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Adding and Subtracting Polynomials

$(x^2 + 3x + 1) - (3x^2 + 4x - 7) = 4x^2 - x + 8$

Add or subtract the following polynomials by combining like terms.

1. $(-2x^2 + 4x - 12) + (5x^2 - 5x)$
2. $(3y^2 - 9y) - (-5y^2 + 7y - 7)$
3. $(3x^4 - 2x + 1) - (4x^3 - 5x - 8)$
4. $(6x^3 - 2x^2 - 12) + (6x^2 + 3x + 8)$
5. $(x^2 - x - 4) - (3x^2 - 4x + 5)$
6. $(x^3 - x^2 + 3) - (4x^3 - x^2 + 7)$
7. $(4x^2 + 6x + 3) + (3x^2 - 3x - 2) + (-4x^2 + 3x - 9)$
8. $(7x^2 + 2x + 7) - (4x^2 - 2x + 3) + (-5x^2 + 6x + 7)$
9. $(3x^3 - 5x^2 - 9) - (5x^3 - 5x - 4) - (5x^3 - 4x^2 - 9)$
10. $(2x^2 - 9x - 8) - (2x^3 - 4x^2 + -2)$
11. $(9x^2 - 8x + -4) + (3x^3 - 7x + -5) + (-4x^2 - 2x - 6)$
12. $(3x^2 + 3x + 2) - (5x^3 - 3x^2 + 8) - (-2x^3 + 9x^2 + 8)$
13. $(-2x^3 + 3x^2 + 9) + (-8x^3 - 2x^2 + -4x)$
14. $(-6x^2 - 3x^3 + 4) + (-7x^3 + 2x + 4) - (-3x^3 + 5x^2 + 2)$
15. $(-3x^2 - 4x^3 - 1) - (2x^3 - 7x - 9) - (2x^3 - 2x^2 - 3)$

Multiplying Exponents

Rule: $x^a \cdot x^b = x^{a+b}$ Example: $a^4 \cdot a^3 = a^7$

Multiply the following polynomials.

1. $a \cdot a^2 \cdot a^3 =$
2. $(2a^2b)(4ab^2) =$
3. $(6x^2)(-3x^5) =$
4. $b^3 \cdot b^4 \cdot b^7 \cdot b =$
5. $(3x^3)(3x^4)(-3x^2) =$
6. $(4c^2)(-8c^7) =$
7. $(5xy)(2x^2y^3) =$
8. $(3x)(-4y^2)(6x^3y) =$
9. $(-2c^4)(6cd)(-cd^2) =$
10. $(6k^2)(-3k)(2k^5) =$
11. $(m^2n)(mn^3)(mn) =$
12. $(-4p^3)(-3p^6)(-2p^9) =$
13. $(12e^3)(2g^3)(4eh) =$
14. $(5f)(-3f^3)(2f) =$
15. $(c^2h)(ch^3)(c^3h^4) =$
16. $(3c^2d^2)(-5cd^4) =$
17. $(5x^2y^3)(x^3y)(-x^2y^2) =$
18. $(-4m^3)(-4m^3) =$
19. $d \cdot d^2 \cdot d^3 \cdot d^4 \cdot d^5 =$
20. $(-1)(x)(-x^2)(x)(-x^2) =$

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Products of Polynomials

$2y(y - 5) = 2y^2 - 10y$

Use the distributive property to multiply these polynomials.

1. $3x(x - 3)$
2. $2xy(2x - 3y)$
3. $4a(2a + 4)$
4. $-5y^2(7y - 8y^2)$
5. $-5ab(6a - 4b)$
6. $a(x + 1)$
7. $y(y - 4)$
8. $5b(3 - b)$
9. $4x(x - 3)$
10. $4x^2(3x^2 - x)$
11. $-3x^2(4x^2 - 3x + 3)$
12. $5b(4b^3 - 6b^2 - 6)$
13. $x(x^2 + x + x)$
14. $(3x^4 - 5x^2 - 4)(-3x^3)$
15. $3y(y^2 - 3y + 2)$
16. $-4x^2(5 - 3x + 3x^2 + 4x^3)$
17. $3b(4b^3 - 12b^2 - 7)$
18. $-4x^2(3x^3 + 8x^2 + -9x)$
19. $(-9x^3)(3x^2 - 1)$
20. $(3x^2 - 6x)(-x)$

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Dividing Exponents

Rule: $\frac{x^a}{x^b} = x^{a-b}$ **Example:** $\frac{x^6}{x^4} = x^{6-4} = x^2$ $\frac{x^3}{x^{-2}} = x^{3-(-2)} = x^5$

Divide the following polynomials.

1. $\frac{x^3}{x}$

2. $\frac{9a^3b^5}{-3ab^2}$

3. $\frac{d^5}{d^3}$

4. $\frac{b^{14}c^9}{b^5c^4}$

5. $\frac{-12m^5}{6m}$

6. $\frac{15k^7r^3}{-3k^5}$

7. $\frac{9a^{13}}{a^3}$

8. $\frac{(3xy)(4x^2y)}{-6xy^2}$

9. $\frac{-14c^{15}d^3}{-2c^9d}$

10. $\frac{(5k)(-8k^5)}{10k^3}$

11. $\frac{18c^3}{-3c^2}$

12. $\frac{-48c^2d^4}{-8cd}$

13. $\frac{22y^5z^8}{2yz^7}$

14. $\frac{28x^2y}{-4x^2}$

15. $\frac{-3p^8}{6p^2}$

16. $\frac{42r^{13}}{-7r^8}$

17. $\frac{(6x^3)(4x^9)}{-12x^{10}}$

18. $\frac{21k^9}{(3k)(7k^4)}$

19. $\frac{4x^2y^3z^4}{2xy^2z^3}$

20. $\frac{(121c^3)(-c^8)}{11c^5}$

Dividing Monomials

$$\frac{25x^9y^6}{5x^7y^8} = \frac{25}{5} \cdot x^{9-7}\ y^{6-8} = \frac{5x^2}{y^2}$$

Simplify.

1. $\frac{x^3}{x^5}$

2. $\frac{a^4b^2}{2a^2}$

3. $\frac{12x^2\ y^4}{3x^2y^3}$

4. $\frac{10a^6b^8}{40a^2b^2}$

5. $\frac{14c^2d^2}{28cd}$

6. $\frac{18a^9b^3}{36a^2b^2}$

7. $\frac{13m^6n^7}{26m^2n^5}$

8. $\frac{35x^9y^{10}z^5}{15x^9y^8z^3}$

9. $\frac{5x^3y^2z^2}{5x^2yz}$

10. $\frac{72x^5y^5z^6}{9x^4yz^3}$

11. $\frac{6x^6y^3z^4}{12x^3y^2z^3}$

12. $\frac{9x^8y^7z^8}{27x^5y^5z^4}$

13. $\frac{18a^6b^2c^6}{36a^4bc^2}$

14. $\frac{33x^7y^2}{11x^7yz}$

Simplifying Rational Expressions

$$\frac{a^2+7a+5}{a} = \frac{a^2}{a} + \frac{7a}{a} + \frac{5}{a}$$

$$= a + 7 + \frac{5}{a}$$

Simplify.

1. $\frac{x^3 + 2x}{x}$

2. $\frac{18x + 36}{9}$

3. $\frac{8y^2 + 12y^3}{6y}$

4. $\frac{10a^6b^8 + 8a^3b^5}{ab}$

5. $\frac{3cd^2 + 6c^2d}{3cd}$

6. $\frac{18x^3 - 9x^2 - 3x}{-3}$

7. $\frac{m^6n^7 + m^2 - m}{m}$

8. $\frac{12a^3 - 9a^2 - 3a}{-3a}$

9. $\frac{9x^4 - 3x^5 - 12x}{3x}$

10. $\frac{2x^3y^5 - 2x^3y^4 - 4x^2y^3}{2x^2y^3}$

11. $\frac{12a^3 - 2a^2 + 12a}{2a}$

12. $\frac{9x^8 + 3x^2 + 3x}{3x}$

13. $\frac{x^3y^3 + x^2 - yx}{x}$

14. $\frac{3x^4y^5 + 12x^2y^3 - 18x^2y}{3x^2y}$

Factoring Monomials From Polynomials

To **factor a polynomial**, write the polynomial as a product of other polynomials.
For example, $4x^2 - 8x$ can be written as $4x(x - 8)$.
$4x$ is the **Greatest Common Factor (GCF)** of $4x^2$ and $8x$.
$4x$ is a **Common Monomial Factor** of the terms of the binomial.
$x - 8$ is a **Binomial Factor** of $4x^2 - 8$.

Factor.

1. $9a^2 - 18a$
2. $16a^5b^3 + 32a^4b$
3. $x^2 + x^4 + x^3$
4. $3x^5 + 4x^4 - 5x^2$
5. $2x^3 - x$
6. $3a^5 - a^3$
7. $32b^2 + 16b$
8. $5x^3 - 7x^2$
9. $3x^2 - 10x^3$
10. $a^{5n} + a^{3n}$
11. $x^3 - 5x^2$
12. $9c - 3c^2$
13. $5x^4 - 12x^2$
14. $x^2 + x$
15. $6x^2 - 12x^3 - 18x^4$
16. $x^3y^4 + x^2y^2$
17. $18b - 9b^2$
18. $2x^3 + 6x^2$
19. $12x^3 + 4x^2$
20. $x^5 + 3x^2$

Products of Polynomials

$(x - 2)(x^2 - x + 4) = x(x^2 - x + 4) - 2(x^2 - x + 4) = x^3 - x^2 + 4x - 2x^2 + 2x - 8$
$= x^3 - 3x^2 + 6x - 8$

Use the distributive property to multiply these polynomials.

1. $(5x + 3)(x + 6)$
2. $(4x + y)(3x - 2y)$
3. $(4a + 1)(4a + 1)$
4. $(x + 4)(x + 4)$
5. $(x + y)(3x + y)$
6. $(x + 1)(1 + x)$
7. $(2b - 8)(3b - 7)$
8. $(3x + y)(x^2 + 3x + 4y)$
9. $(4x^2 - 4y^2)(4x^2 + 4y^2)$
10. $(3x^2 - x)(3x - x^2)$
11. $-3x^2(4x^2 - 3x + 3)$
12. $5b(4b^3 - 6b^2 - 6)$
13. $x^2(x^3 + x^2 + x)$
14. $(3x^4 - 5x^2 - 4)(-3x^3)$
15. $(x - y)(x^2 + y^2)$
16. $(4x + 3)(2x - 4)$
17. $(3b - 2)(3b^3 + 6b^2 + 2)$
18. $(3x - 3)(x - 9)$
19. $(-2x^3 + 4)(2x^2 + 5)$
20. $(x - 7)(x + 6)$

Factoring Trinomials of the form $x^2 + bx + c$

$x^2 + 3x - 28 = (x + 7)(x - 4)$

Factor.

1. $x^2 + 4x - 5$
2. $x^2 + 15x + 50$
3. $x^2 + 4x - 32$
4. $x^2 + 7x + 6$
5. $x^2 + 12x + 11$
6. $x^2 + 12x + 20$
7. $x^2 + 2x - 35$
8. $x^2 - 18x + 72$
9. $x^2 - 15x + 56$
10. $x^2 - 6x - 16$
11. $x^2 - 8x + 15$
12. $x^2 + x - 72$
13. $x^2 - 16x + 39$
14. $x^2 + 22x + 121$
15. $x^2 + 13x + 12$
16. $x^2 - 3xy + 2y^2$
17. $x^2 - 14xy + 24y^2$
18. $x^2 + 5xy + 6y^2$
19. $x^2 + 2xy - 63y^2$
20. $x^2 + 8xy - 33y^2$

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Factoring Trinomials of the form $ax^2 + bx + c$

$3x^2 - 9x - 12 = 3(x^2 - 3x - 4) = 3(x - 4)(x + 1)$

Factor.

1. $5x^2 - 10x - 15$
2. $6x^2 - 15x - 21$
3. $3x^2 - 10x + 7$
4. $2x^2 - 11x - 21$
5. $4x^2 + 2x - 20$
6. $3x^2 - 5x - 12$
7. $7x^2 - 26x - 8$
8. $12x^2 - 6x - 18$
9. $6x^2 - 13x + 6$
10. $2x^2 + 9x + 10$
11. $3x^2 - 4x - 32$
12. $4x^2 - 16x + 15$
13. $4x^2 + 7x - 15$
14. $6a^2 - 21a + 15$
15. $11x^2 + 122x + 11$
16. $3x^2 - 20x - 7$
17. $2y^2 - 17y + 35$
18. $4x^2 - 16x + 15$
19. $6x^2 + 25x + 25$
20. $7c^2 - 16c + 9$

Factoring Trinomials of the form $ax^2 + bx + c$

$3x^2 - 9x - 12 = (3x + 3)(x - 4)$

Factor.

1. $7x^2 + 17x + 6$
2. $5x^2 - 18x + 16$
3. $12x^2 - 40x + 25$
4. $6x^2 - 21x - 12$
5. $4x^2 + 7x - 15$
6. $11x^2 - 122x + 11$
7. $9x^2 - 9x - 28$
8. $2x^2 + 13x + 6$
9. $6x^2 + 5x - 6$
10. $2x^2 - 11x - 40$
11. $10x^2 - 28x - 6$
12. $4x^2 - x - 5$
13. $12x^2 + 16x - 3$
14. $2x^2 + 17x + 35$
15. $15x^2 - 29x - 14$
16. $4x^2 - 7x - 15$
17. $14x^2 - 11x + 2$
18. $2x^2 + 7x + 3$
19. $4x^2 - 15x + 9$
20. $6x^2 + x - 12$

Factoring: Difference of Two Squares

Rule: a2 – b2 = (a + b) (a – b) **Example**: $x^2 - 36 = (x + 6)(x - 6)$

Factor.

1. $x^2 - 16$
2. $y^2 - 49$
3. $4x^2 - 1$
4. $81x^2 - 4$
5. $16x^2 - 121$
6. $49x^2 - 36$
7. $1 - 9x^2$
8. $16 - 81x^2$
9. $x^2y^2 - 100$
10. $x^2y^2 - 25$
11. $x^2 - 4$
12. $25 - x^2y^2$
13. $64 - x^2y^2$
14. $4x^2 - y^2$
15. $49x^2 - 16y^4$
16. $a^2 - 1$
17. $c^2 - 16$
18. $a^2 - 36$
19. $b^2 - 9$
20. $y^2 - 81$

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Factoring Perfect Square Trinomials

Rule: $a^2 + 2ab + b^2 = (a + b)^2$ $a^2 - 2ab + b^2 = (a - b)^2$
Example: $4x^2 + 4x + 1 = (2x + 1)^2$ $x^2 - 4x + 4 = (x + 2)^2$

Factor.

1. $x^2 - 14x + 49$
2. $b^2 - 18b + 81$
3. $x^2 - 12x + 36$
4. $c^2 - 6c + 9$
5. $x^2 - 2x + 1$
6. $x^2 + 14x + 49$
7. $16x^2 - 40x + 25$
8. $49x^2 + 28x + 4$
9. $4x^2 + 4x + 1$
10. $9x^2 + 12x + 4$
11. $x^2 + 8x + 16$
12. $x^2 - 10x + 25$
13. $a^2 + 12ab + 36b^2$
14. $x^2 - 14x + 49$
15. $9x^2 - 6x + 1$
16. $x^2 - 16x + 64$
17. $y^2 - 24y + 144$
18. $25a^2 - 40ab + 16b^2$
19. $x^2 - 4x + 4$
20. $c^2 - 20c + 100$