

# Quadratic Applications and Modeling

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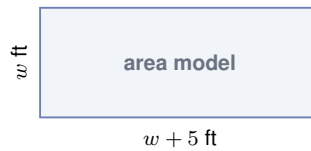
## Quick Review

Quadratic models are useful when a situation has a maximum, a minimum, an area made from two changing dimensions, or a path that curves like a parabola. The **vertex** answers highest, lowest, or best-value questions. The **zeros** answer break-even, landing-time, and ground-level questions. Always read the meaning of the variable before choosing an answer, and reject values that do not make sense in the situation.

## PRACTICE

Read each application carefully and answer the question.

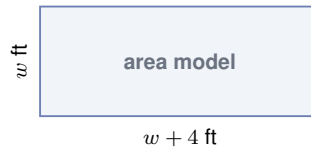
1. A rectangular stage has area  $84 \text{ ft}^2$ . Its length is 5 ft more than its width. Find the width.



Width	Length	Area equation
$w$	$w + 5$	$w(w + 5) = 84$

Answer: \_\_\_\_\_

2. A garden has area  $96 \text{ ft}^2$ . Its length is 4 ft more than its width. Find the dimensions.



Width	Length	Area equation
$w$	$w + 4$	$w(w + 4) = 96$

Answer: \_\_\_\_\_

3. A poster has area  $150 \text{ in}^2$ . Its length is 5 in less than twice its width. Find the width.



Width	Length	Area equation
$w$	$2w - 5$	$w(2w - 5) = 150$

Answer: \_\_\_\_\_



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4. Two consecutive positive integers have product 72. Find the integers.

Smaller integer	Next integer	Product
$n$	$n + 1$	$n(n + 1) = 72$

Answer: \_\_\_\_\_

5. A number is multiplied by a number 6 greater than itself, and the product is 16. Find all possible values.

Number	Number plus 6	Product
$x$	$x + 6$	$x(x + 6) = 16$

Answer: \_\_\_\_\_

6. A ball's height in feet is  $h(t) = -16t^2 + 48t + 4$ . Find the starting height.

Time	0	1	2
Height		36	36

What starting height means

Use  $t = 0$  because the ball has just been thrown.

Answer: \_\_\_\_\_

7. A rocket's height in feet is  $h(t) = -16t^2 + 64t + 80$ . When does it land?

Time	0	2	4	5
Height	80	144	80	

Answer: \_\_\_\_\_

8. A ball's height in feet is  $h(t) = -16t^2 + 32t$ . Find the maximum height.

Time	0	1	2
Height	0		0

Vertex time

$$t = -\frac{b}{2a} = -\frac{32}{2(-16)} = 1$$

Answer: \_\_\_\_\_

9. A store's revenue from selling one item is modeled by  $R(p) = -2p^2 + 40p$ , where  $p$  is the price in dollars. Find the price that gives the greatest revenue.

Price $p$	6	8	10	12	14
Revenue $R(p)$	168	192		192	168

Answer: \_\_\_\_\_



10. Profit is modeled by  $P(x) = -x^2 + 12x - 20$ . Find the break-even values.

$x$	0	2	6	10	12
$P(x)$	-20		16		-20

Answer: \_\_\_\_\_

11. A rectangular animal pen uses a wall as one side. The area is  $A = x(40 - 2x)$ , where  $x$  is the width. Find the width for maximum area.



Width $x$	5	10	15
Area $A$	150		150

Answer: \_\_\_\_\_

12. A 10 ft by 6 ft garden gets a border of width  $x$  around all sides. The total area is  $96 \text{ ft}^2$ . Find  $x$ .



Outer length	Outer width	Area equation
$10 + 2x$	$6 + 2x$	$(10 + 2x)(6 + 2x) = 96$

Answer: \_\_\_\_\_

13. A square's side length grows from  $s$  cm to  $s + 3$  cm. The new area is  $121 \text{ cm}^2$ . Find the original side length.



New side	New area
$s + 3$	$(s + 3)^2 = 121$

Answer: \_\_\_\_\_

14. A ball's height in meters is  $h(t) = -5t^2 + 20t + 1$ . Find the maximum height.

Time	0	1	2	3	4
Height	1	16		16	1

Answer: \_\_\_\_\_



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15. A football's height in feet is  $h(t) = -16t^2 + 96t$ . How long is it in the air?

Time	0	3	6
Height	0	144	

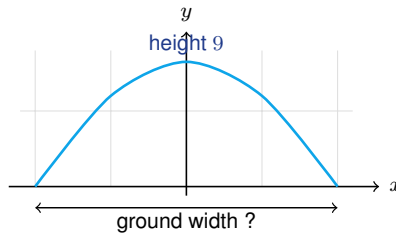
Answer: \_\_\_\_\_

16. A company models profit with  $P(x) = -0.5x^2 + 30x - 200$ . Find the value of  $x$  that maximizes profit.

$x$	20	30	40
$P(x)$	200		200

Answer: \_\_\_\_\_

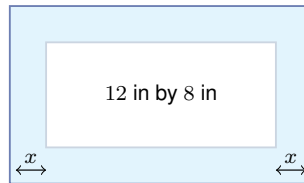
17. A bridge arch is modeled by  $y = -\frac{1}{25}x^2 + 9$ . Find its ground-level width.



Ground level means
Set $y = 0$ and find both $x$ -intercepts.

Answer: \_\_\_\_\_

18. An 8 in by 12 in photo gets a frame of width  $x$  around all sides. The total area is  $192 \text{ in}^2$ . Find  $x$ .



Outer length	Outer width	Area equation
$12 + 2x$	$8 + 2x$	$(12 + 2x)(8 + 2x) = 192$

Answer: \_\_\_\_\_

19. A square's area equals its perimeter. Find the positive side length  $x$ .



Area	Perimeter	Equation
$x^2$	$4x$	$x^2 = 4x$

Answer: \_\_\_\_\_



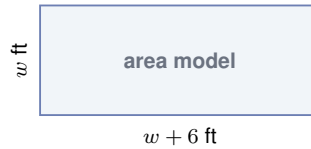
20. A drone's height in meters is  $h(t) = -4.9t^2 + 19.6t + 14.7$ . Find the maximum height.

Time	0	1	2	3	4
Height	14.7	29.4		29.4	14.7

Answer: \_\_\_\_\_

◆ Word Problems

21. A mural is painted on a rectangular wall. The area is  $160 \text{ ft}^2$ , and the length is 6 ft more than the width. Find the mural's dimensions.



Width	Length	Area equation
$w$	$w + 6$	$w(w + 6) = 160$

Answer: \_\_\_\_\_

22. A theater models ticket revenue with  $R(p) = -25p^2 + 600p$ , where  $p$  is the ticket price in dollars. Find the price that gives maximum revenue.

Price $p$	8	10	12	14	16
Revenue	3200	3500		3500	3200

Answer: \_\_\_\_\_



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◆ Word Problems

23. A 5 in by 7 in photo has a frame of width  $x$  around all sides. The total area is  $99 \text{ in}^2$ . Find the border width.



Outer length	Outer width	Area equation
$7 + 2x$	$5 + 2x$	$(7 + 2x)(5 + 2x) = 99$

Answer: \_\_\_\_\_

24. A bridge arch is modeled by  $y = -\frac{1}{16}x^2 + 25$ , with the road at  $y = 0$ . Find the arch height and the ground-level width.



Feature	What it tells you
Vertex	maximum height
$x$ -intercepts	ground-level width

Answer: \_\_\_\_\_



## Answer Keys

- |                          |                                  |
|--------------------------|----------------------------------|
| 1. 7 ft                  | 13. 8 cm                         |
| 2. 8 ft by 12 ft         | 14. 21 m                         |
| 3. 10 in                 | 15. 6 sec                        |
| 4. 8 and 9               | 16. $x = 30$                     |
| 5. 2 or $-8$             | 17. 30 units                     |
| 6. 4 ft                  | 18. 2 in                         |
| 7. 5 sec                 | 19. $x = 4$                      |
| 8. 16 ft                 | 20. 34.3 m                       |
| 9. \$10                  | 21. 10 ft by 16 ft               |
| 10. $x = 2$ and $x = 10$ | 22. \$12                         |
| 11. 10 ft                | 23. 2 in                         |
| 12. 1 ft                 | 24. 25 units high, 40 units wide |

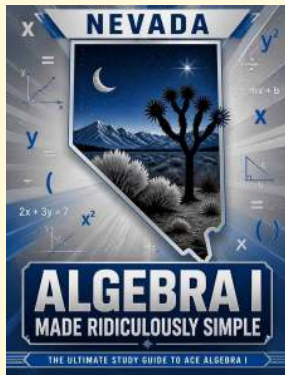
### Step-by-Step Tutor Notes

1. The rectangle gives  $w(w + 5) = 84$ . After factoring,  $(w + 12)(w - 7) = 0$ . A width cannot be negative, so  $w = 7$  ft.
2. Set up  $w(w + 4) = 96$ . This factors as  $(w + 12)(w - 8) = 0$ , so the usable width is 8 ft and the length is 12 ft.
3. The model is  $w(2w - 5) = 150$ . Solving  $2w^2 - 5w - 150 = 0$  gives  $w = 10$  or  $w = -7.5$ . Use 10 in.
4. Let the smaller integer be  $n$ . Then  $n(n + 1) = 72$ , so  $(n + 9)(n - 8) = 0$ . The positive pair is 8 and 9.
5. The equation is  $x^2 + 6x = 16$ . Move everything to one side:  $x^2 + 6x - 16 = 0 = (x + 8)(x - 2)$ . So  $x = 2$  or  $x = -8$ .
6. The starting height is the value at  $t = 0$ .  $h(0) = -16(0)^2 + 48(0) + 4 = 4$  ft.
7. Landing means height 0. Set  $-16t^2 + 64t + 80 = 0$ , which leads to  $(t - 5)(t + 1) = 0$ . The positive time is 5 sec.
8. The vertex gives the maximum. The vertex time is  $t = 1$ , and  $h(1) = -16 + 32 = 16$  ft.
9. The table is symmetric around  $p = 10$ , and the vertex formula also gives  $p = -\frac{40}{2(-2)} = 10$ . The best price is \$10.
10. Break-even means profit is 0. Solve  $-x^2 + 12x - 20 = 0$ , which gives  $x = 2$  and  $x = 10$ .
11. The area model is  $A = -2x^2 + 40x$ . Its vertex is at  $x = -\frac{40}{2(-2)} = 10$ , so the width is 10 ft.
12. The border is added to both ends of each dimension. The model simplifies to  $x^2 + 8x - 9 = 0 = (x + 9)(x - 1)$ , so  $x = 1$  ft.
13. The new side is  $s + 3$ . Since the area is 121,  $(s + 3)^2 = 121$ , so  $s + 3 = 11$  and  $s = 8$  cm.
14. The vertex time is  $t = -\frac{20}{2(-5)} = 2$ . Then  $h(2) = -20 + 40 + 1 = 21$  m.
15. The ball is in the air until it returns to height 0.  $-16t^2 + 96t = -16t(t - 6)$ , so the second zero is 6 sec.
16. The values are symmetric around the vertex. The vertex formula gives  $x = -\frac{30}{2(-0.5)} = 30$ .
17. At ground level,  $0 = -\frac{1}{25}x^2 + 9$ . Then  $x^2 = 225$ , so  $x = -15$  and  $x = 15$ . The full width is 30.
18. The full framed photo has dimensions  $12 + 2x$  by  $8 + 2x$ . The equation simplifies to  $(x + 12)(x - 2) = 0$ , so  $x = 2$  in.
19. Area equals perimeter gives  $x^2 = 4x$ . Then  $x(x - 4) = 0$ . The positive side length is 4.
20. The vertex time is  $t = -\frac{19.6}{2(-4.9)} = 2$ . Substitute to get  $h(2) = 34.3$  m.
21. Let the width be  $w$ . Then  $w(w + 6) = 160$ , so  $(w + 16)(w - 10) = 0$ . Use  $w = 10$ , and the length is 16 ft.
22. The maximum is at the vertex.  $p = -\frac{600}{2(-25)} = 12$ , so the best price is \$12.
23. Use  $(5 + 2x)(7 + 2x) = 99$ . This simplifies to  $x^2 + 6x - 16 = 0 = (x + 8)(x - 2)$ . The border is 2 in.
24. The vertex is at  $(0, 25)$ , so the height is 25. For ground level, set  $y = 0$  to get  $x = \pm 20$ , so the full width is 40 units.



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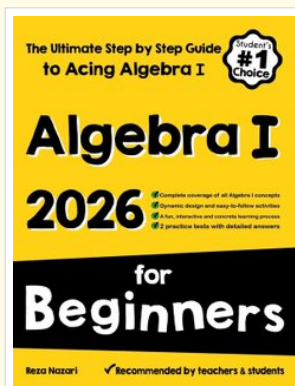
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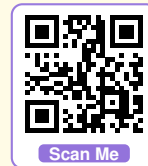
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