# Multiplying and Dividing Functions

| Name: ______________ | Date: ______________ | Score: ______ / 36 |
|---|---|---|

## 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.*

1. $f(x) = x + 2,\ g(x) = x - 3;\ (f \cdot g)(x)$ ________
2. $f(x) = 6x^2,\ g(x) = 3x;\ (f/g)(x),\ x \neq 0$ ________
3. 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 |

4. $f(x) = x^2 - 9,\ g(x) = x - 3;\ (f/g)(x),\ x \neq 3$ ________
5. $f(x) = -3x,\ g(x) = x^2 + 2;\ (f \cdot g)(x)$ ________
6. $f(x) = x^2 - 4,\ g(x) = x - 2;$ domain of $(f/g)$ ________
7. $f(x) = 2x - 3,\ g(x) = x + 4;\ (f \cdot g)(x)$ ________
8. $f(x) = x^2 - 1,\ g(x) = x + 1;\ (f/g)(x),\ x \neq -1$ ________
9. $f(x) = x,\ g(x) = x;\ (f \cdot g)(x)$ ________
10. $f(x) = 2x,\ g(x) = 5x - 1;\ (f \cdot g)(x)$ ________
11. $f(x) = x^2 + x,\ g(x) = x;\ (f/g)(x),\ x \neq 0$ ________
12. $D(t) = 60t$ (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

| | |
|---|---|
| 1. $x^2 - x - 6$ | 13. $-5$ |
| 2. $2x$ | 14. $x + 3$ |
| 3. $-7$ | 15. yes |
| 4. $x + 3$ | 16. $8x^5$ |
| 5. $-3x^3 - 6x$ | 17. $x$ |
| 6. $\{x \in \mathbb{R} : x \neq 2\}$ | 18. $x - 1,\ x \neq -1$ |
| 7. $2x^2 + 5x - 12$ | 19. $7$ |
| 8. $x - 1$ | 20. $x + 5,\ x \neq 5$ |
| 9. $x^2$ | 21. $A(x) = 2x^2 + x - 3,\ A(5) = 52$ ft$^2$ |
| 10. $10x^2 - 2x$ | 22. $S(t) = 60 + \frac{5}{t},\ S(5) = 61$ mph |
| 11. $x + 1$ | 23. $(f/g)(x) = x + 4,\ x \neq 4$ |
| 12. 60 mph | 24. $P(x) = 5x + 20$ thousand dollars per thousand units |

### Additional Practice Answers

| | |
|---|---|
| 25. $3$ | 31. $f^{-1}(x) = x + 9$ |
| 26. $10$ | 32. $f^{-1}(x) = \frac{x-1}{3}$ |
| 27. $x = 4$ | 33. $x \geq 4$ |
| 28. $3x - 4$ | 34. $x \neq -6$ |
| 29. $x^2 + x - 6$ | 35. $y = \lvert x \rvert$ |
| 30. $2x + 14$ | 36. $y = (x + 4)^2$ |

**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 linears 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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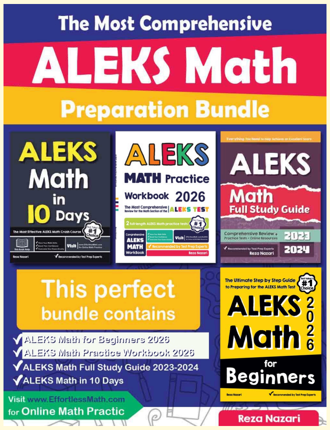


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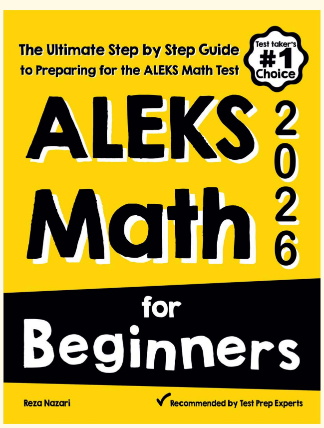


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