## The Golden Ratio

The ancient Greeks constructed rectangles called golden rectangles because they were thought to be pleasing to the eye. A rectangle is considered golden if the dimensions of the rectangle are in a certain ratio.

$$\frac{l}{W} = \frac{l+W}{l}$$

The ratio  $\frac{1}{W}$  is called the golden ratio. A golden rectangle

with length *l* and width *w* has the property that if it is joined to a square of side length / to form a larger rectangle, the length-to-width ratio of the larger rectangle is the same as that of the original rectangle.



## Solve.

- 1. a. Clear the equation of fractions and collect all the terms that contain variables on the left side of the equation.
  - b. Complete the square and solve for / in terms of w. Ignore the negative solution since / must be a positive number. Use the result to find both the exact value of  $\frac{1}{W}$  and a decimal approximation.

- 2. Measure the length and width of a credit card and calculate the ratio of the length and width. Does this closely approximate the golden ratio?
- **3.** a. In the Fibonacci Sequence, {1, 1, 2, 3, 5, 8, 13, 21, 34, ...}, each term from the third term on is the sum of the previous two terms. Make a list of values of the ratio of a term and it predecessor.
  - **b.** What decimal value do these ratios approximate as the list is continued?
- as the list is continued: 4. Consider the continued fraction  $1 + \frac{1}{1 + \frac{1}{1 + \frac{1}{1 + \dots}}}$ .

Round the values to the nearest thousandth. What value do the fractions seem to approach?

	Oballanaa
5-4 Completing the Square (continued)	
You can use a process called completing the square to rewrite	The ancient Greeks constructed rectangles called golden rectangles
a quadratic of the form $x^2 + bx$ as a perfect square trinomial.	because they were thought to be pleasing to the eye. A rectangle is
To complete the Think: Multiply the	considered golden if the dimensions of the rectangle are in a certain ratio. I = I + w
square of $x^2 + bx$ , coefficient of x by (b) <sup>2</sup> 1 $x^2 + bx + (b)^2 - (x + b)^2$	$\overline{W} = -\frac{1}{I}$ The ratio $\frac{1}{I}$ is called the golden ratio A golden rectangle
add $\left(\frac{b}{2}\right)$ . $\frac{1}{2}$ . Then square it. $x + bx + (\frac{1}{2}) - (x + \frac{1}{2})$	with length / and width w has the property that if it is joined
Complete the square: $x^2 - 8x + ?$ .	to a square of side length / to form a larger rectangle, the
<b>Step 1</b> Identify <i>b</i> , the coefficient of $x: b = -8$ .	that of the original rectangle.
Step 2 Find $\left(\frac{b}{2}\right)^2$ : $\left(\frac{b}{2}\right)^2 = \left(\frac{-8}{2}\right)^2 = (-4)^2 = 16$	Solve
$(2) (2) (2) (2)$ Stop 2 Add $(b)^2$ , $x^2$ 8x 1 16	1. a. Clear the equation of fractions and collect all the terms that contain
Step 5 Add $(\overline{2})$ . $x = 6x + 10$	variables on the left side of the equation.
Step 4 Factor: $x^2 - 8x + 16 = (x - 4)^2$	$l^{2} = wl + w^{2}, l^{2} - wl - w^{2} = 0$
Check: $(x - 4)^2 = (x - 4)(x - 4)$ Use $\frac{b}{2}$ as a factor.	<b>b.</b> Complete the square and solve for <i>I</i> in terms of <i>w</i> . Ignore the negative solution since <i>I</i> must be a positive number. Use the result to find both the
$= x^2 - 8x + 16 \checkmark$	exact value of $\frac{1}{2}$ and a decimal approximation.
Complete each square and factor.	$W^{2}$ and $W^{2}$ $W^{2}$ $W^{2}$
<b>5.</b> $x^2 + 9x + ?$ <b>6.</b> $x^2 - 4x + ?$	$I - WI = W, I - WI + \left(\frac{W}{2}\right) = W + \left(\frac{W}{2}\right),$
$b = 9 \cos \frac{b}{2} = \frac{9}{2}$ $b = -4 \sin \frac{b}{2} = -2$	$(I - \frac{W}{2})^2 = \frac{5W^2}{2}, I - \frac{W}{2} = \frac{\sqrt{5}W}{2}, I = \frac{1 + \sqrt{5}}{2}W, I \cong 1.618W$
8 - 3, 30 2 - <u>2</u>	
$(\underline{b})^2 = \frac{0}{4}$ $(\underline{b})^2 = 4$	2. Measure the length and width of a credit card Possible answer: The ratio of
(2) (2)	and calculate the ratio of the length and width. length to width is about 1.588, a
$x^2 + 9x + \frac{4}{4}$ $x^2 - 4x + 4$	Does this closely approximate the golden ratio? IITTLE LESS TRAIN THE GOLDEN RATIO.
0	3. a. In the Fibonacci Sequence, {1, 1, 2, 3, 5, 8, 13, 21, 34,}, each term from the third term on is the sum of the previous two terms. Make a list of
$\left(\begin{array}{c} \left(\begin{array}{c} \frac{y}{2}\end{array}\right)^2 & (x-2)^2 \end{array}\right)$	values of the ratio of a term and it predecessor.
	$1, 2, \frac{5}{2}, \frac{5}{3}, \frac{6}{5}, \frac{13}{8}, \frac{21}{13}, \frac{54}{21}, \frac{55}{34}, \dots$
<b>7</b> $y^2 = 10y \pm 2$ <b>8</b> $y^2 \pm 3y \pm 2$	b. What decimal value do these ratios approximate
0	as the list is continued?
$x^2 - 10x + 25$ $x^2 + 3x + \frac{9}{4}$	4. Consider the continued fraction $1 + \frac{1}{1 $
	$1 + \frac{1}{1 + \dots}$
$(x-5)^2$ $(x+\frac{3}{2})^2$	Make a table of decimal values for this fraction when 1 fraction is used, then 2, then 3, and so on. Round the values to the nearest thousandth. What value do the fractions seem to approach?
\Z/	2, 1.5, 1.667, 1.6, 1.625, 1.615, 1.619, 1.618; they seem to approach the
	golden ratio.
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	<b>Reading Strategy</b>
5-4 Completing the Square	5-4 Use a Model
Sean and Mason run out of gas while fishing from their boat in the	
	Just as some numbers are perfect squares, some quadratic expressions
of 30 meters per second. The height of the flare in meters can be	Just as some numbers are perfect squares, some quadratic expressions are perfect squares.
Last, they set on an energency hate with an initial vertical velocity of 30 meters per second. The height of the flare in meters can be modeled by $h(t) = -5t^2 + 30t$ , where <i>t</i> represents the number of seconds after launch.	Just as some numbers are perfect squares, some quadratic expressions are perfect squares. $(x + 2)^2 = x^2 + 4x + 4$ Perfect square
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bay, they set out, the registion of the flare will at initial vertical verticity of 30 meters per second. The height of the flare in meters can be modeled by $h(t) = -5t^2 + 30t$ , where t represents the number of seconds after launch.         1. Sean thinks the flare should reach at least 15 meters to be seen from the shore. They want to know how long the flare will take to reach this height.         a. Write an equation to determine how long it will take the flare to reach 15 meters.         b. Simplify the function so you can complete the square.         c. Solve the equation by completing the square.         d. Mason thinks that the flare will reach 15 meters in 5.4 seconds. Is he correct? Explain.         Possible answer: He is partially correct. The flare will first reach 15 meters at 0.6 second after firing and then again at 5.4 seconds. (The function has two solutions.)         e. Sean thinks the flare will reach 15 meters concert? Explain.         Possible answer: He is correct. The flare will first reach 15 meters at 0.6 second after firing and then again at 5.4 seconds. (The function has two solutions.)         e. Sean thinks the flare will reach 15 meters concert? Explain.         Possible answer: He is correct. The flare will first reach 15 meters at 0.6 second 3 fler firing. Also, the difference between 5.4 and 0.6 seconds. (the two solutions) is 4.8 seconds, which is about 5 seconds.	Just as some numbers are perfect squares, some quadratic expressions are perfect squares. $(x + 2)^2 = x^2 + 4x + 4$ Perfect square You can model this expression with the area of algebra tiles. You can use three types of tiles. Idgebraic       Type of Tile       Model $x^2$ Square with sides x       x $(x + 2)^2 = x^2 + 4x + 4$ $x^2$ Square with sides x       x $(x + 2)^2 = x^2 + 4x + 4$ $x$ Rectangle with sides x and 1       x $(x + 2)^2 = x^2 + 4x + 4$ $x$ Rectangle with sides x and 1       1 $x^2$ x         1       Square with sides 1       1       1       1         You can make a quadratic expression $x^2 + bx$ into a perfect square.       Perfect Square $x^2$ $x$
bay, they set out a reinergency hate with a finite in meters can be modeled by $h(t) = -5t^2 + 30t$ , where t represents the number of seconds after launch.         1. Sean thinks the flare should reach at least 15 meters to be seen from the shore. They want to know how long the flare will take to reach this height.         a. Write an equation to determine how long it will take the flare to reach 15 meters.         b. Simplify the function so you can complete the square.         c. Solve the equation by completing the square.         d. Mason thinks that the flare will reach 15 meters in 5.4 seconds. Is he correct? Explain.         Possible answer: He is partially correct. The flare will first reach 15 meters at 0.6 second after firing and then again at 5.4 seconds. In the will stay above 15 meters for about 5 seconds. Is he correct? Explain.         e. Sean thinks the flare will reach 15 meters sooner, but then the flare will first reach 15 meters at 0.6 second after firing and then again at 5.4 seconds. In the second society is correct. The flare will first reach 16 second after firing. Also, the difference between 5.4 and 0.6 seconds. (the two solutions) is 4.8 seconds, which is about 5 seconds.         2. Sean wants to know how high the flare will each above the surface of the water.         e. Write the surface is partially correct. The flare will first reach 15 meters at 0.6 seconds.	Just as some numbers are perfect squares, some quadratic expressions are perfect squares. $(x + 2)^2 = x^2 + 4x + 4$ Perfect square You can model this expression with the area of algebra tiles. You can use three types of tiles. Algebraic       Type of Tile       Model $x^2$ Square with sides x       x $(x + 2)^2 = x^2 + 4x + 4$ $x^2$ Square with sides x       x $(x + 2)^2 = x^2 + 4x + 4$ $x$ Rectangle with sides x and 1       x $(x + 2)^2 = x^2 + 4x + 4$ $x$ Rectangle with sides x and 1       1 $x^2$ x         1       Square with sides 1       1       1       1         You can make a quadratic expression $x^2 + bx$ into a perfect square.       Perfect Square         Not a Perfect Square $x^2 + bx$ $x$ $x^2 + bx + \frac{b^2}{4} = (x + \frac{1}{2}b)^2$
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