. In the Plots tab, click the Add button and select Function. Specify the parameters of the function as follows:

Tab	Item	Value
Plots	f(x)	$\sim a(x \sim h)^2 + \sim k$
	Color	Red

When entering the algorithmic values, you can either type the algorithmic value name directly or right-click in the box and select Editing Options to pick the algorithmic values.

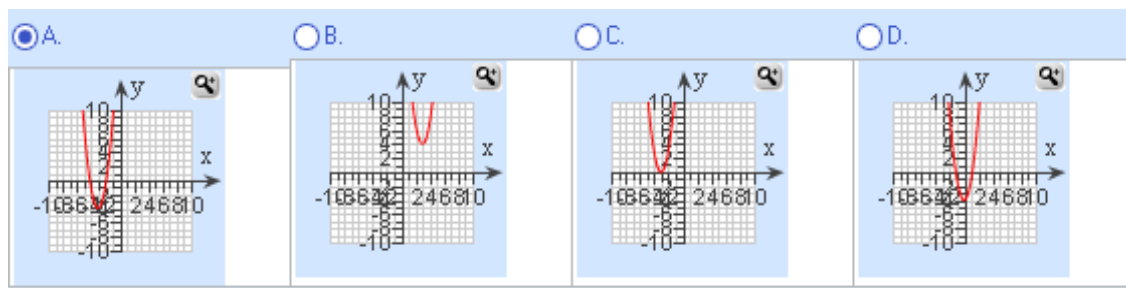
Notice that the graph is displayed in the Preview. Click Next, and then click Save to enter your graph into your question. In the same way, add the three distractor graphs into the multiple-choice grid, using the following definitions for each function.

Answer Choice	Function	Comment
B	$\sim a(x + \sim h)^2 - \sim k$	both shifts are in the wrong direction
C	$\sim a(x - \sim h)^2$	only the horizontal shift is graphed
D	$\sim ax^2 + \sim k$	only the vertical shift is graphed

When all four graphs are in the multiple-choice grid, notice that you have to scroll down in the answer area to view all the graphs. You can change the settings for the multiple-choice answer to remove the need to scroll. With your cursor anywhere in the multiple-choice grid, click the Feedback and Settings button in the Multiple Choice Options window. Specify the options as shown below.

Option	Value	Comment
# of Columns	4	displays the graphs from left to right
Distractor Label Position	Top	allows more space for the graph display

With these settings, your graphs should be displayed from left to right as shown below.



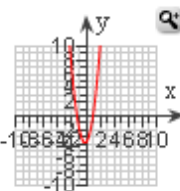
5. Test the question.

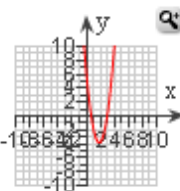
Regenerate values several times to see that all four graphs are displayed clearly. In particular, make sure that none of the graphs are displayed off the axis scale. In the Preview window, the magnify button is displayed at the top right of each graph. This allows students to zoom in on the graph while they are working on the question.

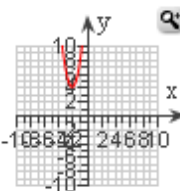
Graph the quadratic function.

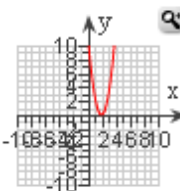
$$f(x) = 3(x - 2)^2 + -4$$

Choose the correct graph.

☐ A. 

☐ B. 

☐ C. 

☐ D. 

6. Save the question.

Example 6B – Graph a system of inequalities

The second example in this lesson will illustrate the use of shading in the Graph tool. To graph a linear inequality, you first graph the boundary line and then shade the appropriate half-plane. To graph a system of linear inequalities, you first graph each boundary line and then shade the solution to the system.

1. Design the question.

The system of inequalities is modeled on the right. You will define the slopes and y-intercepts so that the lines do not intersect on the y-axis, and so that the slopes are of different sign. Also, you will define algorithmic values to display the signs and coefficients correctly. Here are the algorithmic values needed to define the system of inequalities.

$$\begin{cases} y1 < m1x + b1 \\ y2 \geq m2x + b2 \end{cases}$$

Name	Definition	Constraints
m1	slope of line 1	integer, equal to 1, 2, or 3
m1coeff	coefficient of x in line 1	IFTHEN(~m1=1,"","~m1")
b1	y-intercept of line 1	integer between (and including) -3 and 3, not equal to 0
b1sign	sign of b1	IFTHEN(~b1>0,"+", "")
m2	slope of line 2	integer, equal to -1, -2, or -3
m2coeff	coefficient of x in line 2	IFTHEN(~m2=-1,"-", "~m2")
b2	y-intercept of line 2	integer between (and including) -3 and 3, not equal to 0 or ~b1
b2sign	sign of b2	IFTHEN(~b2>0,"+", "")

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

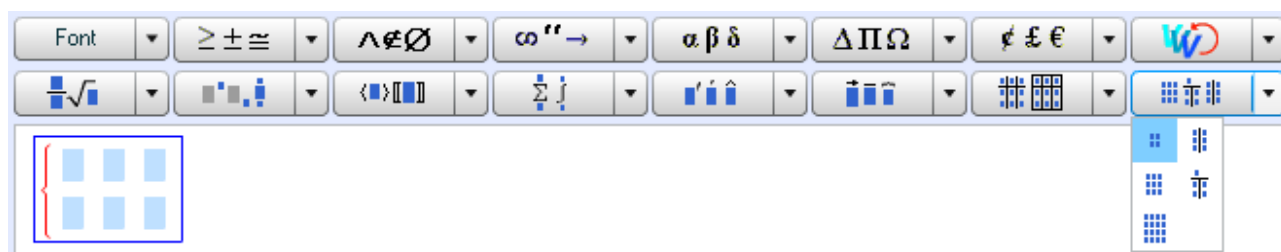
3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	b1	Integer	-	$\geq -3, \leq 3, \neq 0$		3	y-intercept of line 1
Edit	b1sign	Text	-	$=\text{IFTHEN}(\sim b1 > 0, "+", "-")$		+	sign of b1
Edit	b2	Integer	-	$\geq -3, \leq 3, \neq [0, \sim b1]$		2	y-intercept of line 2
Edit	b2sign	Text	-	$=\text{IFTHEN}(\sim b2 > 0, "+", "-")$		+	sign of b2
Edit	m1	Integer	-	$\in [1, 2, 3]$		2	slope of line 1
Edit	m1coeff	Text	-	$=\text{IFTHEN}(\sim m1 = 1, "", "\sim m1")$		2	coefficient of line 1
Edit	m2	Integer	-	$\in [-1, -2, -3]$		-3	slope of line 2
Edit	m2coeff	Text	-	$=\text{IFTHEN}(\sim m2 = -1, "", "\sim m2")$		-3	coefficient of line 2

4. Enter the question.

Use the Equation Editor to enter the system of inequalities. To help with the spacing of each inequality, type the left brace and then select the matrix template and enter a matrix with 2 rows and 3 columns, as shown below.



When done, your problem statement and answer prompt should look like this.

Graph the system of inequalities.

$$\begin{cases} y < \sim m1coeffx \sim b1sign \sim b1 \\ y \geq \sim m2coeffx \sim b2sign \sim b2 \end{cases}$$

Choose the correct graph.

Follow the steps in Example 6A to add a multiple-choice answer below the answer prompt and enter the correct graph in answer choice A. Change the graph settings to Small, Anisotropic, but do not change the axes settings. In the Plots tab, enter line 1 as the function, $f(x) = \sim m1x + \sim b1$. Change the line color to "blue" and the style to "Dashed" since the inequality for line 1 is strict.

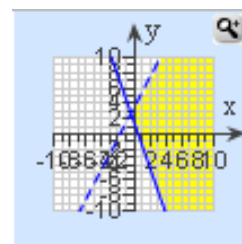
Next, click the Add button again and enter line 2. Select the same line color but leave the line style as solid since the inequality for line 2 is not strict. Click Next, then Save to add the graph to the multiple-choice grid. You will add the shading later.

To graph the solution to the system of inequalities, you have to specify the seed position for the shaded region. You can either enter a fixed seed position or enter algorithmic values for

the coordinates of the seed position. Since you used algorithmic values for both graphs in this example, the coordinates of the seed position must also be algorithmic. For this first graph, the solution will be the region below the dashed line and above the solid line; in other words, the region to the right of the intersection point. Regardless of how both lines change, the seed position will always be to the right of the x-intercept of the rightmost line. Therefore, you can specify the seed position to have an x-coordinate to the right of this x-intercept, and a y-coordinate of 0. Here's the list of algorithmic values you need to define the seed position.

Name	Definition	Constraints
Xint1	x-intercept of line 1	decimal, 3 places, equal to $-b_1/m_1$
Xint2	x-intercept of line 2	decimal, 3 places, equal to $-b_2/m_2$
XseedA	x-coordinate of seed position for graph A	decimal, equal to the maximum value of the two x-intercepts plus 1
YseedA	y-coordinate of seed position for graph A	integer, equal to 0 since the seed position is on the x-axis

Add these algorithmic values. Then, edit the graph and go to the Shaded Region tab. Click the Add button and enter $\sim X_{\text{seedA}}$ as the x-coordinate of the seed position and $\sim Y_{\text{seedA}}$ as the y-coordinate of the seed position. Choose a shading color of yellow or some other color that will be a good contrast to the blue lines. Click Save to finish. Your graph should look like the one shown on the right.



In the same way, add the three distractor graphs into the multiple-choice answer, using the following definitions for the functions.

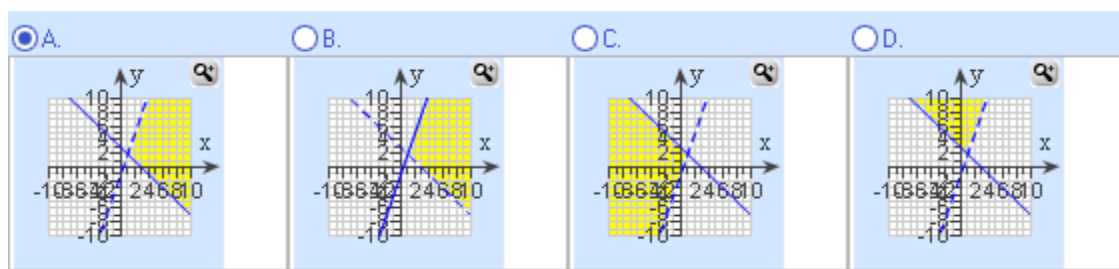
Answer Choice	Functions	Comment
B	$y_1 \leq -m_1x + -b_1$ $y_2 > -m_2x + -b_2$	line 1 is solid and line 2 is dashed
C	$y_1 > -m_1x + -b_1$ $y_2 \leq -m_2x + -b_2$	shading is above line 1 and below line 2
D	$y_1 < -m_1x + -b_1$ $y_2 \geq -m_2x + -b_2$	shading is above line 1 and above line 2

You will need to define the following algorithmic values for the seed positions of each line.

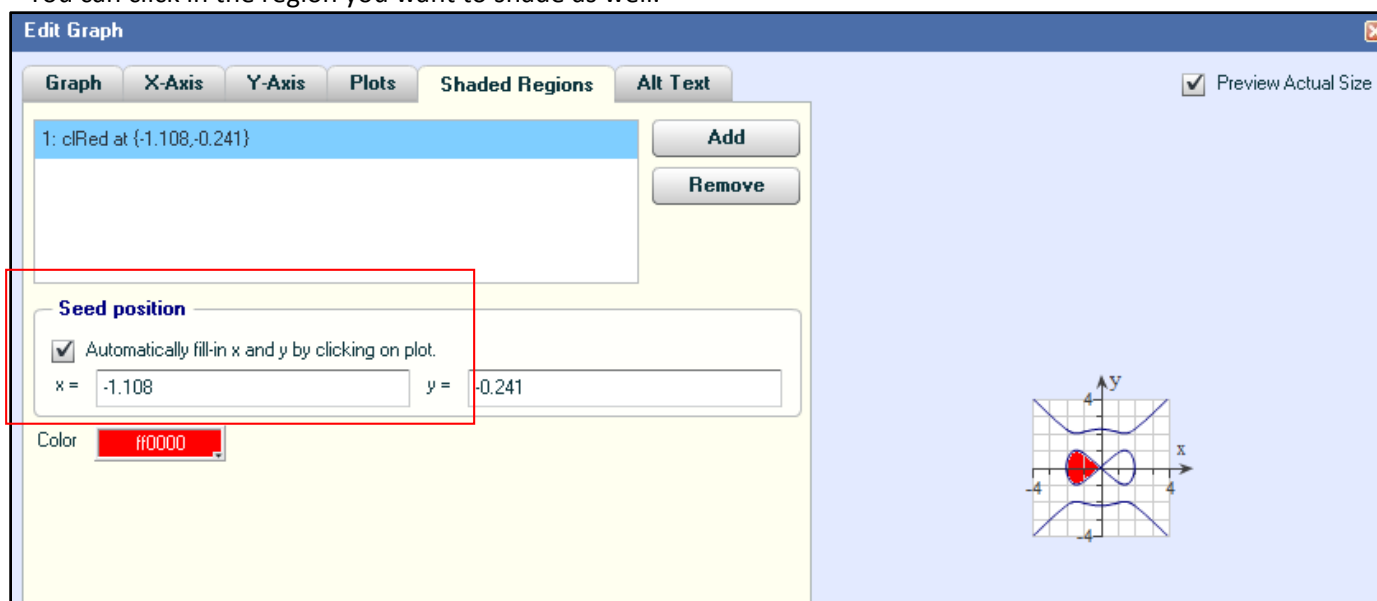
Name	Definition	Constraints
XseedB	x-coordinate of seed position for graph B	decimal, equal to the maximum value of the two x-intercepts plus 1
YseedB	y-coordinate of seed position for graph B	integer, equal to 0 since the seed position is on the x-axis
XseedC	x-coordinate of seed position for graph C	decimal, equal to the minimum value of the two x-intercepts minus 1
YseedC	y-coordinate of seed position for graph C	integer, equal to 0 since the seed position is on the x-axis
XseedD	x-coordinate of seed position for graph D	integer, equal to 0 since the seed position is on the y-axis
YseedD	y-coordinate of seed position for graph D	decimal, equal to the maximum value of the two y-intercepts plus 1

Note: Since some of the seed coordinates are equal to 0, you do not need to define algorithmic values for these. However, for consistency, it is a good idea to define all of the seed coordinates. This will also make it easier for you to revise the question in the future.

Don't forget to change the settings for the multiple-choice answer so that there are 4 columns with the distractor label position on top. When you are done, your graphs should look like this.



You can click in the region you want to shade as well.



5. Test the question.

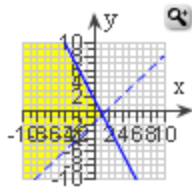
Regenerate values several times to see that the shading for each graph is displayed correctly. Preview the question and use the magnify button to zoom in on a graph so that you can check the shading in detail.

Graph the system of inequalities.

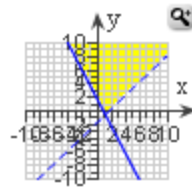
$$\begin{cases} y < x - 2 \\ y \geq -2x + 2 \end{cases}$$

Choose the correct graph.

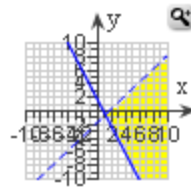
☐ A.



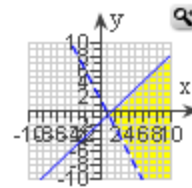
☐ B.



☐ C.



☐ D.



6. Save the question.

Example 6C – Graph a piecewise-defined function

This last example will show you how to use the Graph tool to graph a piecewise-defined function.

1. Design the question.

You will graph the piecewise-defined function modeled after the one shown on the right. You will define algorithmic values for the slope of line 1 and the y-intercept of line 2, and for the domain limits, as follows.

$$71. f(x) = \begin{cases} 3x & \text{if } -1 \leq x < 1 \\ x + 1 & \text{if } 1 \leq x \leq 2 \end{cases}$$

Name	Definition	Constraints
~m1	slope of line 1	integer, can be -3, -2, 2, or 3
~b2	y-intercept of line 2	integer between (and including) -5 and 5, not equal to 0
~b2sign	sign of b2	IFTHEN(~b2>0,"+", "-")
~a	leftmost domain limit	integer between -10 and 0
~b	middle domain limit	integer at least 3 more than ~a and at least 3 less than ~c
~c	rightmost domain limit	integer between 0 and 10

When graphing the function, you will need to separately plot the endpoints of each line. To do this, you need to calculate the coordinates of each of the four endpoints. The x-coordinate of the endpoints will be the domain limits. The y-coordinates are calculated from the equations of the lines. You have to restrict the limits for the y-coordinates since you want the endpoints of each line to lay within the graph limits of -10 and 10. Lastly, you have to make sure that the two endpoints at the middle domain limit are not identical, so that there is a clear separation between the two pieces.

Note: If you did not figure out all the constraints during the design phase, you can always edit the algorithms as you develop the question.

Here is the list of algorithms needed for the y-coordinates.

Name	Definition	Constraints
~Y1a	y-coordinate of left endpoint of line 1	integer, equal to ~m1*~a, between -10 and 10
~Y1b	y-coordinate of right endpoint of line 1	integer, equal to ~m1*~b, between -10 and 10
~Y2b	y-coordinate of left endpoint of line 2	integer, equal to ~b+~b2, between -10 and 10, not equal to ~Y1b
~Y2c	y-coordinate of right endpoint of line 2	integer, equal to ~c+~b2, between -10 and 10

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	a	Integer	-	>-10, <0		-2	leftmost domain limit
Edit	b	Integer	-	>~a+3, <~c-3		2	middle domain limit
Edit	b2	Integer	-	>=-5, <=5, <>0		1	y-intercept of line 2
Edit	b2sign	Text	-	=IFTHEN(~b2>0,"+", "")		+	sign of b2
Edit	c	Integer	-	>0, <10		6	rightmost domain limit
Edit	m1	Integer	-	=[-3,-2,2,3]		-3	slope of line 1
Edit	Y1a	Integer	-	>-10, <10, =~m1~~a		6	y-coordinate of left endpoint of line 1
Edit	Y1b	Integer	-	>-10, <10, =~m1~~b		-6	y-coordinate of right endpoint of line 1
Edit	Y2b	Integer	-	>-10, <10, =~b+~b2, <>~Y1b		3	y-coordinate of left endpoint of line 2
Edit	Y2c	Integer	-	>-10, <10, =~c+~b2		7	y-coordinate of right endpoint of line 2

4. Enter the question.

Here's how your problem statement and answer prompt should look with algorithmic values shown. Use a matrix with 2 rows and 2 columns (left justify) to space the two functions correctly.

Graph the piecewise-defined function.

$$f(x) = \begin{cases} \sim m1x & \sim a \leq x < \sim b \\ x \sim b2sign \sim b2 & \sim b \leq x \leq \sim c \end{cases}$$

Choose the correct graph.

Next, add a multiple-choice answer below the answer prompt. Change the settings to show 4 columns, like you did in Examples 6A and 6B. Enter the correct graph in answer choice A. When plotting the lines, change the x-Limits to Custom and enter the appropriate algorithmic value for the domain limits. For line 1, you would enter ~a for the left limit and ~b for the right limit, as shown below.

f(x)

Line

Color Style **Solid**

x-Limits

☐ Use Graph Limits

☒ Custom <

For line 2, you would enter $\sim b$ for the left limit and $\sim c$ for the right limit. Once you have both lines plotted, you will graph the endpoints of each line. For each endpoint, click the Add button and select Points. Enter each endpoint as a separate data set, filling in the algorithmic values in the x- and y-columns. Check the "Filled" box as needed depending on whether the interval is open or closed at that endpoint, as shown below for the left endpoint of line 1.

List your data points. Enter one set of coordinates per row.

x	y
$\sim a$	$\sim y_1 a$

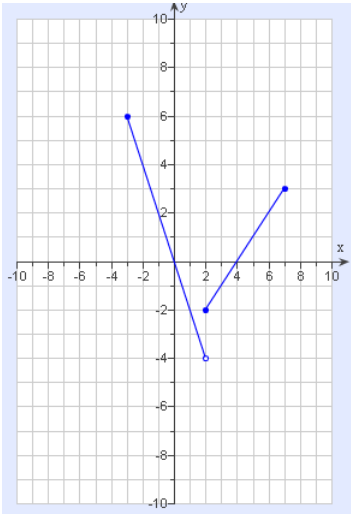
Points

Color

0000ff

Size

☒ Filled

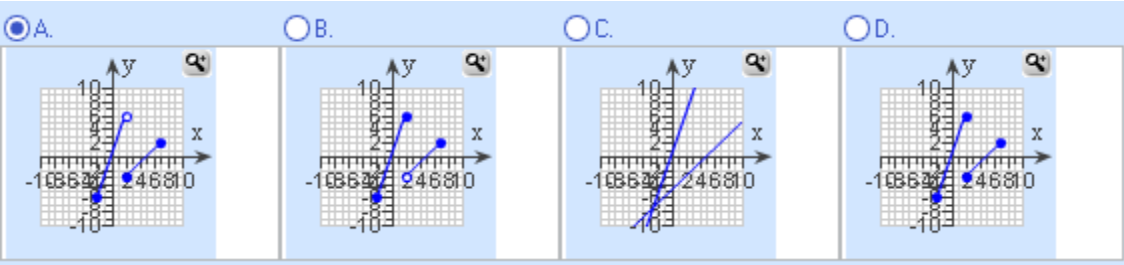


When done, your graph should look like the one shown on the right.

In the same way, add the three distractor graphs into the multiple-choice answer, using the following definitions for the graphs and endpoints.

Answer Choice	Functions	Comment
B	$y_1 = \sim m_1 x$ $y_2 = x + \sim b_2$	right endpoint of line 1 is solid left endpoint of line 2 is open
C	$y_1 = \sim m_1 x$ $y_2 = x + \sim b_2$	no limits on either line
D	$y_1 = \sim m_1 x$ $y_2 = x + \sim b_2$	all endpoints are solid

When you are done, your graphs should look like this.



5. Test the question.

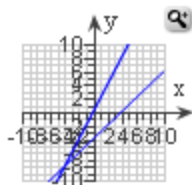
Regenerate values several times to see that the functions in each graph are displayed correctly. Preview the question and use the magnify button to zoom in on a graph so that you can check the endpoints in detail.

Graph the piecewise-defined function.

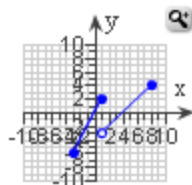
$$f(x) = \begin{cases} 2x & -3 \leq x < 1 \\ x-4 & 1 \leq x \leq 8 \end{cases}$$

Choose the correct graph.

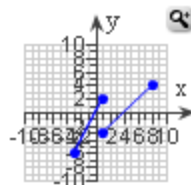
☐ A.



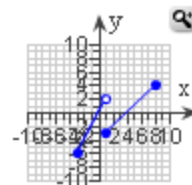
☐ B.



☐ C.



☐ D.



6. Save the question.

LESSON 7 – ADD A NUMBER LINE TO A QUESTION

Learn about the Number Line tool

In this lesson, you will learn how to use the Number Line tool to insert a number line into your custom question. You can graph points or inequalities on the number line, defining the endpoints using circle or interval notation. Number lines can only be displayed in your question and students will not be able to draw a graph on the number line. Therefore, as in Lesson 6, you will need to create a multiple-choice answer and ask students to select the correct graph from the list of possible graphs.

To add a number line to your question, click the Number Line button in the Math Objects toolbar, as shown on the right. The Edit Number Line window will be displayed, and you will customize the number line from this window.

The "Edit Number Line" window has a title bar with a close button. It contains two tabs: "Number Line" (selected) and "Plots". Under the "Number Line" tab, there are three sections: "Axis Scales" with input fields for "Minimum" (-10), "Maximum" (10), and "Tick Spacing" (1); "Axis Label" with radio buttons for "Label Minimum and Maximum" (selected) and "Label Every" (1) followed by a "Tick(s)" label; and "Authoring notes (optional)" with a large text area. To the right of these settings is a preview of the number line, showing a horizontal axis with arrows at both ends, major ticks at -10, 0, and 10, and minor ticks every 1 unit. At the bottom right are three buttons: "Next", "Cancel", and "Help".

There are two tabbed pages in this window, and the table below gives you a brief description of the customization you can do in each tab. The right side of the Edit Number Line window shows you a preview of your number line.

Tab	Item	Description	Default Value
Number Line	Minimum*	Specify the minimum limit of the axis.	-10
	Maximum*	Specify the maximum limit of the axis.	10
	Tick Spacing*	Specify the increments of the tick marks.	1
	Axis Labels	Choose the values to label along the axis.	Label Minimum and Maximum
	Authoring notes	Enter your annotations for the graph. (optional)	None
Plots	Add	Add a graph to the number line.*	N/A
	Remove	Remove a graph from the number line.	N/A

*You can include algorithmic values when defining these items.

Example 7A – Graph a linear inequality.

You will start with Example 2B, where you created a question to solve an inequality and write the answer using interval notation. In this example, you will add to this question by asking students to choose the correct graph of the inequality.

1. Design the question.

The inequality is defined as $x + \sim a \leq 3x + \sim b$, and the solution is $x \geq \sim c$. Here is the list of algorithmic values you defined in Example 2B.

Name	Definition	Constraints
$\sim b$	constant term on right side of inequality	integer between (and including) -9 and 9, not equal to 0
$\sim c$	left endpoint of solution	integer between (and including) -9 and 9, but not equal to 0
$\sim a$	constant term on left side of inequality	integer equal to $\sim b + 2 \cdot \sim c$
$\sim \text{assign}$	sign of the constant term on the left	text value, displays the + sign only when the $\sim a$ is positive <code>IFTHEN($\sim a > 0$, "+", "")</code>
$\sim \text{bsign}$	sign of the constant term on the right	text value, displays the + sign only when the $\sim b$ is positive <code>IFTHEN($\sim b > 0$, "+", "")</code>

2. Create a new question.

If you completed Example 2B, you can copy that question to create the question for this example. Otherwise, start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
				Regenerate algorithmic values			
	Name 1▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	a	Integer	-	$\sim b + 2 \cdot \sim c$		20	constant term on left of inequality
Edit	assign	Text	-	<code>=IFTHEN($\sim a > 0$, "+", "")</code>		+	sign of $\sim a$
Edit	b	Integer	-	$\geq -9, \leq 9, \neq 0$		8	constant term on right of inequality
Edit	bsign	Text	-	<code>=IFTHEN($\sim b > 0$, "+", "")</code>		+	sign of $\sim b$
Edit	c	Integer	-	$\geq -9, \leq 9, \neq 0$		6	left endpoint of solution

4. Enter the question.

For this example, you will ask students to write the answer in interval notation and choose the correct graph of the inequality. You will use a short answer interaction for the interval notation answer, choosing the "Answer is text or contains a symbol." answer rule, and entering the value as " $[-c, \infty)$ ". If you started with a new question, you will need to customize the symbol palette so that the infinity symbol is displayed. Here's how your question should look at this point.

Solve the inequality. Write your answer in interval notation and graph the solution on a number line.

$x - a \leq 3x - b$

The solution in interval notation is $[-c, \infty)$

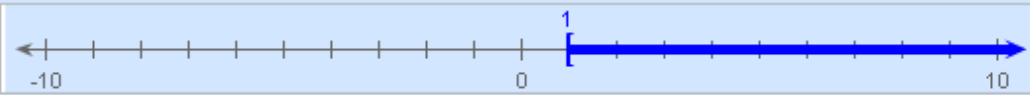
Add a multiple-choice answer below the answer prompt. Place your cursor in the box to the right of answer choice A, and click the Number Line button in the Math Objects toolbar. Do not change any of the settings in the Number Line tab. In the Plots tab, click the Add button to add a graph to the number line. Specify the parameters of the graph as follows:

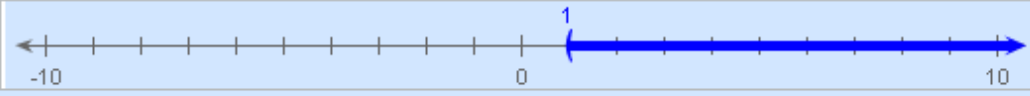
Plot	Item	Value
Plot 1	Minimum Value	$-c$, includes minimum value, show label
	Maximum Value	∞ , do not include maximum value, do not show label
	Color	Blue, visible
	Use Interval Notation	select this option

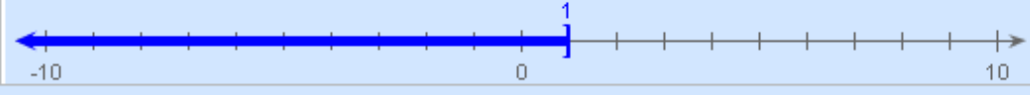
Notice that your graph is displayed in the Preview. Click Save to enter the graph into your question. In the same way, add the three distractor graphs into the multiple-choice grid, using the following definitions for each number line.

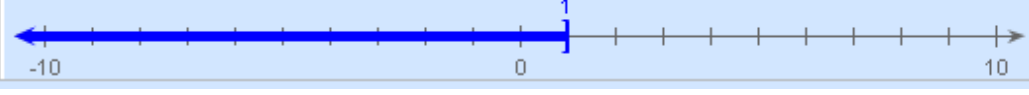
Answer Choice	Inequality	Comment
B	$x > -c$	inequality is strict
C	$x \leq -c$	inequality points to the left
D	$x < -c$	inequality is strict and points to the left

Here's how your multiple-choice grid should look after you have entered all the number lines.

☒ A. 

☐ B. 

☐ C. 

☐ D. 

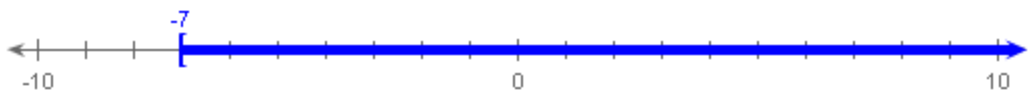
5. Test the question.

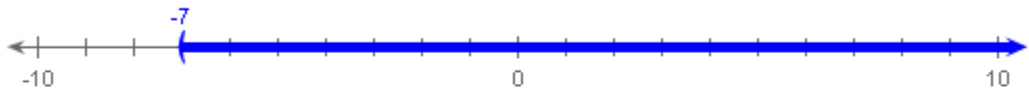
Regenerate values several times to see that all four graphs are displayed clearly. In particular, make sure that none of the graphs are displayed off the axis scale.


Solve the inequality. Write your answer in interval notation and graph the solution on a number line.


$$x - 21 \leq 3x - 7$$

The solution in interval notation is

☐ A. 

☐ B. 

☐ C. 

☐ D. 

6. Save the question.

Example 7B – Graph a compound linear inequality.

The second example in this lesson will illustrate the process for graphing a compound inequality on a number line.

1. Design the question.

You will solve an absolute value inequality modeled by $|x + \sim a| > \sim b$. The solution will be the union of the inequalities $x > \sim c$ and $x < \sim d$, where $\sim c = -\sim a + \sim b$ and $\sim d = -\sim a - \sim b$. Here is the list of algorithmic values needed for this question.

Name	Definition	Constraints
$\sim a$	constant term in absolute value	integer between (and including) -5 and 5, not equal to 0
$\sim \text{sign}$	sign of $\sim a$	IFTHEN($\sim a > 0$, "+", "-")
$\sim b$	constant term on right of inequality	integer between (and including) 1 and 10, not equal to $\sim a$
$\sim c$	left endpoint of right-hand graph	integer, equal to $-\sim a + \sim b$, constrained to be less than 9 so that the graph displays within the axis scale
$\sim d$	right endpoint of left-hand graph	integer, equal to $-\sim a - \sim b$, constrained to be greater than -9 so that the graph displays within the axis scale

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	a	Integer	-	$\geq -5, \leq 5, < 0$		4	constant term in absolute value
Edit	assign	Text	-	$\text{=IFTHEN}(\sim a > 0, "+", "")$		+	sign of a
Edit	b	Integer	-	$\geq 1, \leq 10, < 0$		2	constant term on right of inequality
Edit	c	Integer	-	$< 9, = \sim a + \sim b$		-2	left endpoint of right-hand graph
Edit	d	Integer	-	$> -9, = \sim a - \sim b$		-6	right endpoint of left-hand graph

4. Enter the question.

Here's how your problem statement and answer prompt should look with algorithmic values shown.

Solve the absolute value inequality and graph the solution on a number line.

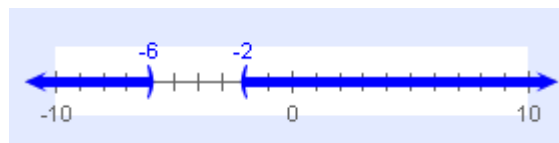
$$|x - \text{assign} \sim a| > \sim b$$

Choose the correct graph.

Next, add a multiple-choice answer below the answer prompt, and enter the correct graph in answer choice A. Specify the parameters of the graph as follows:

Plot	Item	Value
Plot 1	Minimum Value	$\sim c$, do not include minimum value, show label
	Maximum Value	∞ , do not include maximum value, do not show label
	Color	Blue, visible
	Use Interval Notation	select this option
Plot 2	Minimum Value	$-\infty$, do not include minimum value, do not show label
	Maximum Value	$\sim d$, do not include maximum value, show label
	Color	Blue, visible
	Use Interval Notation	select this option

Here's how the preview should look with both plots entered.



In the same way, add the three distractor graphs into the multiple-choice grid, using the following definitions for each number line.

Answer Choice	Inequality	Comment
B	$\sim d < x < \sim c$	inequality is between endpoints
C	$x \leq d$ or $x \geq \sim c$	inequalities are not strict
D	$x > \sim c$	plot right-hand graph only

5. **Test the question.**

Here's how the preview looks.

Solve the absolute value inequality and graph the solution on a number line.

$|x - 1| > 3$

Choose the correct graph.

☐ A.

☐ B.

☐ C.

☐ D.

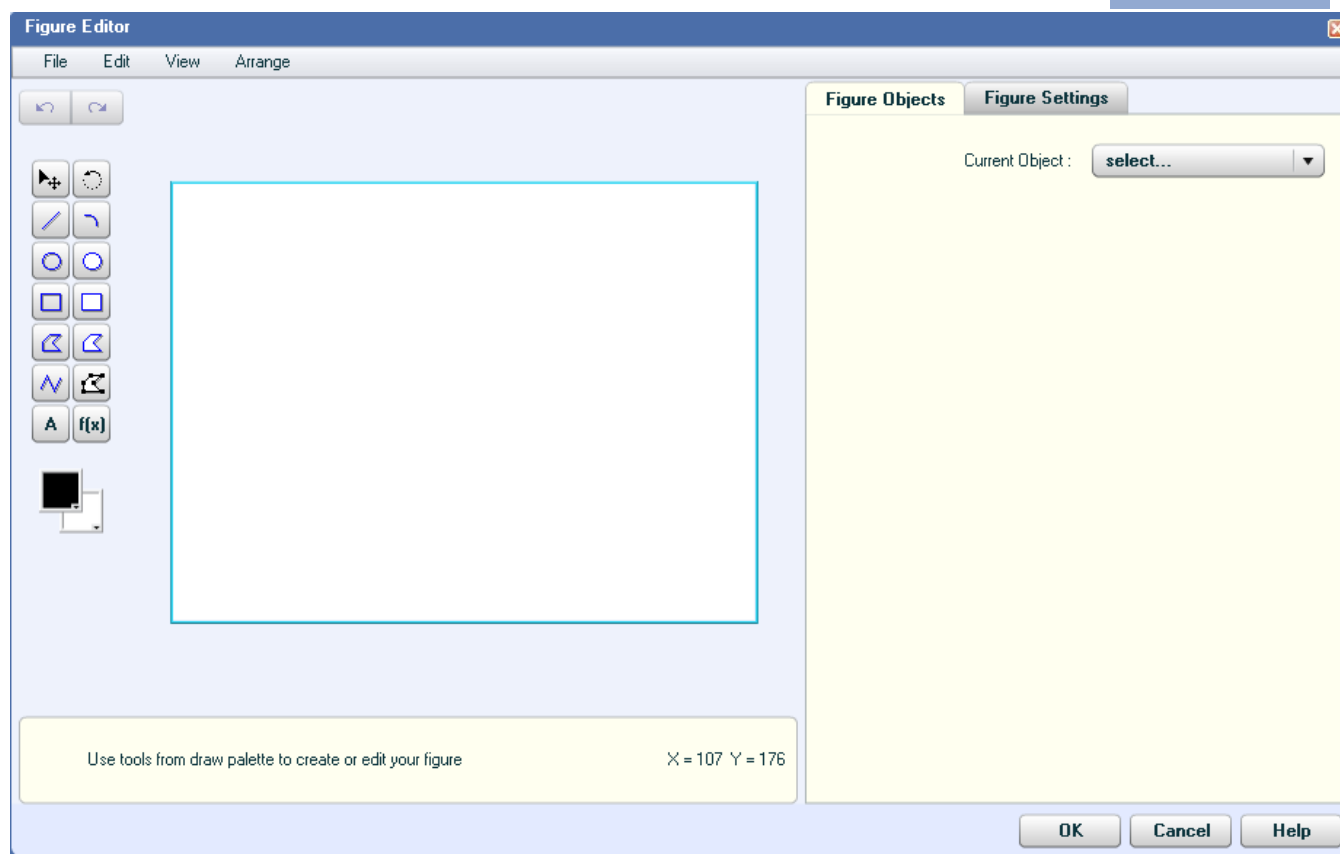
6. **Save the question.**

LESSON 8 – ADD A FIGURE TO A QUESTION

Learn about the Figure Editor

In this lesson, you will learn how to use the Figure Editor to insert and edit figures in your custom question. You can import graphic files or create your own figures using the drawing tool palette. Imported files can be in any of the following formats: GIF, JPG, PNG, and BMP.

The Figure Editor has three components: drawing tool palette, drawing area, and Objects and Settings area. You use these three components together to create your figures.



The menus at the top of the window contain additional options for working with your figures.

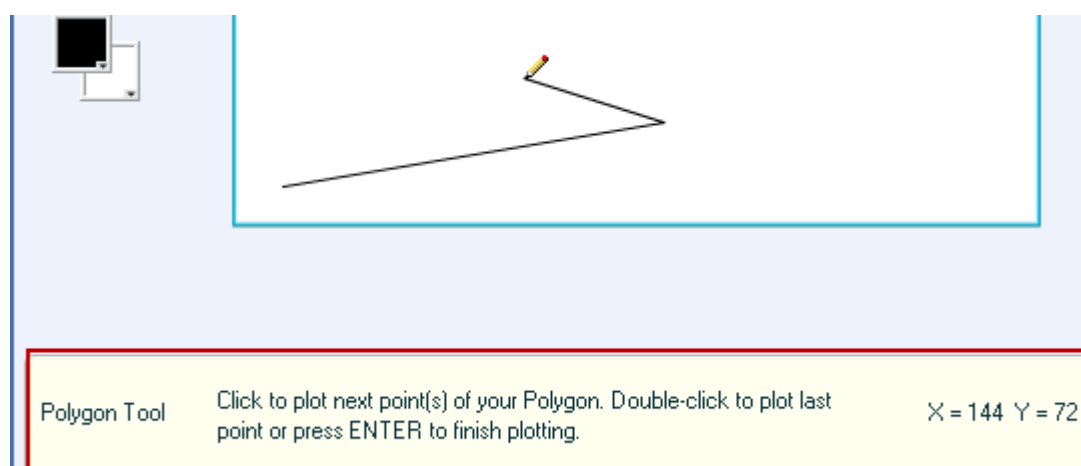
Menu Item	Description
File menu	Contains the standard options to create a new drawing area, open a previously saved figure, and save your figure as an XML file.
Edit menu	Contains the standard options to undo and redo actions in the drawing area. You can also edit the XML source file for your image and insert a graphic file from this menu.
View menu	Allows you to display and format a drawing grid to help you align the objects in your drawing. Also, allows you to hide or display the Objects and Settings area.
Arrange menu	Allows you to specify how graphic objects, including text, overlap each other.

The drawing tool palette, shown on the right, contains the tools you need to draw figures and annotate them. The table below gives you a brief description of each tool.



Icon	Tool	Description
	Undo and redo	The left button undoes your previous action in the drawing area; the right button redoes an action that you previously undid. You have multiple levels of undo and redo.
	Select	Lets you select objects and text.
	Rotate	Lets you rotate an object around a pivot point.
	Line	Lets you draw a line or an arrow.
	Arc	Lets you draw an arc.
	Ellipse	Lets you draw an open ellipse or circle.
	Filled Ellipse	Lets you draw a filled ellipse or circle.
	Rectangle	Lets you draw an open rectangle or square.
	Filled Rectangle	Lets you draw a filled rectangle or square.
	Polygon	Lets you draw an open polygon.
	Filled Polygon	Lets you draw a filled polygon.
	Polyline	Lets you draw a polyline.
	Vertex Edit	Lets you change the vertices of polygons and polylines.
	Text	Lets you enter text. You can enter static text or predefined algorithmic values in a text box.
	Formula	Lets you enter mathematical formulas.
	Fill	Lets you specify the foreground and background (fill) colors of objects.

When you select a tool, directions for using the tool are given below the drawing area, as shown below.



When any drawing object is selected, you can set its properties on the Figure Objects tab in the Objects and Settings area.

In the example shown on the right, an open rectangle is selected in the drawing area. The Figure Objects tab allows you to change the size & coordinates, lines, and background of the rectangle. You can also change some of these properties directly in the drawing area, although the Object Info window allows you more precise control over these properties.

The Current Object dropdown list at the top of the Figure Objects tab lists all the objects in your drawing area. You can select an object from this list to edit it. Each object in your drawing is assigned a descriptive name and type by the system. The Object Name box lets you rename any selected object.

The Figure Settings tab lets you specify the dimensions of your figure and add notes about it.

Once you save the figure, it will be displayed in your question. If you inserted algorithmic values in the figure, these values will regenerate according to the constraints you defined.

Example 8A – Find the length of the hypotenuse of a right triangle.

In this example, you will use the Figure Editor to draw a right triangle, inserting algorithmic values for the length of the two sides of the triangle.

1. Design the question.

You want students to find the exact value of the length of the hypotenuse of a right triangle. The dimensions of the triangle will be given in the figure, and students will need to use the Pythagorean Theorem to find the length of the hypotenuse. The answer is to be written as a radical, and you will need to use the GCS and GCSR functions to simplify the radical. Here are the algorithmic values needed for this question.

Name	Definition	Constraints
~a	length of side 1	integer between (and including) 5 and 20
~b	length of side 2	integer between (and including) ~a+5 and 25
~c2	radicand of the length of the hypotenuse	integer, equal to the sum of the squares of ~a and ~b
~fact	factor in front of the radical answer	integer, equal to GCS(~c2)
~rad	radicand of answer	integer, equal to GCSR(~c2)
~ans	answer, length of hypotenuse	text value, used to correctly display the radical answer when either ~fact or ~rad is equal to 1. IFTHEN(~fact=1,"@RT{ ~rad}",IFTHEN(~rad=1,"~fact","~fact@RT{ ~rad}"))

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	a	Integer	-	>=5, <=20		12	length of side 1
Edit	ans	Text	-	=IFTHEN(~fact=1,"@RT{~..		12@RT{5}	length of hypotenuse
Edit	b	Integer	-	>=~a+5, <=25		24	length of side 2
Edit	c2	Integer	-	=~a^2+~b^2		720	radicand of hypotenuse
Edit	fact	Integer	-	=GCS(~c2)		12	factor in front of simplified radical answer
Edit	rad	Integer	-	=GCSR(~c2)		5	radicand of simplified radical answer

4. Enter the question.

When entering a figure into a question, it is a good idea to place the figure in a table. This allows you to locate the figure to the side of your problem statement. With your cursor in the question area, select Table from the menu and then select Insert Table. Alternatively, click the Table icon in the formatting toolbar. In the Insert Table window, change the number of rows to 1 and click OK. You will see a faint outline of the table in the question area.

Put your cursor in the left cell of the table and type the problem statement, as shown below.

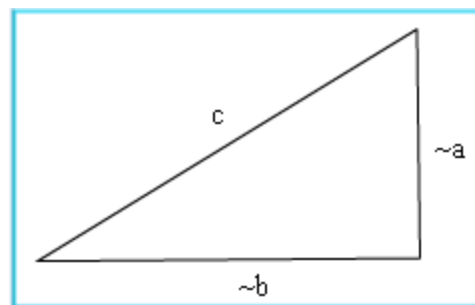
Find the length of the hypotenuse, c , of the right triangle shown on the right. Write your answer as a radical. Simplify the radical if needed.

Next, put your cursor in the right cell of the table, and click the Figure button in the Math Objects toolbar. You will first draw the right triangle. Select the Polygon tool from the drawing palette. Move your cursor to the drawing area and notice that the pointer becomes a pencil. Directions for drawing the polygon are given below the drawing area.

Here's how you will draw the triangle.

- o Click the left mouse button to set the bottom left corner.
- o Move the mouse to the right to draw the bottom side.
- o Click the left mouse button to set the bottom right corner.
- o Move the mouse up to draw the right side.
- o Click the left mouse button to set the top right corner.
- o Press Enter to finish plotting the triangle.

Next, select the Text tool. Move the cursor to the right of the right side and click the left mouse button. Type $\sim a$ in the text box. In the same way, type $\sim b$ next to the bottom side and c next to the hypotenuse. If you need to adjust the placement of any of the text boxes, use the Select tool and select the text box to move it around.



Lastly, adjust the size of the drawing area by clicking and dragging the blue outline of the drawing area. Click OK to place the figure in your question.

Find the length of the hypotenuse, c , of the right triangle shown on the right. Write your answer as a radical. Simplify the radical if needed.

Type the answer prompt and short answer box in the answer area. Select the answer rule "Accept similar answer or algebraic function." When you are done, your answer area should look like this.

The length of the hypotenuse is $\sim ans$.

(Write your answer as a radical. Simplify the radical if needed.)

5. Test the question.

Here's how the preview looks. Notice that the outline of the table is not visible.

Find the length of the hypotenuse, c , of the right triangle shown on the right. Write your answer as a radical. Simplify the radical if needed.

The length of the hypotenuse is .

(Write your answer as a radical. Simplify the radical if needed.)

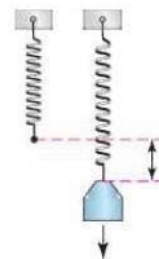
6. Save the question.

Example 8B – Solve an application problem.

The second example in this lesson will show you how to insert an image into your question. You will also learn how to add algorithmic values to the image.

1. Design the question.

The image you will insert into this example is shown on the right. Copy the image and save it on your hard drive as a JPG file, as you will need the file later in this example. The figure illustrates Hooke's Law, which states that the distance that an elastic spring stretches beyond its natural length is directly proportional to the amount of weight hung on the spring. In other words, $F=kx$, where k is the constant of proportionality or spring constant. For this example, you will define algorithmic values for F and x and ask students to find the spring constant. Here is the list of algorithmic values that you will define.



Name	Definition	Constraints
~F	weight applied to the spring	integer between (and including) 10 and 20
~x	distance the spring stretches	integer between (and including) 2 and 6
~k	spring constant	decimal, 2 places, equal to $\sim F/\sim x$

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	F	Integer	-	$\geq 10, \leq 20$		10	weight applied to spring
Edit	k	Real	---	$= \sim F / \sim x$		2	spring constant
Edit	x	Integer	-	$\geq 2, \leq 6$		5	distance the spring stretches

4. Enter the question.

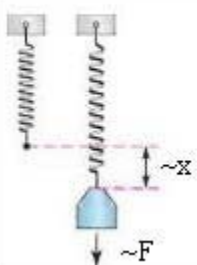
Insert a table with 1 row and 2 columns in the question area, like you did in Example 8A. Type the problem statement in the left cell of the table. Insert the algorithmic values $\sim F$ and $\sim x$ in the appropriate locations, as shown below.

<p>A $\sim F$-pound weight is hung on a spring, and it stretches $\sim x$ inches. Find the spring constant. Round your answer to two decimal places.</p>	
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--

Next, put your cursor in the right cell of the table, and click the Figure button in the Math Objects toolbar. In the Figure Editor, select Edit from the menu and then select Insert Picture. Locate the image of the spring on your hard drive and click Open to insert the image in the drawing area. Select the Text tool and insert the algorithmic values $\sim F$ and $\sim x$ next to the

bottom and right arrows, respectively. Lastly, adjust the size of the drawing area and click OK to place the figure in your question.

A $\sim F$ -pound weight is hung on a spring, and it stretches $\sim x$ inches. Find the spring constant. Round your answer to two decimal places.



Type the answer prompt and short answer box in the answer area. Select the answer rule "Accept integer or decimal equivalents only." and set the correct answer format option to show 2 decimal places. When you are done, your answer area should look like this.

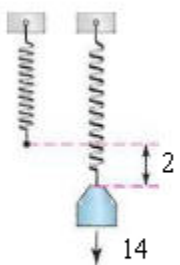
The spring constant is .

(Round your answer to two decimal places.)

5. Test the question.

Here's how the preview looks.

A 14-pound weight is hung on a spring, and it stretches 2 inches. Find the spring constant. Round your answer to two decimal places.



The spring constant is .

(Round your answer to two decimal places.)

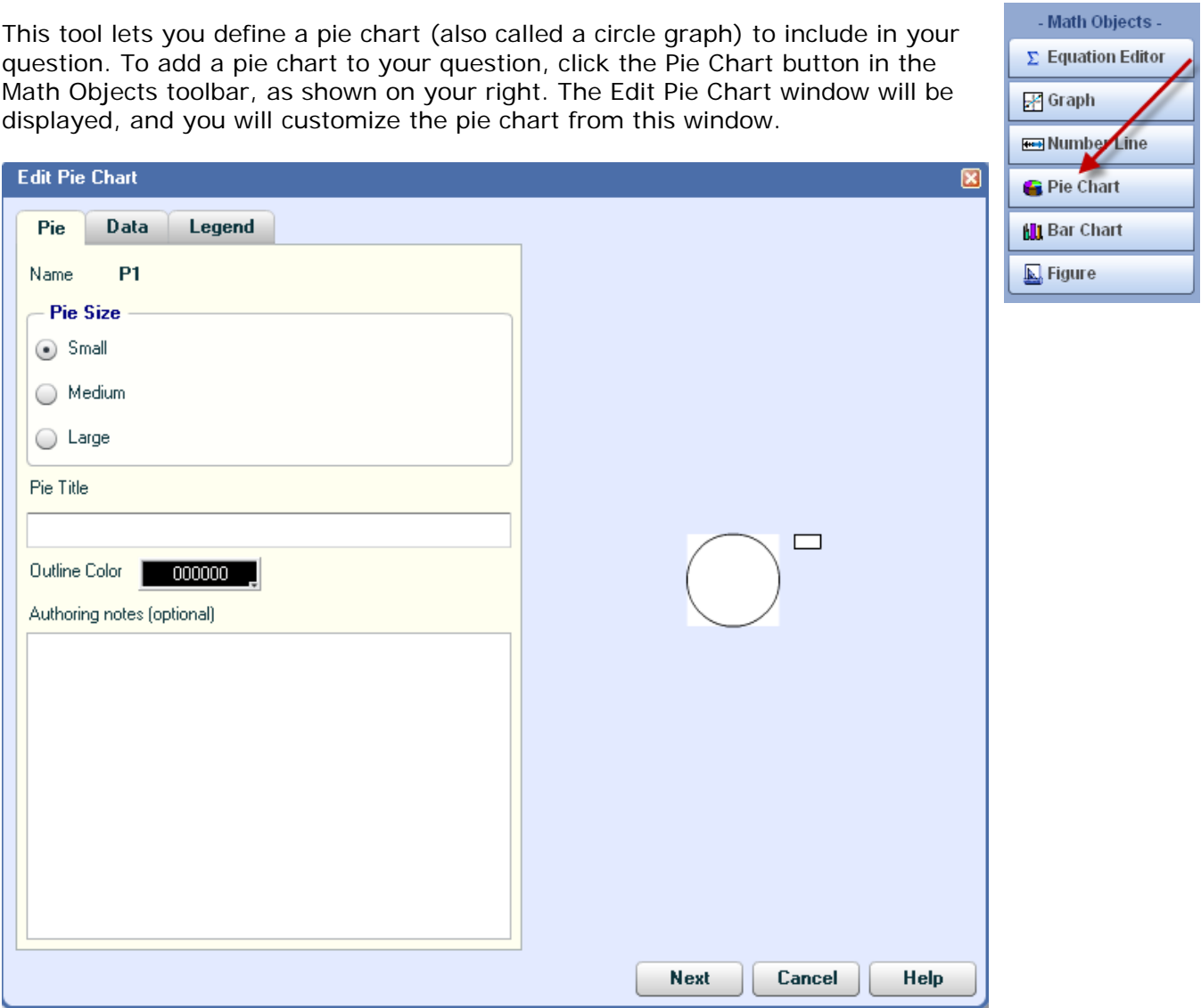
6. Save the question.

LESSON 9 – ADD A PIE CHART OR BAR GRAPH TO A QUESTION

In this lesson, you will learn how to use the remaining two tools in the Math Objects toolbar – Pie Chart and Bar Chart. You will use these tools in each example.

Learn about the Pie Chart tool

This tool lets you define a pie chart (also called a circle graph) to include in your question. To add a pie chart to your question, click the Pie Chart button in the Math Objects toolbar, as shown on your right. The Edit Pie Chart window will be displayed, and you will customize the pie chart from this window.



There are three tabbed pages in this window, and the table below gives you a brief description of the customization you can do in each tab. The right side of the Edit Pie Chart window shows you a preview of your pie chart.

Tab	Item	Description	Default Value
Pie	Pie Size	Specify the size of the pie chart.	Small
	Pie Title*	Add a title to the pie chart. The title is displayed above the pie chart. (optional)	None
	Outline Color	Color of outline of pie chart.	Black
	Authoring notes	Enter your annotations for the pie chart. (optional)	None
Data	Add	Add a wedge to the pie chart.*	N/A
	Remove	Remove a wedge from the pie chart.	N/A

Tab	Item	Description	Default Value
Legend	Label Spacing	Specify the spacing between the items in the legend.	See slider
	Legend Spacing	Specify the space between the pie and the legend.	See slider
	Show Legend	Show or hide the legend.	Show
	Legend Position	Specify where the legend appears in relation to the pie chart.	Right
	Label Format	Specify how wedge values are displayed.	Percent
	Number of decimal places	Specify the number of decimal places to be displayed.	0
	Show trailing zeros	Show or hide trailing zeros in the labels.	Show
	Show commas between periods	Show or hide commas in large numbers.	Hide

*You can include algorithmic values when defining these items.

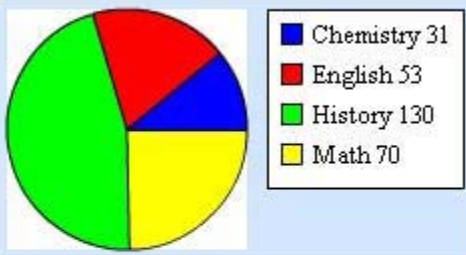
Once you save the pie chart, it will be displayed in your question. Note that you can only display a pie chart in your question; students will not be able to draw pie charts or otherwise interact with the displayed pie chart. Therefore, if you want students to draw a pie chart, you will need to create a multiple-choice answer and ask students to select the correct pie chart from a list of possible pie charts.

Example 9A – Use a pie chart to find percentages.

1. Design the question.

This question will ask students to use the data presented in a pie chart to figure out the percentage of students enrolled in a given subject. The data values will be algorithmic, and you will also vary the subject in the question. Here's how the question will look when you are done.

The pie chart on the right represents the number of students enrolled in each course at Ridge View High School. Using this information, find the percentage of students enrolled in Chemistry. Round your answer to the nearest tenth.



The percentage of students enrolled in Chemistry is % (Round your answer to the nearest tenth.)

You will define algorithms for the subject, the number of students enrolled in each subject, and the percentage of students enrolled in each subject. Since you need to match the subject with the percentage of students enrolled in that subject, you will use a synchronized list to accomplish this. Here is the list of algorithms needed.






Name	Definition	Constraints
~SUBJ	title of subject	text value, list the four subjects in order: Chemistry, English, History, Math
~CHEM	# of students enrolled in Chemistry	integer between (and including) 30 and 70
~ENG	# of students enrolled in English	integer between (and including) 50 and 120
~HIST	# of students enrolled in History	integer between (and including) 60 and 140
~MATH	# of students enrolled in Math	integer between (and including) 40 and 100
~TOT	total # of students enrolled in the 4 subjects	integer, equal to the sum of ~CHEM, ~ENG, ~HIST, and ~MATH
~pCHEM	% of students enrolled in Chemistry	decimal to 1 place, equal to $\sim\text{CHEM}/\sim\text{TOT} \times 100$
~pENG	% of students enrolled in English	decimal to 1 place, equal to $\sim\text{ENG}/\sim\text{TOT} \times 100$
~pHIST	% of students enrolled in History	decimal to 1 place, equal to $\sim\text{HIST}/\sim\text{TOT} \times 100$
~pMATH	% of students enrolled in Math	decimal to 1 place, equal to $\sim\text{MATH}/\sim\text{TOT} \times 100$
~ANS	answer to the question	decimal to 1 place, list the four percentage values in order of the subject

2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

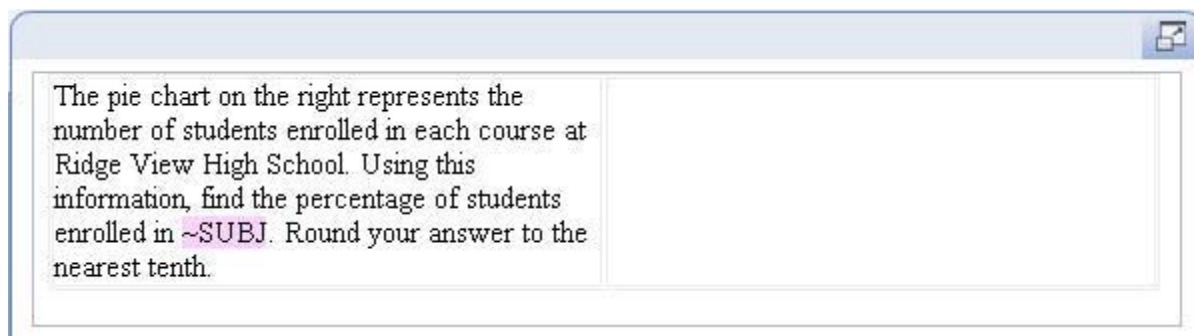
3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
 Edit  Add  Duplicate  Delete  Regenerate algorithmic values							
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	ANS	Real	-.-	=["~pCHEM,~pENG,~pHIS...	1	26.8	Final answer
Edit	CHEM	Integer	-	>=30, <=70		50	# students in Chemistry
Edit	ENG	Integer	-	>=50, <=120		95	# students in English
Edit	HIST	Integer	-	>=60, <=140		137	# students in History
Edit	MATH	Integer	-	>=40, <=100		73	# students in Math
Edit	pCHEM	Real	-.-	=~CHEM/~TOT*100		14.1	% enrolled in Chemistry
Edit	pENG	Real	-.-	=~ENG/~TOT*100		26.8	% enrolled in English
Edit	pHIST	Real	-.-	=~HIST/~TOT*100		38.6	% enrolled in History
Edit	pMATH	Real	-.-	=~MATH/~TOT*100		20.6	% enrolled in Math
Edit	SUBJ	Text	-	=["Chemistry","English","Hi..	1	English	Title of subject
Edit	TOT	Integer	-	=~CHEM+~ENG+~HIST+~...		355	Total # of students

4. Enter the question.

When entering a pie chart into a question, it is a good idea to place the pie chart in a table, like you did with the figures in Lesson 8. This allows you to locate the pie chart to the side of your problem statement. Insert a table with 1 row and 2 columns in the question area. Type the problem statement in the left cell of the table, inserting the algorithmic value, ~SUBJ, in the appropriate location, as shown below.



The pie chart on the right represents the number of students enrolled in each course at Ridge View High School. Using this information, find the percentage of students enrolled in ~SUBJ. Round your answer to the nearest tenth.	
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--

Next, put your cursor in the right cell of the table, and click the Pie Chart button in the Math Objects toolbar. In the Edit Pie Chart window, customize the settings as follows:

Tab	Item	Value
Pie	Pie Size	Medium
Legend	Label Format	Data Values

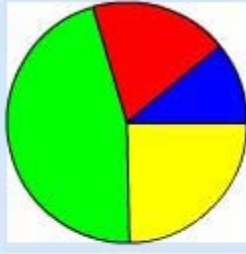
Next, click on the Data tab. You will enter each wedge of the pie chart by clicking the Add button and entering the following specifications.

Wedge	Label	Value
1	Chemistry	~CHEM
2	English	~ENG
3	History	~HIST
4	Math	~MATH

Notice that the program automatically selects a different color for each wedge and enters the label and value in the legend. Click Save to finish.

Complete the question by entering the answer prompt and short answer box. Use the answer rule "Accept integer or decimal equivalents only." and enter the answer as ~ANS. Set the answer format to display 1 decimal place. Here's how your finished question should look.

The pie chart on the right represents the number of students enrolled in each course at Ridge View High School. Using this information, find the percentage of students enrolled in ~SUBJ. Round your answer to the nearest tenth.



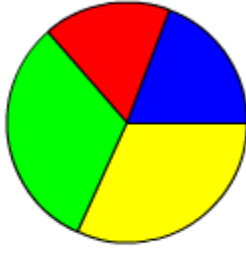
Chemistry	31
English	53
History	130
Math	70

The percentage of students enrolled in ~SUBJ is ~ANS%
(Round your answer to the nearest tenth.)

5. Test the question.

Preview the question. Regenerate values several times to make sure that the correspondence between the subject and percentage enrolled in that subject is correct.

The pie chart on the right represents the number of students enrolled in each course at Ridge View High School. Using this information, find the percentage of students enrolled in History. Round your answer to the nearest tenth.



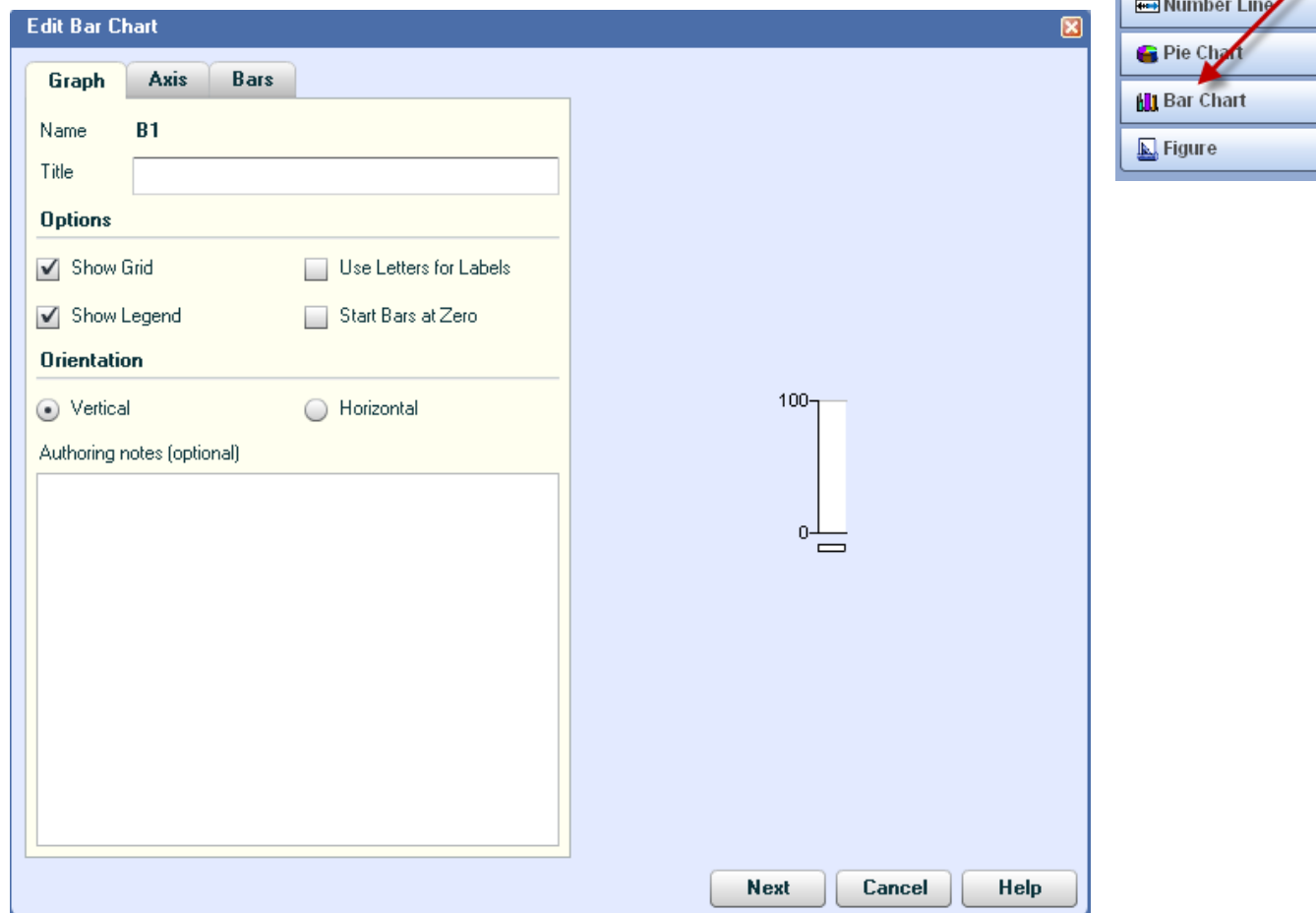
Chemistry	58
English	52
History	96
Math	96

The percentage of students enrolled in History is %
(Round your answer to the nearest tenth.)

6. Save the question.

Learn about the Bar Chart tool

This tool lets you define a bar chart to include in your question. To add a bar chart to your question, click the Bar Chart button in the Math Objects toolbar, as shown on your right. The Edit Bar Chart window will be displayed, and you will customize the bar chart from this window.



There are three tabbed pages in this window, and the table below gives you a brief description of the customization you can do in each tab. The right side of the Edit Bar Chart window shows you a preview of your bar chart.

Tab	Item	Description	Default Value
Graph	Title*	Add a title to the bar chart. The title is displayed above the chart. (optional)	None
	Show Grid	Show or hide grid lines in the bar chart.	Show
	Show Legend	Show or hide the legend.	Show
	Use Letters for Labels	Choose letters for labels in the legend	No
	Start Bars at Zero	Choose to begin each bar at 0 instead of the minimum value.	No
	Orientation	Select either vertical or horizontal orientation for the chart.	Vertical
	Authoring notes	Enter your annotations for the bar chart. (optional)	None

Tab	Item	Description	Default Value
Axis	Title*	Add a label to the axis of the bar chart.	None
	Minimum*	Specify the lowest value to display at the bottom or left of the bar chart axis.	0
	Maximum*	Specify the highest value to display at the top or right of the bar chart axis.	100
	Tick Spacing	Specify the increments of the tick marks.	5
	Axis Label	Choose the values to label along the axis.	Every 2 ticks
Bars	Add	Add a bar to the bar chart.*	N/A
	Remove	Remove a bar from the bar chart.	N/A

*You can include algorithmic values when defining these items.

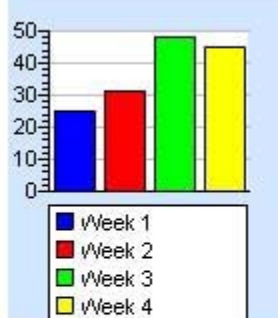
Once you save the bar chart, it will be displayed in your question. Note that you can only display a bar chart in your question; students will not be able to draw bar charts or otherwise interact with the displayed bar chart. Therefore, if you want students to draw a bar chart, you will need to create a multiple-choice answer and ask students to select the correct bar chart from a list of possible bar charts.

Example 9B – Use a bar chart to find percent increase and decrease.

1. Design the question.

This question will ask students to use the data presented in a bar chart to calculate percent increase and decrease. Here's how the question will look when you are done.

The attendance at the weekly meetings of a community forum is shown on the bar chart on the right. Use this bar chart to answer the following questions.



a) What is the percent increase in the attendance from Week 2 to Week 4?

b) What is the percent decrease in the attendance from Week 3 to Week 4?

a) The percent increase in the attendance from Week 2 to Week 4 is %.
(Write your answer as a percent rounded to the nearest hundredth.)

b) The percent decrease in the attendance from Week 3 to Week 4 is %.
(Write your answer as a percent rounded to the nearest hundredth.)

You will define algorithms for the attendance in each week and for the percent increase and percent decrease. Here is the list of algorithms needed.

Name	Definition	Constraints
~W1	Week 1 attendance	integer between (and including) 10 and 30
~W2	Week 2 attendance	integer between (and including) 20 and 40
~W3	Week 3 attendance	integer greater than ~W1 and less than or equal to 50
~W4	Week 4 attendance	integer between ~W2 and ~W3

~Pinc	% increase from Week 2 to Week 4	decimal, 2 places, equal to $(\sim W4 - \sim W2) / \sim W2 * 100$
~Pdec	% decrease from Week 3 to Week 4	decimal, 2 places, equal to $(\sim W3 - \sim W4) / \sim W4 * 100$

2. Create a new question.

Start with a new template.

3. Enter the algorithms.

Enter the algorithms as defined in the design step above. When you are done, your Algorithmic Values List should look like this:

Algorithmic Values List							
Edit	Add	Duplicate	Delete	Regenerate algorithmic values			
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	Pdec	Real	---	$=(\sim W3 - \sim W4) / \sim W4 * 100$		6.67	% decrease from Week 3 to Week 4
Edit	Pinc	Real	---	$=(\sim W4 - \sim W2) / \sim W2 * 100$		45.16	% increase from Week 2 to Week 4
Edit	W1	Integer	-	$>=10, <=30$		25	Week 1 attendance
Edit	W2	Integer	-	$>=20, <=40$		31	Week 2 attendance
Edit	W3	Integer	-	$>\sim W1, <=50$		48	Week 3 attendance
Edit	W4	Integer	-	$>\sim W2, <\sim W3$		45	Week 4 attendance

4. Enter the question.

Insert a table with 1 row and 2 columns in the question area, like you did in Example 9A. Type the problem statement in the left cell of the table.

Next, put your cursor in the right cell of the table, and click the Bar Chart button in the Math Objects toolbar. In the Edit Bar Chart window, customize the settings as follows:

Tab	Item	Value
Axis	Maximum	50
	Tick Spacing	2
	Label Every	5 Ticks

Next, click on the Bars tab. You will enter each bar of the bar chart by clicking the Add button and entering the following specifications.

Bar	Value	Bar Label
1	$\sim W1$	Week 1
2	$\sim W2$	Week 2
3	$\sim W3$	Week 3
4	$\sim W4$	Week 4


Notice that the program automatically selects a different color for each bar and enters the label and value in the legend. Click Save to finish.

In the question area, move your cursor over the vertical line between the two table cells until your cursor changes to a double arrow. Press the left mouse button down and move the cell boundary to the right so that the right cell just fits around the bar chart. Your problem statement should now look like this.

The attendance at the weekly meetings of a community forum is shown on the bar chart on the right. Use this bar chart to answer the following questions.

a) What is the percent increase in the attendance from Week 2 to Week 4?

b) What is the percent decrease in the attendance from Week 3 to Week 4?



Week	Attendance
Week 1	25
Week 2	32
Week 3	48
Week 4	45

In the answer area, enter the answer prompts, as shown below.

a) The percent increase in the attendance from Week 2 to Week 4 is
(Write your answer as a percent rounded to the nearest hundredth.)

b) The percent decrease in the attendance from Week 3 to Week 4 is
(Write your answer as a percent rounded to the nearest hundredth.)

Enter a short answer box at the end of each sentence. In the answer box for part a), select the answer rule "Accept integer or decimal equivalents only." and enter the answer as ~Pinc. Set the answer format to display 2 decimal places. Similarly, enter ~Pdec in the short answer box for part b).

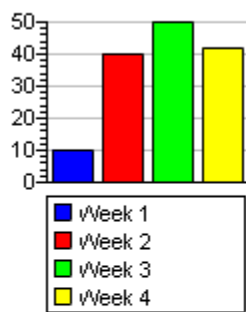
5. Test the question.

Preview and test the question.

The attendance at the weekly meetings of a community forum is shown on the bar chart on the right. Use this bar chart to answer the following questions.

a) What is the percent increase in the attendance from Week 2 to Week 4?

b) What is the percent decrease in the attendance from Week 3 to Week 4?



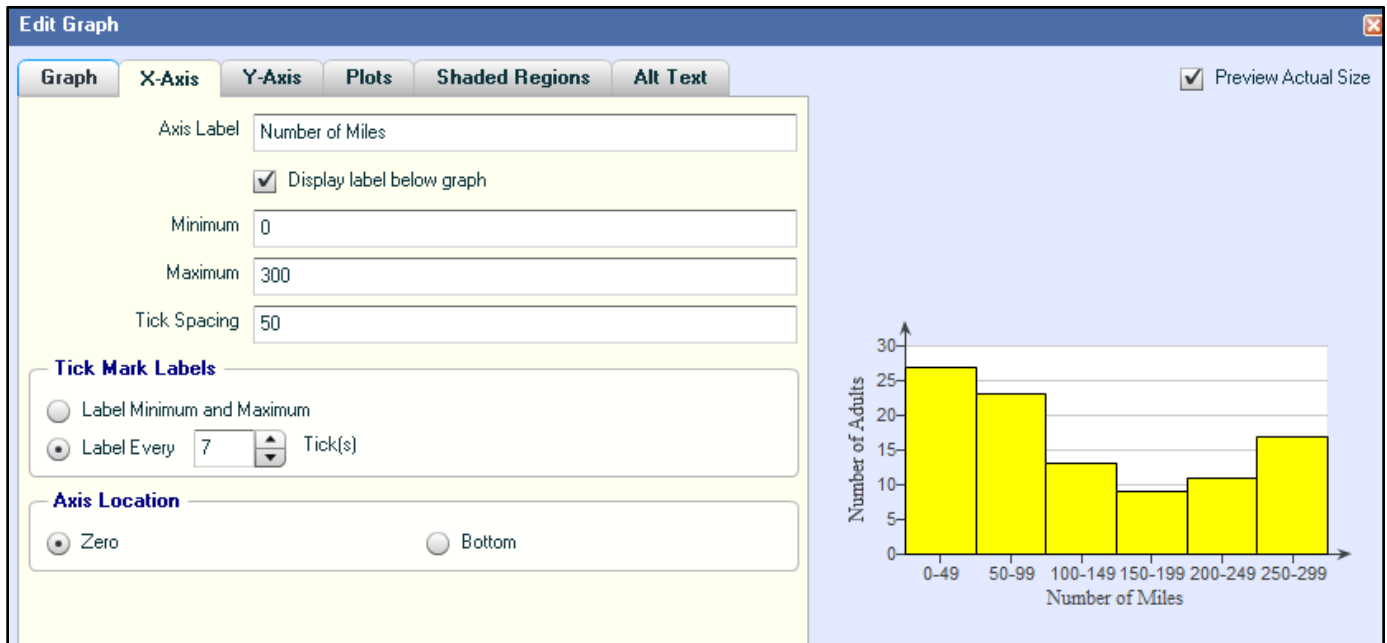
Week	Attendance
Week 1	10
Week 2	40
Week 3	50
Week 4	42

a) The percent increase in the attendance from Week 2 to Week 4 is %.
(Write your answer as a percent rounded to the nearest hundredth.)

b) The percent decrease in the attendance from Week 3 to Week 4 is %.
(Write your answer as a percent rounded to the nearest hundredth.)

6. Save the question.

7. If you wanted to create a histogram instead, you would need to modify the values for the intervals.

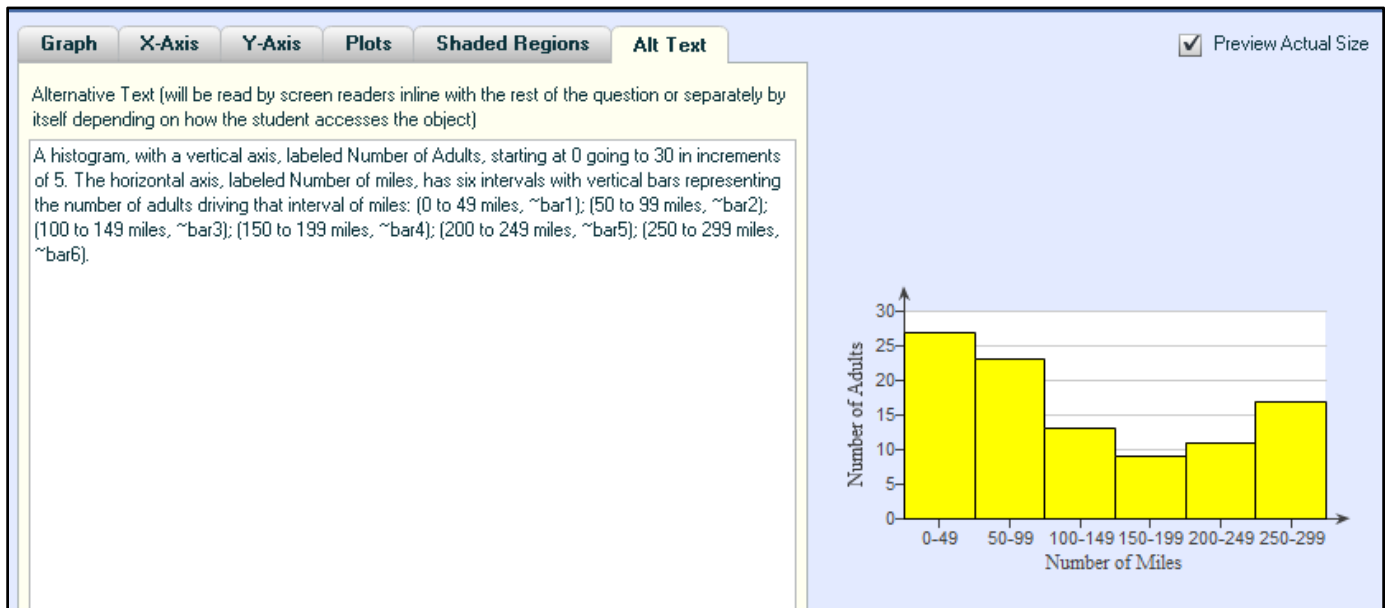


The variable constraints are defined to enable a bar to touch the adjacent bar.

Algorithmic Values List							
Edit Add Duplicate Delete Regenerate algorithmic values							
	Name 1 ▲	Type	Format	Constraints	Link ID	Value	Authoring Notes
Edit	diflo	Integer	#	=~dif-1		13	
Edit	Hi	Text or Sy..		=~m1 ?(~a2>~a1) , =~m2		50-99	
Edit	Lo	Text or Sy..		=~m1,~m2, <>~Hi		150-199	
Edit	m1	Text or Sy..		=~0-49' ?(~a1=~bar2) , =~50-99' ?(~a1=~bar3) , =~100-149' ?(~a1=~bar4) , =~150-199' ?(~a1=~bar5) , =~200-249' ?(~a1=~bar6) , =~250-299'		150-199	
Edit	m2	Text or Sy..		=~0-49' ?(~a2=~bar2) , =~50-99' ?(~a2=~bar3) , =~100-149' ?(~a2=~bar4) , =~150-199' ?(~a2=~bar5) , =~200-249' ?(~a2=~bar6) , =~250-299'		50-99	
Edit	total	Integer	#	=100		100	

Close
Help

Note alternative text is included for screen readers.



LESSON 10 – USE A COMBINATION OF TOOLS AND TECHNIQUES

In this lesson, you will walk through the steps for writing a more complicated custom question that will use a variety of tools and techniques. Additionally, instead of completely designing the question at the start of the process, you will model the process of experimentation, where you may need to revise algorithms as you develop the question.

1. Design the question.

In this question, students are asked to solve a quadratic equation of the form: $u^2 + Cu + D = 0$, where U is the expression $Ex + F$. You begin the design process by defining the algorithmic values for the solutions to the quadratic equation in u , $\sim A$ and $\sim B$. The quadratic equation in x will be: $(Ex + F)^2 + C(Ex + F) + D = 0$ with solutions $x = \frac{A - F}{E}$ and $x = \frac{B - F}{E}$.

You'll define the algorithmic values as follows:

Name	Definition	Constraints
$\sim A$	1st solution to quadratic equation in u	integer between (and including) -10 and 10, not equal to 0
$\sim B$	2nd solution to quadratic equation in u	integer between (and including) -10 and 10, not equal to 0
$\sim C$	coefficient of u in quadratic equation in u	integer, equal to $-(\sim A + \sim B)$
$\sim D$	constant term in quadratic equation in u	integer, equal to $\sim A * \sim B$
$\sim E$	coefficient of linear factor $(Ex + F)$ in quadratic equation in x	integer between (and including) 1 and 10
$\sim F$	constant term of linear factor $(Ex + F)$ in quadratic equation in x	integer between (and including) 1 and 10
$\sim \text{num1}$	numerator of 1st solution	integer, equal to $\sim A - \sim F$
$\sim \text{num2}$	numerator of 2nd solution	integer, equal to $\sim B - \sim F$
$\sim \text{den}$	denominator of both solutions	integer, equal to $\sim E$
$\sim \text{ans1}$	1st solution to quadratic equation in x	algebraic expression, equal to $\sim \text{num1} / \sim \text{den}$
$\sim \text{ans2}$	2nd solution to quadratic equation in x	algebraic expression, equal to $\sim \text{num2} / \sim \text{den}$


2. Create a new question.

Start with a new template and choose the Top/Bottom layout.

Instead of going through each step of the question creation process separately, you will model the following process of experimentation:

- Enter the algorithmic values
- Enter the question
- Test the question
- Revise/add algorithmic values
- Revise the question
- Test the question
- Revise/add algorithmic values
- Revise the question
- etc

After you have entered the initial set of algorithmic values, problem statement and answer, here's what the question should look like.




Find all real solution(s) of the equation.

$$(\sim Ex + \sim F)^2 + \sim C(\sim Ex + \sim F) + \sim D = 0$$

The solutions are $\sim ans1, \sim ans2$

When entering the short answer, use the answer rule "Accept fully-reduced form", and be sure to check the box in Step 2 for "All solutions listed above are required for the correct answer."

Regenerate the algorithmic values several times. Notice that sometimes the equation displays correctly, like this:



Find all real solution(s) of the equation.

$$(7x + 1)^2 + 9(7x + 1) + 14 = 0$$

The solutions are $-\frac{3}{7}, -\frac{8}{7}$

In other versions, the coefficient of the second term could be negative, 1, or -1, the third term could be negative, or the coefficient of x could be 1.



Find all real solution(s) of the equation.

$$(1x + 5)^2 + -3(1x + 5) + -40 = 0$$

To display these values correctly, you will define new algorithmic values using the IFTHEN function to choose when to display the sign or coefficient. Refer to Lesson 1 if you need to refresh your memory of how this is done. Here's the list of algorithmic values you will add.

Name	Definition	Constraints
$\sim Csign$	Used to display the sign of C correctly	$IFTHEN(\sim C > 0, "+", "")$
$\sim Cterm$	Used to display the coefficient C correctly	$IFTHEN(\sim C = 1, "", IFTHEN(\sim C = -1, "-", "\sim C"))$
$\sim Dsign$	Used to display the sign of D correctly	$IFTHEN(\sim D > 0, "+", "")$
$\sim Dterm$	Used to display the coefficient E correctly	$IFTHEN(\sim E = 1, "", IFTHEN(\sim E = -1, "-", "\sim E"))$

Next, edit the equation and insert these algorithmic values in the appropriate locations.

Find all real solution(s) of the equation.

$$(\sim\text{Etermx} + \sim\text{F})^2 \sim\text{Csign} \sim\text{Cterm}(\sim\text{Etermx} + \sim\text{F}) \sim\text{Dsign} \sim\text{D} = 0$$

Find all real solution(s) of the equation.

$$(x + 3)^2 - 3(x + 3) - 70 = 0$$

Now that you have fixed the display issue, notice that sometimes the coefficient of the second term is 0.

Find all real solution(s) of the equation.

$$(10x + 7)^2 0(10x + 7) - 9 = 0$$

This occurs when $\sim A$ is equal to the opposite of $\sim B$. There are two ways of resolving this issue. The first solution is to constrain $\sim A$ and $\sim B$ so that they cannot be opposites. The second solution is to hide the second term when the coefficient is equal to 0. For illustrative purposes, this lesson shows you how to hide the second term. Create a new algorithmic value, $\sim\text{term2}$, to represent the second term.

$$\sim\text{term2} = \text{IFTHEN}(\sim\text{C}=0, "", "\sim\text{Csign} \sim\text{Cterm}(\sim\text{Etermx} + \sim\text{F})")$$

Edit the equation as follows.

Find all real solution(s) of the equation.

$$(\sim\text{Etermx} + \sim\text{F})^2 \sim\text{term2} \sim\text{Dsign} \sim\text{D} = 0$$

Find all real solution(s) of the equation.

$$(10x + 7)^2 - 9 = 0$$

Continue testing to see if there are any more display errors in the problem statement. Once you are satisfied that the equation displays correctly, turn your focus to the two solutions to the equation. Regenerate the question several times, and notice that sometimes the solutions are identical. To resolve this issue, you could constrain $\sim A$ and $\sim B$ so that they are not equal to each other. This would in turn ensure that $\sim\text{ans1}$ and $\sim\text{ans2}$ are distinct.

6. Save the question.

APPENDIX A – CUSTOM QUESTION BUILDER FUNCTIONS

Refer to Lessons 1 and 4 of the Custom Question Builder – Advanced tutorials to learn how to use these functions in your custom question.

Simple mathematical functions

Function	Description	Example
ABS(X)	Absolute value of X	$ABS(-3.75) = 3.75$
DIV(A,B)	Integer part of division A/B	$DIV(7,2) = 3$
CEIL(A)	Rounds A to the smallest integer not less than the given number	$CEIL(2.93) = 3$
FLOOR(A)	Rounds A to the largest integer not less than the given number	$FLOOR(2.93) = 2$
GCF(A,B)	Greatest common factor of A and B	$GCF(6,8) = 2$
IFTHEN(A,B,C)	If condition A is true, then the algorithmic value equals B; otherwise, it equals C	See Lesson 1
LCM(A,B)	Least common multiple of A and B	$LCM(6,8) = 24$
MIN(A,B)	Selects smallest number of A or B	$MIN(6,8) = 6$
MAX(A,B)	Selects greatest number of A or B	$MAX(6,8) = 8$
MOD(A,B)	Modulus	$MOD(11,3) = 2$
RTX(N,X)	nth root of X	$RTX(4,16) = 2$
ROUND(X,P)	Round X to P places	$ROUND(3.14159,-3) = 3.142$
SQRT(X)	Square root of X	$SQRT(16) = 4$
TRUNC(X,P)	Truncate X to P places	$TRUNC(3.14159,-3) = 3.141$
SIMPAB(A,B)	Divide A by the GCF of A and B	$SIMPAB(6,8) = 3$
SIMPBA(A,B)	Divide B by the GCF of A and B	$SIMPBA(6,8) = 4$
GCS(X)	Find the square root of the largest perfect square in X	$GCS(18) = 3$
GCSR(X)	Find the remaining factor after finding GCS(X)	$GCSR(18) = 2$
FRAC2MNUM(A,B,C)	When the value of C is any non-zero number, the fraction part of the mixed number is fully reduced. When C is 0 or not included, then the fraction is not fully reduced.	$FRAC2MNUM(10,4,0) = 2 \frac{2}{4}$ $FRAC2MNUM(10,4,1) = 2 \frac{1}{2}$

Trigonometric mathematical functions

Function	Description
SIN(X)	Sine of X (X must be in radians, result will be a decimal)
COS(X)	Cosine of X (X must be in radians, result will be a decimal)
TAN(X)	Tangent of X (X must be in radians, result will be a decimal)
ARCSIN(X)	Arc sine of X (X must be in the interval $[-1, 1]$, result will be in radians)
ARCCOS(X)	Arc cosine of X (X must be in the interval $[-1, 1]$, result will be in radians)
ARCTAN(X)	Arc tangent of X (X must be a real number, result will be in radians)

Logarithmic mathematical functions

Function	Description
EXP(X)	e^x (result will be a decimal)
LN(X)	Log base e of X (Natural Log)
LOG(X)	Log base 10 of X (Common Log)
LOGX(N,X)	Log base N of X

Miscellaneous mathematical functions

Function	Description
PERM(N,R)	Permutation of R objects chosen from N distinct objects without repetition
COMB(N,R)	Combination of N distinct objects chosen R at a time

Statistical functions

Function	Description
\$Mean(x1,x2,...,xn)	Returns the mean of a series of numbers
\$Median(x1,x2,...,xn)	Returns the median of a series of numbers
\$Mode(x1,x2,...,xn)	Returns the mode of a series of numbers
\$NormCurve(mu,sd,x)	Returns the value on a normal curve with a given mean and standard deviation at x
\$NormDist(x)	Returns the cumulative area under standard normal curve from far left to x
\$StdDev(x1,x2,...,xn)	Returns the standard deviation of a dataset or series of numbers

APPENDIX B – CUSTOM QUESTION BUILDER SYMBOL CODES

Refer to Lesson 2 of the Custom Question Builder – Advanced tutorials to learn how to use these symbol codes in your custom question.

Important: The symbol codes *MUST* include the ampersand (&), and the semicolon (;).

Symbol	Code
α	α
\wedge	∧
\angle	∠
\approx	≈
β	β
\cap	∩
Δ	&cdelta;
¢	¢
Γ	&cgamma;
χ	χ
Λ	&clambda;
Ω	&comega;
\circ	∘
\equiv	≅
Φ	&cphi;
Π	&cpi;
Ψ	&cpsi;
Σ	&csigma;
Θ	&ctheta;
\cup	∪
Υ	&cupsi;
Ξ	&cxi;
$^\circ$	°
δ	δ
\div	÷
\downarrow	↓
\emptyset	∅
ε	ε
η	η
€	€
\exists	&exists;
\forall	∀
γ	γ
\geq	≥
$>$	>
\in	∈
∞	&inf;
\int	&integral;
ι	ι
κ	κ
λ	&lambd;
\langle	⟨
\leq	≤
\leftarrow	←

Symbol	Code
\neg	&lognot;
$<$	<
—	—
μ	μ
\neq	≠
\notin	∉
$\not\subset$	¬prosubset;
\nsubseteq	¬subset;
ν	ν
ω	ω
ξ	ο
\oplus	⊕
\vee	∨
\otimes	⊗
∂	&partial;
ϕ	φ
φ	ϕ
π	π
ϖ	ϖ
\pm	&plusminus;
£	£
\subset	&prosubset;
ψ	ψ
\rangle	⟩
ρ	ρ
\rightarrow	→
σ	σ
ς	ς
$\sqrt{\quad}$	&sqrt;
$*$	☆
\subseteq	⊂
Σ	∑
\supset	⊃
\supseteq	⊇
τ	τ
θ	θ
ϑ	ϑ
\sim	˜
\times	×
\uparrow	↑
υ	υ
ξ	ξ
¥	¥
ζ	ζ

APPENDIX C – CUSTOM QUESTION BUILDER TEMPLATE CODES

Refer to Lesson 3 of the Custom Question Builder – Advanced tutorials to learn how to use these template codes in your custom question.

Template	Syntax	Example	Display
Division	@DIV{numerator; denominator}	@DIV{3;4}	$\frac{3}{4}$
Mixed number	@MNUM{whole number part; numerator; denominator}	@MNUM{a;b;c}	$a\frac{b}{c}$
Superscript	@SUP{superscript}	x@SUP{2}	x^2
Subscript	@SUB{subscript}	y@SUB{3}	y_3
Square root	@RT{radicand}	@RT{x}	\sqrt{x}
Higher-order root	@RT{radicand; index}	@RT{x;3}	$\sqrt[3]{x}$
Absolute value	@ABS{value}	@ABS{ab}	$ ab $