Operations with Polynomials

Name: _____	Date: _____	Score: _____ / 33

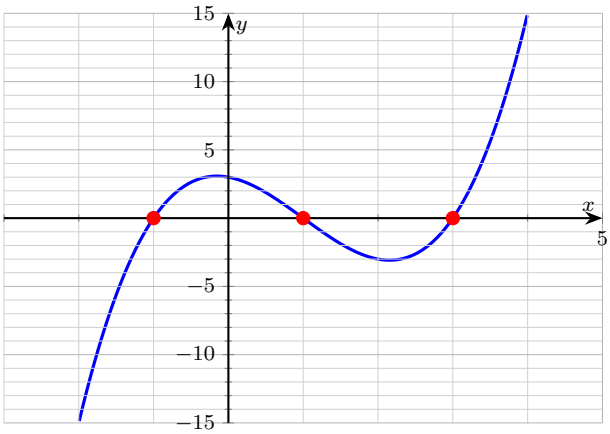
Quick Review

This worksheet ties together every polynomial operation from the chapter: adding, subtracting, multiplying, and combining. The big rules:

- *Addition / subtraction:* combine like terms; for subtraction, distribute the minus to every term in the second polynomial.
- *Multiplication:* distribute each term of one factor across every term of the other. Coefficients multiply; matching variable exponents add.
- *Negative outside parentheses:* flips every sign inside.

Properties: polynomial addition and multiplication are both commutative ($P + Q = Q + P$, $PQ = QP$) and associative. Multiplication distributes over addition. The set of polynomials is closed under $+$, $-$, and $\times$ — but not under division ($1/x$ is not a polynomial).

The graph below shows $f(x) = x^3 - 3x^2 - x + 3$, a cubic with three real zeros at $x = -1, 1, 3$. Notice that these zeros correspond to the factored form $(x+1)(x-1)(x-3)$, which expands back to the original polynomial. Operations and factoring are two sides of the same coin.



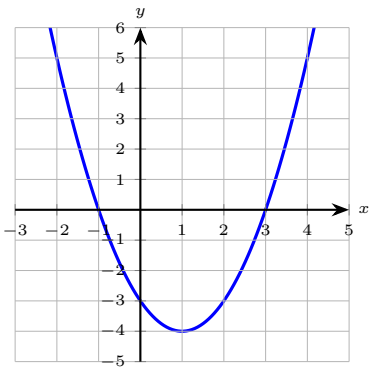
PRACTICE

Perform each polynomial operation. Write answers in standard form.

1. Let $P = x^2 + 3x + 2$ and $Q = 2x^2 - x + 5$. Find $(P + Q)(x)$, then use the table to evaluate $(P + Q)(2)$. _____

x	-1	0	1
P	0	2	6
Q	8	5	6

2. The graph shows the product $R(x) = (x-3)(x+1)$. Use it to read the two x-values where $R(x) = 0$ (where the curve crosses the x-axis). _____



3. Use the FOIL box to expand $(x+5)(x-3)$. _____

$\times$	x	-3
x		
5		

4. $(2x+1)(x-3)+(x^2+5x)$ _____

5. $-(x-2)(x+4)$ _____

6. $(x+1)^2-(x-1)^2$ _____

7. Compute $P^2+3PQ-2Q^2$ where $P=2x+3,\ Q=x-1$ _____

8. Let $D(x)=(2x^2+9x+20)-(x^2+4x+12)$. Simplify $D(x)$, then use the table to predict $D(3)$. _____

x	-2	-1	0	1
$D(x)$	2	4	8	14

9. $(x+4)(2x-1)-2(x+4)$ _____

10. $3(x^2+2x)-(x^2-x+4)$ _____

11. $(x-2)(x+2)+(x-1)^2$ _____

12. $2(x^2-3x)+x(x-5)$ _____

13. $(x+3)^3$ _____

14. $(x^2+x-1)(x-2)$ _____

15. $(3x-2)^2-(2x+1)^2$ _____

16. $(2x+y)^2$ _____

17. Closure: is the product of two polynomials always a polynomial? _____

18. $(x^3+2x)-2x(x^2+1)$ _____

19. $(x+4)(x^2-4x+16)$ _____

20. Compute PR where $P=x+2,\ R=x^2-2x+4$ _____

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Word Problems

21. A company's revenue is $R(x) = 2x^2 + 9x + 20$ thousand dollars, and its cost is $C(x) = x^2 + 4x + 12$ thousand dollars. Write a polynomial for the company's profit $P(x) = R(x) - C(x)$ in standard form. ____

22. A rectangle has length $(x + 5)$ and width $(2x - 3)$. Write its area and perimeter as simplified polynomials. ____

23. Let $A(x) = x + 4$ and $B(x) = 2x - 1$. Compute $A(x)B(x) - 2A(x)$ in standard form. ____

24. A polynomial model is built from $f(x) = x + a$ and $g(x) = x - a$. Show that $f(x)g(x) = x^2 - a^2$ for any constant a. ____

Additional Practice

25. Write $3x - 5 + x^3$ in standard form. _____

26. Find the degree of $7x^4 - 2x^2 + 9$. _____

27. Add $(2x^2 + 3x - 1) + (x^2 - 5x + 4)$. _____

28. Subtract $(5x^2 - x + 6) - (2x^2 + 3x - 1)$. _____

29. Multiply $(x + 4)(x - 3)$. _____

30. Factor $x^2 + 9x + 20$. _____

31. Factor $6x^2 + 9x$. _____

32. Find the GCF of $12x^3$ and $18x^2$. _____

33. Divide $(x^2 + 5x + 6)$ by $(x + 2)$. _____

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Answer Keys

1. $3x^2 + 2x + 7,\ (P+Q)(2) = 23$
2. $x = -1$ or $x = 3$
3. $x^2 + 2x - 15$
4. $3x^2 - 3$
5. $-x^2 - 2x + 8$
6. $4x$
7. $8x^2 + 19x - 2$
8. $x^2 + 5x + 8,\ D(3) = 32$
9. $2x^2 + 5x - 12$
10. $2x^2 + 7x - 4$
11. $2x^2 - 2x - 3$
12. $3x^2 - 11x$
13. $x^3 + 9x^2 + 27x + 27$
14. $x^3 - x^2 - 3x + 2$
15. $5x^2 - 16x + 3$
16. $4x^2 + 4xy + y^2$
17. yes
18. $-x^3$
19. $x^3 + 64$
20. $x^3 + 8$
21. $P(x) = x^2 + 5x + 8$ thousand dollars
22. area $2x^2 + 7x - 15$, perimeter $6x + 4$
23. $2x^2 + 5x - 12$
24. $x^2 - a^2$

Additional Practice Answers

25. $x^3 + 3x - 5$
26. 4
27. $3x^2 - 2x + 3$
28. $3x^2 - 4x + 7$
29. $x^2 + x - 12$
30. $(x + 4)(x + 5)$
31. $3x(2x + 3)$
32. $6x^2$
33. $x + 3$

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

Step-by-Step Explanations

1. Add by degree: $(1+2)x^2+(3-1)x+(2+5) = 3x^2+2x+7$. The table agrees (at $x = 1$, $P+Q = 6+6 = 12 = 3+2+7$). Then $(P+Q)(2) = 12+4+7 = 23$.

2. A product equals zero exactly when one of its factors is zero, so R touches the x-axis wherever a factor vanishes. Read the crossings off the graph: the curve cuts the axis at $x = -1$ and $x = 3$. Check against the factors: $x - 3 = 0$ gives $x = 3$, and $x + 1 = 0$ gives $x = -1$. (Multiplying the factors back out gives the standard form $x^2 - 2x - 3$.)

3. Cells: x^2, $-3x$, $5x$, -15. Combine the middles: $-3x + 5x = 2x$, so the product is $x^2 + 2x - 15$.

4. Start with the key idea: $(2x + 1)(x - 3) = 2x^2 - 5x - 3$. Add $x^2 + 5x$: $(2 + 1)x^2 + (-5 + 5)x - 3 = 3x^2 - 3$. The x-terms cancel. That gives a quick check on the answer.

5. Expand the product first: $(x - 2)(x + 4) = x^2 + 2x - 8$. Now distribute the minus: $-(x^2 + 2x - 8) = -x^2 - 2x + 8$.

6. Expand each square: $(x + 1)^2 = x^2 + 2x + 1$ and $(x - 1)^2 = x^2 - 2x + 1$. Subtract: the x^2 and constant terms cancel, leaving $2x - (-2x) = 4x$.

7. One steady path is: $P^2 = (2x + 3)^2 = 4x^2 + 12x + 9$. $PQ = (2x + 3)(x - 1) = 2x^2 + x - 3$, so $3PQ = 6x^2 + 3x - 9$. $Q^2 = (x - 1)^2 = x^2 - 2x + 1$, so $-2Q^2 = -2x^2 + 4x - 2$. Sum: $(4 + 6 - 2)x^2 + (12 + 3 + 4)x + (9 - 9 - 2) = 8x^2 + 19x - 2$. That gives a quick check on the answer.

8. Subtract term by term: $(2 - 1)x^2 + (9 - 4)x + (20 - 12) = x^2 + 5x + 8$. That matches the table (at $x = 1$, $1 + 5 + 8 = 14$). Then $D(3) = 9 + 15 + 8 = 32$.

9. A careful way to see it: $(x + 4)(2x - 1) = 2x^2 + 7x - 4$. Subtract $2(x + 4) = 2x + 8$: $2x^2 + (7 - 2)x + (-4 - 8) = 2x^2 + 5x - 12$. That gives a quick check on the answer.

10. Keep the rule visible: $3(x^2+2x) = 3x^2+6x$. $-(x^2-x+4) = -x^2+x-4$. Combine: $(3 - 1)x^2 + (6 + 1)x - 4 = 2x^2 + 7x - 4$. That gives a quick check on the answer.

11. One steady path is: $(x - 2)(x + 2) = x^2 - 4$. $(x - 1)^2 = x^2 - 2x + 1$. Sum: $2x^2 - 2x - 3$. This is the part to check before moving on, because it keeps the answer tied to the original question.

12. Start with the key idea: $2(x^2 - 3x) = 2x^2 - 6x$. $x(x - 5) = x^2 - 5x$. Sum: $3x^2 - 11x$. This is the part to check before moving on, because it keeps the answer tied to the original question.

13. A careful way to see it: $(a+b)^3$ with $a = x$, $b = 3$: $x^3+3x^2(3)+3x(9)+27 = x^3 + 9x^2 + 27x + 27$. That gives a quick check on the answer.

14. Keep the rule visible: $x(x^2 + x - 1) = x^3 + x^2 - x$. $-2(x^2 + x - 1) = -2x^2 - 2x + 2$. Sum: $x^3 - x^2 - 3x + 2$. That gives a quick check on the answer.

15. One steady path is: $(3x - 2)^2 = 9x^2 - 12x + 4$. $(2x + 1)^2 = 4x^2 + 4x + 1$. Subtract: $(9 - 4)x^2 + (-12 - 4)x + (4 - 1) = 5x^2 - 16x + 3$. That gives a quick check on the answer.

16. Start with the key idea: $(a + b)^2$ with $a = 2x$, $b = y$: $4x^2 + 2(2x)(y) + y^2$. This is the part to check before moving on, because it keeps the answer tied to the original question.

17. Polynomials are closed under multiplication: any product of polynomials gives another polynomial. Same is true for $+$ and $-$, but not division.

18. Keep the rule visible: $2x(x^2 + 1) = 2x^3 + 2x$. Subtract: $(x^3 - 2x^3) + (2x - 2x) = -x^3 + 0 = -x^3$. That gives a quick check on the answer.

19. Recognize the sum-of-cubes pattern: $(a + b)(a^2 - ab + b^2) = a^3 + b^3$ with $a = x$, $b = 4$ gives $x^3 + 64$.

20. Start with the key idea: Same sum-of-cubes pattern, with $b = 2$: $(x + 2)(x^2 - 2x + 4) = x^3 + 8$. That gives a quick check on the answer.

21. Profit is revenue minus cost. Subtract term by term, distributing the minus: $R - C = (2 - 1)x^2 + (9 - 4)x + (20 - 12) = x^2 + 5x + 8$. (At $x = 10$, profit is $100 + 50 + 8 = \$158$k — positive, sensible.)

22. Area: $(x+5)(2x-3) = 2x^2 - 3x + 10x - 15 = 2x^2 + 7x - 15$. Perimeter: $2(x + 5) + 2(2x - 3) = 2x + 10 + 4x - 6 = 6x + 4$. (For positive dimensions, $x > 3/2$.)

23. One steady path is: $AB = (x+4)(2x-1) = 2x^2-x+8x-4 = 2x^2+7x-4$. Then $2A = 2(x+4) = 2x+8$. Subtract: $AB - 2A = 2x^2 + 7x - 4 - 2x - 8 = 2x^2 + 5x - 12$. That gives a quick check on the answer.

24. This is the difference-of-squares pattern. $(x+a)(x-a) = x^2-ax+ax-a^2$. The middle terms $-ax$ and $+ax$ cancel, leaving $x^2 - a^2$. True regardless of a — the identity holds for all real values.

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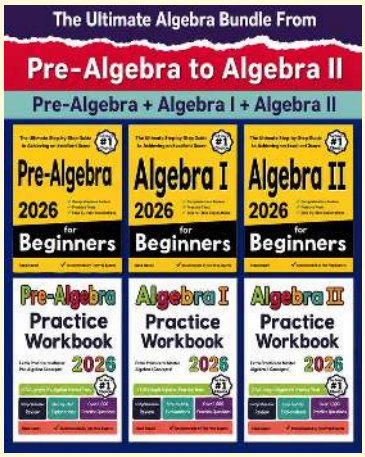

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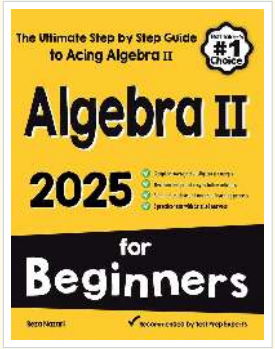

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