

Multiplying and Dividing Functions

Name: _____

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Q Quick Review

To **multiply** two functions, multiply their outputs at each input: $(f \cdot g)(x) = f(x) \cdot g(x)$. To **divide**, divide the outputs: $(f/g)(x) = \frac{f(x)}{g(x)}$, valid wherever $g(x) \neq 0$. The new function still has x as its input.

Degree adds when you multiply. Two linear functions multiplied give a quadratic: $(x + 2)(x - 3) = x^2 - x - 6$. A linear times a quadratic gives a cubic.

Domains. The product $f \cdot g$ is defined on the intersection of the two domains. The quotient f/g has one extra restriction: throw out any x where $g(x) = 0$. *Even if the expression simplifies and the canceled factor disappears, the original quotient is still undefined at that input.* For instance, $\frac{x^2 - 9}{x - 3}$ simplifies to $x + 3$ on its natural domain, but $x = 3$ is excluded because the *original* denominator was zero there.

Common slip. Division is not commutative: f/g and g/f are reciprocals of each other. And $(f \cdot g)(c)$ equals $f(c) \cdot g(c)$ — evaluate first, then multiply — which is often quicker than expanding.

PRACTICE

Multiply or divide and simplify. Note any excluded inputs.

- $f(x) = x + 2$, $g(x) = x - 3$; $(f \cdot g)(x)$ _____
- $f(x) = 6x^2$, $g(x) = 3x$; $(f/g)(x)$, $x \neq 0$ _____
- The tables give f and g . Find $(f \cdot g)(3)$. _____

| | | | | |
|--------|---|---|---|---|
| x | 1 | 2 | 3 | 4 |
| $f(x)$ | 3 | 5 | 7 | 9 |

| | | | | |
|--------|----|----|----|---|
| x | 1 | 2 | 3 | 4 |
| $g(x)$ | -3 | -2 | -1 | 0 |

- $f(x) = x^2 - 9$, $g(x) = x - 3$; $(f/g)(x)$, $x \neq 3$ _____
- $f(x) = -3x$, $g(x) = x^2 + 2$; $(f \cdot g)(x)$ _____
- $f(x) = x^2 - 4$, $g(x) = x - 2$; domain of (f/g) _____
- $f(x) = 2x - 3$, $g(x) = x + 4$; $(f \cdot g)(x)$ _____
- $f(x) = x^2 - 1$, $g(x) = x + 1$; $(f/g)(x)$, $x \neq -1$ _____
- $f(x) = x$, $g(x) = x$; $(f \cdot g)(x)$ _____
- $f(x) = 2x$, $g(x) = 5x - 1$; $(f \cdot g)(x)$ _____
- $f(x) = x^2 + x$, $g(x) = x$; $(f/g)(x)$, $x \neq 0$ _____
- $D(t) = 60t$ (miles), $T(t) = t$ (hours). Average speed for $t > 0$: _____



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13. The tables give f and g . Find $(f \cdot g)(0)$. _____

| | | | | |
|--------|---|---|---|----|
| x | 0 | 1 | 2 | 3 |
| $f(x)$ | 1 | 4 | 7 | 10 |

| | | | | |
|--------|----|----|----|---|
| x | 0 | 1 | 2 | 3 |
| $g(x)$ | -5 | -3 | -1 | 1 |

14. $f(x) = x^2 + 5x + 6$, $g(x) = x + 2$; $(f/g)(x)$, $x \neq -2$ _____

15. $f(x) = x - 2$ and $g(x) = x + 2$. Does $(f \cdot g)(x) = x^2 - 4$? _____

16. $f(x) = 4x^2$, $g(x) = 2x^3$; $(f \cdot g)(x)$ _____

17. $f(x) = \sqrt{x}$, $g(x) = \sqrt{x}$; $(f \cdot g)(x)$, $x \geq 0$ _____

18. $f(x) = x + 1$, $g(x) = x^2 - 1$. Simplify $(g/f)(x)$. _____

19. The tables give f and g . Find $(f \cdot g)(2)$. _____

| | | | | |
|--------|---|---|---|---|
| x | 0 | 1 | 2 | 3 |
| $f(x)$ | 3 | 5 | 7 | 9 |

| | | | | |
|--------|----|---|---|---|
| x | 0 | 1 | 2 | 3 |
| $g(x)$ | -1 | 0 | 1 | 2 |

20. $f(x) = x^2 - 25$, $g(x) = x - 5$. Simplify $(f/g)(x)$ and state the excluded value. _____

◆ Word Problems

21. A rectangle has length $\ell(x) = 2x + 3$ feet and width $w(x) = x - 1$ feet, where $x > 1$. Write the area function $A(x) = \ell(x) \cdot w(x)$ in standard form, then find $A(5)$. _____

22. A spreadsheet shows distance $D(t) = 60t + 5$ miles and time $T(t) = t$ hours, where $t > 0$. Write the average speed $S(t) = D(t)/T(t)$ in simplified form, then find $S(5)$. _____

23. Let $f(x) = x^2 - 16$ and $g(x) = x - 4$. Simplify $(f/g)(x)$ and state the input that must be excluded. _____

24. A factory's revenue is $R(x) = 5x^2 + 20x$ thousand dollars and the number of units sold is $U(x) = x$ thousand, where $x > 0$. Find the revenue per unit $P(x) = R(x)/U(x)$. _____

Additional Practice

25. If $f(x) = 2x - 5$, find $f(4)$. _____

26. If $g(x) = x^2 + 1$, find $g(-3)$. _____

27. For $f(x) = 3x + 2$, solve $f(x) = 14$. _____

28. Find $(f + g)(x)$ if $f = x + 1$, $g = 2x - 5$. _____

29. Find $(fg)(x)$ if $f = x - 2$, $g = x + 3$. _____

30. Find $f(g(x))$ if $f(x) = 2x$, $g(x) = x + 7$. _____

31. Find the inverse of $f(x) = x - 9$. _____



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32. Find the inverse of $f(x) = 3x + 1$.

33. Domain of $f(x) = \sqrt{x - 4}$.

34. Domain of $f(x) = \frac{1}{x + 6}$.

35. Parent function for $y = |x| + 3$.

36. Shift $y = x^2$ left 4.



Answer Keys

- $x^2 - x - 6$
- $2x$
- -7
- $x + 3$
- $-3x^3 - 6x$
- $\{x \in \mathbb{R} : x \neq 2\}$
- $2x^2 + 5x - 12$
- $x - 1$
- x^2
- $10x^2 - 2x$
- $x + 1$
- 60 mph

Additional Practice Answers

- 3
- 10
- $x = 4$
- $3x - 4$
- $x^2 + x - 6$
- $2x + 14$

- -5
- $x + 3$
- yes
- $8x^5$
- x
- $x - 1, x \neq -1$
- 7
- $x + 5, x \neq 5$
- $A(x) = 2x^2 + x - 3, A(5) = 52 \text{ ft}^2$
- $S(t) = 60 + \frac{5}{t}, S(5) = 61 \text{ mph}$
- $(f/g)(x) = x + 4, x \neq 4$
- $P(x) = 5x + 20$ thousand dollars per thousand units

- $f^{-1}(x) = x + 9$
- $f^{-1}(x) = \frac{x-1}{3}$
- $x \geq 4$
- $x \neq -6$
- $y = |x|$
- $y = (x + 4)^2$

Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

1. FOIL: $x \cdot x + x \cdot (-3) + 2 \cdot x + 2 \cdot (-3) = x^2 - 3x + 2x - 6 = x^2 - x - 6$. Two linear factors give a quadratic.

2. Divide the outputs: $\frac{6x^2}{3x}$. The coefficients give $6 \div 3 = 2$, and the powers subtract: $x^2 \div x = x$. So $(f/g)(x) = 2x$, valid for $x \neq 0$ since $g(0) = 0$.

3. Read at $x = 3$: $f(3) = 7$ and $g(3) = -1$. Multiply the outputs: $(f \cdot g)(3) = 7 \cdot (-1) = -7$. Evaluate first, then multiply.

4. Factor: $x^2 - 9 = (x - 3)(x + 3)$. Cancel $(x - 3)$: $x + 3$. Note: $x = 3$ stays excluded from the domain because the original denominator was zero there.

5. Multiply the outputs: $(-3x)(x^2 + 2)$. Distribute the $-3x$ to each term inside: $-3x \cdot x^2 = -3x^3$ and $-3x \cdot 2 = -6x$. So $(f \cdot g)(x) = -3x^3 - 6x$.

6. Keep the rule visible: $g(x) = 0$ at $x = 2$, so exclude it. Even though the simplified form $x + 2$ is defined at $x = 2$, the original quotient isn't. That gives a quick check on the answer.

7. One steady path is: FOIL: $2x^2 + 8x - 3x - 12 = 2x^2 + 5x - 12$. Middle terms combine. This is the part to check before moving on, because it keeps the answer tied to the original question.

8. Factor the numerator as a difference of squares: $x^2 - 1 = (x - 1)(x + 1)$. Then $\frac{(x - 1)(x + 1)}{x + 1}$ cancels the shared $(x + 1)$, leaving $x - 1$. Keep $x \neq -1$ excluded, since the original denominator was zero there.

9. A careful way to see it: $x \cdot x = x^2$. Multiplying a function by itself squares the output. That gives a quick check on the answer.

10. Multiply the outputs: $(2x)(5x - 1)$. Distribute the $2x$: $2x \cdot 5x = 10x^2$ and $2x \cdot (-1) = -2x$. So $(f \cdot g)(x) = 10x^2 - 2x$.

11. Factor the numerator: $x^2 + x = x(x + 1)$. Then $\frac{x(x + 1)}{x}$ cancels the shared x , leaving $x + 1$. The input $x = 0$ stays excluded because $g(0) = 0$.

12. Start with the key idea: $\frac{D(t)}{T(t)} = \frac{60t}{t} = 60$ mph. Speed is constant, which makes sense for a steady cruise. That gives a quick check on the answer.

13. A careful way to see it: Read down the $x = 0$ column: $f(0) = 1$ and $g(0) = -5$. Multiply: $(f \cdot g)(0) = 1 \cdot (-5) = -5$. That gives a quick check on the answer.

14. Factor the numerator: $x^2 + 5x + 6 = (x + 2)(x + 3)$ (two numbers that multiply to 6 and add to 5). Then $\frac{(x + 2)(x + 3)}{x + 2}$ cancels the shared $(x + 2)$, leaving $x + 3$, with $x \neq -2$ still excluded.

15. One steady path is: $(x - 2)(x + 2)$ is a difference of squares: $x^2 - 4$. Confirmed. That gives a quick check on the answer.

16. Multiply the outputs: $(4x^2)(2x^3)$. Multiply the coefficients ($4 \cdot 2 = 8$) and add the exponents on the shared base ($x^2 \cdot x^3 = x^{2+3} = x^5$). So $(f \cdot g)(x) = 8x^5$.

17. A careful way to see it: $\sqrt{x} \cdot \sqrt{x} = x$ when $x \geq 0$. The radical and its square cancel. This is the part to check before moving on, because it keeps the answer tied to the original question.

18. Keep the rule visible: $\frac{x^2 - 1}{x + 1} = \frac{(x - 1)(x + 1)}{x + 1} = x - 1$. Exclude $x = -1$ since the original denominator was zero there. That gives a quick check on the answer.

19. One steady path is: Read at $x = 2$: $f(2) = 7$ and $g(2) = 1$. Multiply the outputs: $(f \cdot g)(2) = 7 \cdot 1 = 7$. That gives a quick check on the answer.

20. Start with the key idea: $\frac{(x - 5)(x + 5)}{x - 5} = x + 5$, excluding $x = 5$ (the original denominator hits zero there). That gives a quick check on the answer.

21. FOIL: $(2x + 3)(x - 1) = 2x^2 - 2x + 3x - 3 = 2x^2 + x - 3$. At $x = 5$: $A(5) = 50 + 5 - 3 = 52$ square feet. Check: length = 13, width = 4, area = 52. The $x > 1$ restriction keeps the width positive.

22. Divide: $\frac{60t + 5}{t} = 60 + \frac{5}{t}$. At $t = 5$: $S(5) = 60 + 1 = 61$ mph. (The starting five-mile head start gets averaged in: longer trips dilute it, so the speed approaches 60 as t grows.)

23. Factor the numerator: $x^2 - 16 = (x - 4)(x + 4)$. Cancel $(x - 4)$ to get $x + 4$. The crucial bit: the original denominator $x - 4$ is zero at $x = 4$, so $x = 4$ stays out of the domain. The graph of f/g has a hole at $(4, 8)$, not a point.

24. Divide: $\frac{5x^2 + 20x}{x} = \frac{x(5x + 20)}{x} = 5x + 20$ for $x > 0$. So revenue per thousand-unit batch is $5x + 20$ thousand dollars — the more units sold, the higher the price per unit (likely because of premium pricing on high-volume orders).



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