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Just-in-Time Review

1. Real Numbers

1. Rational numbers: $\frac{2}{3}$, 6, -2.45 , $18.\bar{4}$, -11 , $\sqrt[3]{27}$, $5\frac{1}{6}$, $-\frac{8}{7}$, 0, $\sqrt{16}$
2. Rational numbers but not integers: $\frac{2}{3}$, -2.45 , $18.\bar{4}$, $5\frac{1}{6}$, $-\frac{8}{7}$
3. Irrational numbers: $\sqrt{3}$, $\sqrt[4]{26}$, $7.151551555\dots$, $-\sqrt{35}$, $\sqrt[5]{3}$
(Although there is a pattern in $7.151551555\dots$, there is no repeating block of digits.)
4. Integers: 6, -11 , $\sqrt[3]{27}$, 0, $\sqrt{16}$
5. Whole numbers: 6, $\sqrt[3]{27}$, 0, $\sqrt{16}$
6. Real numbers: All of them

2. Properties of Real Numbers

1. $-24 + 24 = 0$ illustrates the additive inverse property.
2. $7(xy) = (7x)y$ illustrates the associative property of multiplication.
3. $9(r - s) = 9r - 9s$ illustrates a distributive property.
4. $11 + z = z + 11$ illustrates the commutative property of addition.
5. $-20 \cdot 1 = -20$ illustrates the multiplicative identity property.
6. $5(x + y) = (x + y)5$ illustrates the commutative property of multiplication.
7. $q + 0 = q$ illustrates the additive identity property.
8. $75 \cdot \frac{1}{75} = 1$ illustrates the multiplicative inverse property.
9. $(x + y) + w = x + (y + w)$ illustrates the associative property of addition.
10. $8(a + b) = 8a + 8b$ illustrates a distributive property.

3. Order on the Number Line

1. 9 is to the right of -9 on the number line, so it is false that $9 < -9$.
2. -10 is to the left of -1 on the number line, so it is true that $-10 \leq -1$.

3. $-5 = -\sqrt{25}$, and $-\sqrt{26}$ is to the left of $-\sqrt{25}$, or -5 , on the number line. Thus it is true that $-\sqrt{26} < -5$.
4. $\sqrt{6} = \sqrt{6}$, so it is true that $\sqrt{6} \leq \sqrt{6}$.
5. -30 is to the left of -25 on the number line, so it is false that $-30 > -25$.
6. $-\frac{4}{5} = -\frac{16}{20}$ and $-\frac{5}{4} = -\frac{25}{20}$; $-\frac{16}{20}$ is to the right of $-\frac{25}{20}$, so it is true that $-\frac{4}{5} > -\frac{5}{4}$.

4. Absolute Value

1. $|-98| = 98$ ($|a| = -a$, if $a < 0$.)
2. $|0| = 0$ ($|a| = a$, if $a \geq 0$.)
3. $|4.7| = 4.7$ ($|a| = a$, if $a \geq 0$.)
4. $\left| -\frac{2}{3} \right| = \frac{2}{3}$ ($|a| = -a$, if $a < 0$.)
5. $|-7 - 13| = |-20| = 20$, or
 $|13 - (-7)| = |13 + 7| = |20| = 20$
6. $|2 - 14.6| = |-12.6| = 12.6$, or
 $|14.6 - 2| = |12.6| = 12.6$
7. $|-39 - (-28)| = |-39 + 28| = |-11| = 11$, or
 $|-28 - (-39)| = |-28 + 39| = |11| = 11$
8. $\left| -\frac{3}{4} - \frac{15}{8} \right| = \left| -\frac{6}{8} - \frac{15}{8} \right| = \left| -\frac{21}{8} \right| = \frac{21}{8}$, or
 $\left| \frac{15}{8} - \left(-\frac{3}{4} \right) \right| = \left| \frac{15}{8} + \frac{6}{8} \right| = \left| \frac{21}{8} \right| = \frac{21}{8}$

5. Operations with Real Numbers

1. $8 - (-11) = 8 + 11 = 19$
2. $-\frac{3}{10} \cdot \left(-\frac{1}{3} \right) = \frac{3 \cdot 1}{10 \cdot 3} = \frac{3}{3} \cdot \frac{1}{10} = 1 \cdot \frac{1}{10} = \frac{1}{10}$
3. $15 \div (-3) = -5$
4. $-4 - (-1) = -4 + 1 = -3$
5. $7 \cdot (-50) = -350$
6. $-0.5 - 5 = -0.5 + (-5) = -5.5$
7. $-3 + 27 = 24$
8. $-400 \div -40 = 10$
9. $4.2 \cdot (-3) = -12.6$

- $-13 - (-33) = -13 + 33 = 20$
- $-60 + 45 = -15$
- $\frac{1}{2} - \frac{2}{3} = \frac{1}{2} + \left(-\frac{2}{3}\right) = \frac{3}{6} + \left(-\frac{4}{6}\right) = -\frac{1}{6}$
- $-24 \div 3 = -8$
- $-6 + (-16) = -22$
- $-\frac{1}{2} \div \left(-\frac{5}{8}\right) = -\frac{1}{2} \cdot \left(-\frac{8}{5}\right) = \frac{1 \cdot 8}{2 \cdot 5} = \frac{1 \cdot \cancel{2} \cdot 4}{\cancel{2} \cdot 5} = \frac{4}{5}$

6. Interval Notation

- This is a closed interval, so we use brackets. Interval notation is $[-5, 5]$.
- This is a half-open interval. We use a parenthesis on the left and a bracket on the right. Interval notation is $(-3, -1]$.
- This interval is of unlimited extent in the negative direction, and the endpoint -2 is included. Interval notation is $(-\infty, -2]$.
- This interval is of unlimited extent in the positive direction, and the endpoint 3.8 is not included. Interval notation is $(3.8, \infty)$.
- $\{x|7 < x\}$, or $\{x|x > 7\}$.
This interval is of unlimited extent in the positive direction and the endpoint 7 is not included. Interval notation is $(7, \infty)$.
- The endpoints -2 and 2 are not included in the interval, so we use parentheses. Interval notation is $(-2, 2)$.
- The endpoints -4 and 5 are not included in the interval, so we use parentheses. Interval notation is $(-4, 5)$.
- The interval is of unlimited extent in the positive direction, and the endpoint 1.7 is included. Interval notation is $[1.7, \infty)$.
- The endpoint -5 is not included in the interval, so we use a parenthesis before -5 . The endpoint -2 is included in the interval, so we use a bracket after -2 . Interval notation is $(-5, -2]$.
- This interval is of unlimited extent in the negative direction, and the endpoint $\sqrt{5}$ is not included. Interval notation is $(-\infty, \sqrt{5})$.

7. Integers as Exponents

- $3^{-6} = \frac{1}{3^6}$ Using $a^{-m} = \frac{1}{a^m}$
- $\frac{1}{(0.2)^{-5}} = (0.2)^5$ Using $a^{-m} = \frac{1}{a^m}$

- $\frac{w^{-4}}{z^{-9}} = \frac{z^9}{w^4}$ Using $\frac{a^{-m}}{b^{-n}} = \frac{b^n}{a^m}$
- $\left(\frac{z}{y}\right)^2 = \frac{z^2}{y^2}$ Raising a quotient to a power
- $100^0 = 1$ Using $a^0 = 1, a \neq 0$
- $\frac{a^5}{a^{-3}} = a^{5-(-3)} = a^{5+3} = a^8$ Using the quotient rule
- $(2xy^3)(-3x^{-5}y) = 2(-3)x \cdot x^{-5} \cdot y^3 \cdot y$
 $= -6x^{1+(-5)}y^{3+1}$
 $= -6x^{-4}y^4$, or $-\frac{6y^4}{x^4}$
- $x^{-4} \cdot x^{-7} = x^{-4+(-7)} = x^{-11}$, or $\frac{1}{x^{11}}$
- $(mn)^{-6} = m^{-6}n^{-6}$, or $\frac{1}{m^6n^6}$
- $(t^{-5})^4 = t^{-5 \cdot 4} = t^{-20}$, or $\frac{1}{t^{20}}$

8. Scientific Notation

- Convert 18,500,000 to scientific notation.

We want the decimal point to be positioned between the 1 and the 8, so we move it 7 places to the left. Since 18,500,000 is greater than 10, the exponent must be positive.

$$18,500,000 = 1.85 \times 10^7$$

- Convert 0.000786 to scientific notation.

We want the decimal point to be positioned between the 7 and the 8, so we move it 4 places to the right. Since 0.000786 is between 0 and 1, the exponent must be negative.

$$0.000786 = 7.86 \times 10^{-4}$$

- Convert 0.000000023 to scientific notation.

We want the decimal point to be positioned between the 2 and the 3, so we move it 9 places to the right. Since 0.000000023 is between 0 and 1, the exponent must be negative.

$$0.000000023 = 2.3 \times 10^{-9}$$

- Convert 8,927,000,000 to scientific notation.

We want the decimal point to be positioned between the 8 and the 9, so we move it 9 places to the left. Since 8,927,000,000 is greater than 10, the exponent must be positive.

$$8,927,000,000 = 8.927 \times 10^9$$

- Convert 4.3×10^{-8} to decimal notation.

The exponent is negative, so the number is between 0 and 1. We move the decimal point 8 places to the left.

$$4.3 \times 10^{-8} = 0.000000043$$

6. Convert 5.17×10^6 to decimal notation.

The exponent is positive, so the number is greater than 10. We move the decimal point 6 places to the right.

$$5.17 \times 10^6 = 5,170,000$$

7. Convert 6.203×10^{11} to decimal notation.

The exponent is positive, so the number is greater than 10. We move the decimal point 11 places to the right.

$$6.203 \times 10^{11} = 620,300,000,000$$

8. Convert 2.94×10^{-5} to scientific notation.

The exponent is negative, so the number is between 0 and 1. We move the decimal point 5 places to the left.

$$2.94 \times 10^{-5} = 0.0000294$$

9. Order of Operations

1. $3 + 18 \div 6 - 3 = 3 + 3 - 3$ Dividing
 $= 6 - 3 = 3$ Adding and subtracting
2. $= 5 \cdot 3 + 8 \cdot 3^2 + 4(6 - 2)$
 $= 5 \cdot 3 + 8 \cdot 3^2 + 4 \cdot 4$ Working inside parentheses
 $= 5 \cdot 3 + 8 \cdot 9 + 4 \cdot 4$ Evaluating 3^2
 $= 15 + 72 + 16$ Multiplying
 $= 87 + 16$ Adding in order
 $= 103$ from left to right
3. $5[3 - 8 \cdot 3^2 + 4 \cdot 6 - 2]$
 $= 5[3 - 8 \cdot 9 + 4 \cdot 6 - 2]$
 $= 5[3 - 72 + 24 - 2]$
 $= 5[-69 + 24 - 2]$
 $= 5[-45 - 2]$
 $= 5[-47]$
 $= -235$
4. $16 \div 4 \cdot 4 \div 2 \cdot 256$
 $= 4 \cdot 4 \div 2 \cdot 256$ Multiplying and dividing
in order from left to right
 $= 16 \div 2 \cdot 256$
 $= 8 \cdot 256$
 $= 2048$
5. $2^6 \cdot 2^{-3} \div 2^{10} \div 2^{-8}$
 $= 2^3 \div 2^{10} \div 2^{-8}$
 $= 2^{-7} \div 2^{-8}$
 $= 2$

6.
$$\frac{4(8 - 6)^2 - 4 \cdot 3 + 2 \cdot 8}{3^1 + 19^0}$$
$$= \frac{4 \cdot 2^2 - 4 \cdot 3 + 2 \cdot 8}{3 + 1}$$
 Calculating in the numerator and in the denominator
$$= \frac{4 \cdot 4 - 4 \cdot 3 + 2 \cdot 8}{4}$$
$$= \frac{16 - 12 + 16}{4}$$
$$= \frac{4 + 16}{4}$$
$$= \frac{20}{4}$$
$$= 5$$

7. $64 \div [(-4) \div (-2)] = 64 \div 2 = 32$

8. $6[9 - (3 - 2)] + 4(2 - 3)$
 $= 6[9 - 1] + 4(2 - 3)$
 $= 6 \cdot 8 + 4(-1)$
 $= 48 - 4$
 $= 44$

10. Introduction to Polynomials

1. $5 - x^6$
The term of highest degree is $-x^6$, so the degree of the polynomial is 6.
2. $x^2y^5 - x^7y + 4$
The degree of x^2y^5 is $2 + 5$, or 7; the degree of $-x^7y$ is $7 + 1$, or 8; the degree of 4 is 0 ($4 = 4x^0$). Thus the degree of the polynomial is 8.
3. $2a^4 - 3 + a^2$
The term of highest degree is $2a^4$, so the degree of the polynomial is 4.
4. $-41 = -41x^0$, so the degree of the polynomial is 0.
5. $4x - x^3 + 0.1x^8 - 2x^5$
The term of highest degree is $0.1x^8$, so the degree of the polynomial is 8.
6. $x - 3$ has two terms. It is a binomial.
7. $14y^5$ has one term. It is a monomial.
8. $2y - \frac{1}{4}y^2 + 8$ has three terms. It is a trinomial.

11. Add and Subtract Polynomials

1. $(8y - 1) - (3 - y)$
 $= (8y - 1) + (-3 + y)$
 $= (8 + 1)y + (-1 - 3)$
 $= 9y - 4$

2. $(3x^2 - 2x - x^3 + 2) - (5x^2 - 8x - x^3 + 4)$
 $= (3x^2 - 2x - x^3 + 2) + (-5x^2 + 8x + x^3 - 4)$
 $= (3 - 5)x^2 + (-2 + 8)x + (-1 + 1)x^3 + (2 - 4)$
 $= -2x^2 + 6x - 2$
3. $(2x + 3y + z - 7) + (4x - 2y - z + 8) +$
 $(-3x + y - 2z - 4)$
 $= (2 + 4 - 3)x + (3 - 2 + 1)y + (1 - 1 - 2)z +$
 $(-7 + 8 - 4)$
 $= 3x + 2y - 2z - 3$
4. $(3ab^2 - 4a^2b - 2ab + 6) +$
 $(-ab^2 - 5a^2b + 8ab + 4)$
 $= (3 - 1)ab^2 + (-4 - 5)a^2b + (-2 + 8)ab + (6 + 4)$
 $= 2ab^2 - 9a^2b + 6ab + 10$
5. $(5x^2 + 4xy - 3y^2 + 2) - (9x^2 - 4xy + 2y^2 - 1)$
 $= (5x^2 + 4xy - 3y^2 + 2) + (-9x^2 + 4xy - 2y^2 + 1)$
 $= (5 - 9)x^2 + (4 + 4)xy + (-3 - 2)y^2 + (2 + 1)$
 $= -4x^2 + 8xy - 5y^2 + 3$

2. $(5x - 3)^2$
 $= (5x)^2 - 2 \cdot 5x \cdot 3 + 3^2$
 $[(A - B)^2 = A^2 - 2AB + B^2]$
 $= 25x^2 - 30x + 9$
3. $(2x + 3y)^2$
 $= (2x)^2 + 2(2x)(3y) + (3y)^2$
 $[(A + B)^2 = A^2 + 2AB + B^2]$
 $= 4x^2 + 12xy + 9y^2$
4. $(a - 5b)^2$
 $= a^2 - 2 \cdot a \cdot 5b + (5b)^2$
 $[(A - B)^2 = A^2 - 2AB + B^2]$
 $= a^2 - 10ab + 25b^2$
5. $(n + 6)(n - 6)$
 $= n^2 - 6^2$ $[(A + B)(A - B) = A^2 - B^2]$
 $= n^2 - 36$
6. $(3y + 4)(3y - 4)$
 $= (3y)^2 - 4^2$ $[(A + B)(A - B) = A^2 - B^2]$
 $= 9y^2 - 16$

12. Multiply Polynomials

1. $(3a^2)(-7a^4) = [3(-7)](a^2 \cdot a^4)$
 $= -21a^6$
2. $(y - 3)(y + 5)$
 $= y^2 + 5y - 3y - 15$ Using FOIL
 $= y^2 + 2y - 15$ Collecting like terms
3. $(x + 6)(x + 3)$
 $= x^2 + 3x + 6x + 18$ Using FOIL
 $= x^2 + 9x + 18$ Collecting like terms
4. $(2a + 3)(a + 5)$
 $= 2a^2 + 10a + 3a + 15$ Using FOIL
 $= 2a^2 + 13a + 15$ Collecting like terms
5. $(2x + 3y)(2x + y)$
 $= 4x^2 + 2xy + 6xy + 3y^2$ Using FOIL
 $= 4x^2 + 8xy + 3y^2$
6. $(11t - 1)(3t + 4)$
 $= 33t^2 + 44t - 3t - 4$ Using FOIL
 $= 33t^2 + 41t - 4$

13. Special Products of Binomials

1. $(x + 3)^2$
 $= x^2 + 2 \cdot x \cdot 3 + 3^2$
 $[(A + B)^2 = A^2 + 2AB + B^2]$
 $= x^2 + 6x + 9$

14. Factor Polynomials; The FOIL Method

1. $3x + 18 = 3 \cdot x + 3 \cdot 6 = 3(x + 6)$
2. $2z^3 - 8z^2 = 2z^2 \cdot z - 2z^2 \cdot 4 = 2z^2(z - 4)$
3. $3x^3 - x^2 + 18x - 6$
 $= x^2(3x - 1) + 6(3x - 1)$
 $= (3x - 1)(x^2 + 6)$
4. $t^3 + 6t^2 - 2t - 12$
 $= t^2(t + 6) - 2(t + 6)$
 $= (t + 6)(t^2 - 2)$
5. $w^2 - 7w + 10$

We look for two numbers with a product of 10 and a sum of -7 . By trial, we determine that they are -5 and -2 .

$$w^2 - 7w + 10 = (w - 5)(w - 2)$$

6. $t^2 + 8t + 15$

We look for two numbers with a product of 15 and a sum of 8. By trial, we determine that they are 3 and 5.

$$t^2 + 8t + 15 = (t + 3)(t + 5)$$

7. $2n^2 - 20n - 48 = 2(n^2 - 10n - 24)$

Now factor $n^2 - 10n - 24$. We look for two numbers with a product of -24 and a sum of -10 . By trial, we determine that they are 2 and -12 . Then $n^2 - 10n - 24 = (n + 2)(n - 12)$. We must include the common factor, 2, to have a factorization of the original trinomial.

$$2n^2 - 20n - 48 = 2(n + 2)(n - 12)$$

8. $y^4 - 9y^3 + 14y^2 = y^2(y^2 - 9y + 14)$

Now factor $y^2 - 9y + 14$. Look for two numbers with a product of 14 and a sum of -9 . The numbers are -2 and -7 . Then $y^2 - 9y + 14 = (y - 2)(y - 7)$. We must include the common factor, y^2 , in order to have a factorization of the original trinomial.

$$y^4 - 9y^3 + 14y^2 = y^2(y - 2)(y - 7)$$

9. $2n^2 + 9n - 56$

1. There is no common factor other than 1 or -1 .
2. The factorization must be of the form $(2n + \quad)(n + \quad)$.
3. Factor the constant term, -56 . The possibilities are $-1 \cdot 56$, $1(-56)$, $-2 \cdot 28$, $2(-28)$, $-4 \cdot 16$, $4(-16)$, $-7 \cdot 8$, and $7(-8)$. The factors can be written in the opposite order as well: $56(-1)$, $-56 \cdot 1$, $28(-2)$, $-28 \cdot 2$, $16(-4)$, $-16 \cdot 4$, $8(-7)$, and $-8 \cdot 7$.
4. Find a pair of factors for which the sum of the outer and the inner products is the middle term, $9n$. By trial, we determine that the factorization is $(2n - 7)(n + 8)$.

10. $2y^2 + y - 6$

1. There is no common factor other than 1 or -1 .
2. The factorization must be of the form $(2y + \quad)(y + \quad)$.
3. Factor the constant term, -6 . The possibilities are $-1 \cdot 6$, $1(-6)$, $-2 \cdot 3$, and $2(-3)$. The factors can be written in the opposite order as well: $6(-1)$, $-6 \cdot 1$, $3(-2)$ and $-3 \cdot 2$.
4. Find a pair of factors for which the sum of the outer and the inner products is the middle term, y . By trial, we determine that the factorization is $(2y - 3)(y + 2)$.

11. $b^2 - 6bt + 5t^2$

We look for two numbers with a product of 5 and a sum of -6 . By trial, we determine that they are -1 and -5 .

$$b^2 - 6bt + 5t^2 = (b - t)(b - 5t)$$

12. $x^4 - 7x^2 - 30 = (x^2)^2 - 7x^2 - 30$

We look for two numbers with a product of -30 and a sum of -7 . By trial, we determine that they are 3 and -10 .

$$x^4 - 7x^2 - 30 = (x^2 + 3)(x^2 - 10)$$

15. Factoring Polynomials; The *ac*-Method

1. $8x^2 - 6x - 9$

1. There is no common factor other than 1 or -1 .
2. Multiply the leading coefficient and the constant: $8(-9) = -72$.
3. Try to factor -72 so that the sum of the factors is the coefficient of the middle term, -6 . The factors we want are -12 and 6.

4. Split the middle term using the numbers found in step (3):

$$-6x = -12x + 6x$$

5. Factor by grouping.

$$\begin{aligned} 8x^2 - 6x - 9 &= 8x^2 - 12x + 6x - 9 \\ &= 4x(2x - 3) + 3(2x - 3) \\ &= (2x - 3)(4x + 3) \end{aligned}$$

2. $10t^2 + 4t - 6$

1. Factor out the largest common factor, 2.

$$10t^2 + 4t - 6 = 2(5t^2 + 2t - 3)$$

Now factor $5t^2 + 2t - 3$.

2. Multiply the leading coefficient and the constant: $5(-3) = -15$.
3. Try to factor -15 so that the sum of the factors is the coefficient of the middle term, 2. The factors we want are 5 and -3 .
4. Split the middle term using the numbers found in step (3):

$$2t = 5t - 3t.$$

5. Factor by grouping.

$$\begin{aligned} 5t^2 + 2t - 3 &= 5t^2 + 5t - 3t - 3 \\ &= 5t(t + 1) - 3(t + 1) \\ &= (t + 1)(5t - 3) \end{aligned}$$

Include the largest common factor in the final factorization.

$$10t^2 + 4t - 6 = 2(t + 1)(5t - 3)$$

3. $18a^2 - 51a + 15$

1. Factor out the largest common factor, 3.

$$18a^2 - 51a + 15 = 3(6a^2 - 17a + 5)$$

Now factor $6a^2 - 17a + 5$.

2. Multiply the leading coefficient and the constant: $6(5) = 30$.
3. Try to factor 30 so that the sum of the factors is the coefficient of the middle term, -17 . The factors we want are -2 and -15 .
4. Split the middle term using the numbers found in step (3):

$$-17a = -2a - 15a.$$

5. Factor by grouping.

$$\begin{aligned} 6a^2 - 17a + 5 &= 6a^2 - 2a - 15a + 5 \\ &= 2a(3a - 1) - 5(3a - 1) \\ &= (3a - 1)(2a - 5) \end{aligned}$$

Include the largest common factor in the final factorization.

$$18a^2 - 51a + 15 = 3(3a - 1)(2a - 5)$$

16. Special Factorizations

- $z^2 - 81 = z^2 - 9^2 = (z + 9)(z - 9)$
- $16x^2 - 9 = (4x)^2 - 3^2 = (4x + 3)(4x - 3)$
- $7pq^4 - 7py^4 = 7p(q^4 - y^4)$
 $= 7p[(q^2)^2 - (y^2)^2]$
 $= 7p(q^2 + y^2)(q^2 - y^2)$
 $= 7p(q^2 + y^2)(q + y)(q - y)$
- $x^2 + 12x + 36 = x^2 + 2 \cdot x \cdot 6 + 6^2$
 $= (x + 6)^2$
- $9z^2 - 12z + 4 = (3z)^2 - 2 \cdot 3z \cdot 2 + 2^2 = (3z - 2)^2$
- $a^3 + 24a^2 + 144a$
 $= a(a^2 + 24a + 144)$
 $= a(a^2 + 2 \cdot a \cdot 12 + 12^2)$
 $= a(a + 12)^2$
- $x^3 + 64 = x^3 + 4^3$
 $= (x + 4)(x^2 - 4x + 16)$
- $m^3 - 216 = m^3 - 6^3$
 $= (m - 6)(m^2 + 6m + 36)$
- $3a^5 - 24a^2 = 3a^2(a^3 - 8)$
 $= 3a^2(a^3 - 2^3)$
 $= 3a^2(a - 2)(a^2 + 2a + 4)$
- $t^6 + 1 = (t^2)^3 + 1^3$
 $= (t^2 + 1)(t^4 - t^2 + 1)$

17. Equation-Solving Principles

- $7t = 70$
 $t = 10$ Dividing by 7
The solution is 10.
- $x - 5 = 7$
 $x = 12$ Adding 5
The solution is 12.
- $3x + 4 = -8$
 $3x = -12$ Subtracting 4
 $x = -4$ Dividing by 3
The solution is -4 .
- $6x - 15 = 45$
 $6x = 60$ Adding 15
 $x = 10$ Dividing by 6
The solution is 10.

- $7y - 1 = 23 - 5y$
 $12y - 1 = 23$ Adding $5y$
 $12y = 24$ Adding 1
 $y = 2$ Dividing by 12

The solution is 2.

- $3m - 7 = -13 + m$
 $2m - 7 = -13$ Subtracting m
 $2m = -6$ Adding 7
 $m = -3$ Dividing by 2

The solution is -3 .

- $2(x + 7) = 5x + 14$
 $2x + 14 = 5x + 14$
 $-3x + 14 = 14$ Subtracting $5x$
 $-3x = 0$ Subtracting 14
 $x = 0$

The solution is 0.

- $5y - (2y - 10) = 25$
 $5y - 2y + 10 = 25$
 $3y + 10 = 25$ Collecting like terms
 $3y = 15$ Subtracting 10
 $y = 5$ Dividing by 3

The solution is 5.

18. Inequality-Solving Principles

- $p + 25 \geq -100$
 $p \geq -125$ Subtracting 25
The solution set is $[-125, \infty)$.
- $-\frac{2}{3}x > 6$
 $x < -\frac{3}{2} \cdot 6$ Multiplying by $-\frac{3}{2}$ and reversing the inequality symbol
 $x < -9$
The solution set is $(-\infty, -9)$.
- $9x - 1 < 17$
 $9x < 18$ Adding 1
 $x < 2$ Dividing by 9
The solution set is $(-\infty, 2)$.
- $-x - 16 \geq 40$
 $-x \geq 56$ Adding 6
 $x \leq -56$ Multiplying by -1 and reversing the inequality symbol
The solution set is $(-\infty, -56]$.

5. $\frac{1}{3}y - 6 < 3$

$$\frac{1}{3}y < 9 \quad \text{Adding 6}$$

$$y < 27 \quad \text{Multiplying by 3}$$

The solution set is $(-\infty, 27)$.

6. $8 - 2w \leq -14$

$$-2w \leq -22 \quad \text{Subtracting 8}$$

$$w \geq 11 \quad \text{Dividing by } -2 \text{ and} \\ \text{reversing the inequality symbol}$$

The solution set is $[11, \infty)$.

7. $x^2 + 13x = 30$

$$x^2 + 13x - 30 = 0$$

$$(x + 15)(x - 2) = 0$$

$$x + 15 = 0 \quad \text{or} \quad x - 2 = 0$$

$$x = -15 \quad \text{or} \quad x = 2$$

The solutions are -15 and 2 .

8. $12x^2 - 7x - 12 = 0$

$$(4x + 3)(3x - 4) = 0$$

$$4x + 3 = 0 \quad \text{or} \quad 3x - 4 = 0$$

$$4x = -3 \quad \text{or} \quad 3x = 4$$

$$x = -\frac{3}{4} \quad \text{or} \quad x = \frac{4}{3}$$

The solutions are $-\frac{3}{4}$ and $\frac{4}{3}$.

19. The Principle of Zero Products

1. $2y^2 + 42y = 0$

$$2y(y + 21) = 0$$

$$2y = 0 \quad \text{or} \quad y + 21 = 0$$

$$y = 0 \quad \text{or} \quad y = -21$$

The solutions are 0 and -21 .

2. $(a + 7)(a - 1) = 0$

$$a + 7 = 0 \quad \text{or} \quad a - 1 = 0$$

$$a = -7 \quad \text{or} \quad a = 1$$

The solutions are -7 and 1 .

3. $(5y + 3)(y - 4) = 0$

$$5y + 3 = 0 \quad \text{or} \quad y - 4 = 0$$

$$5y = -3 \quad \text{or} \quad y = 4$$

$$y = -\frac{3}{5} \quad \text{or} \quad y = 4$$

The solutions are $-\frac{3}{5}$ and 4 .

4. $6x^2 + 7x - 5 = 0$

$$(3x + 5)(2x - 1) = 0$$

$$3x + 5 = 0 \quad \text{or} \quad 2x - 1 = 0$$

$$3x = -5 \quad \text{or} \quad 2x = 1$$

$$x = -\frac{5}{3} \quad \text{or} \quad x = \frac{1}{2}$$

The solutions are $-\frac{5}{3}$ and $\frac{1}{2}$.

5. $t(t - 8) = 0$

$$t = 0 \quad \text{or} \quad t - 8 = 0$$

$$t = 0 \quad \text{or} \quad t = 8$$

The solutions are 0 and 8 .

6. $x^2 - 8x - 33 = 0$

$$(x + 3)(x - 11) = 0$$

$$x + 3 = 0 \quad \text{or} \quad x - 11 = 0$$

$$x = -3 \quad \text{or} \quad x = 11$$

The solutions are -3 and 11 .

20. The Principle of Square Roots

1. $x^2 - 36 = 0$

$$x^2 = 36$$

$$x = \sqrt{36} \quad \text{or} \quad x = -\sqrt{36}$$

$$x = 6 \quad \text{or} \quad x = -6$$

The solutions are 6 and -6 , or ± 6 .

2. $2y^2 - 20 = 0$

$$2y^2 = 20$$

$$y^2 = 10$$

$$y = \sqrt{10} \quad \text{or} \quad y = -\sqrt{10}$$

The solutions are $\sqrt{10}$ and $-\sqrt{10}$, or $\pm\sqrt{10}$.

3. $6z^2 = 18$

$$z^2 = 3$$

$$z = \sqrt{3} \quad \text{or} \quad z = -\sqrt{3}$$

The solutions are $\sqrt{3}$ and $-\sqrt{3}$, or $\pm\sqrt{3}$.

4. $3t^2 - 15 = 0$

$$3t^2 = 15$$

$$t^2 = 5$$

$$t = \sqrt{5} \quad \text{or} \quad t = -\sqrt{5}$$

The solutions are $\sqrt{5}$ and $-\sqrt{5}$, or $\pm\sqrt{5}$.

5. $z^2 - 1 = 24$

$$z^2 = 25$$

$$z = \sqrt{25} \quad \text{or} \quad z = -\sqrt{25}$$

The solutions are 5 and -5 , or ± 5 .

6. $5x^2 - 75 = 0$

$$5x^2 = 75$$

$$x^2 = 15$$

$$x = \sqrt{15} \quad \text{or} \quad x = -\sqrt{15}$$

The solutions are $\sqrt{15}$ and $-\sqrt{15}$, or $\pm\sqrt{15}$.

21. Simplify Rational Expressions

1. $\frac{3x - 3}{x(x - 1)}$

The denominator is 0 when the factor $x = 0$ and also when $x - 1 = 0$, or $x = 1$. The domain is the set of all real numbers except 0 and 1.

2. $\frac{y + 6}{y^2 + 4y - 21} = \frac{y + 6}{(y + 7)(y - 3)}$

The denominator is 0 when $y = -7$ or $y = 3$. The domain is the set of all real numbers except -7 and 3 .

3. $\frac{x^2 - 4}{x^2 - 4x + 4} = \frac{(x + 2)(\cancel{x - 2})}{(x - 2)(\cancel{x - 2})} = \frac{x + 2}{x - 2}$

4. $\frac{x^2 + 2x - 3}{x^2 - 9} = \frac{(x - 1)(\cancel{x + 3})}{(\cancel{x + 3})(x - 3)} = \frac{x - 1}{x - 3}$

5. $\frac{x^3 - 6x^2 + 9x}{x^3 - 3x^2} = \frac{x(x^2 - 6x + 9)}{x^2(x - 3)}$
 $= \frac{\cancel{x}(x - 3)(x - 3)}{\cancel{x} \cdot x(\cancel{x - 3})}$
 $= \frac{x - 3}{x}$

6. $\frac{6y^2 + 12y - 48}{3y^2 - 9y + 6} = \frac{6(y^2 + 2y - 8)}{3(y^2 - 3y + 2)}$
 $= \frac{2 \cdot \cancel{3} \cdot (y + 4)(\cancel{y - 2})}{\cancel{3}(y - 1)(\cancel{y - 2})}$
 $= \frac{2(y + 4)}{y - 1}$

22. Multiply and Divide Rational Expressions

1. $\frac{r - s}{r + s} \cdot \frac{r^2 - s^2}{(r - s)^2} = \frac{(r - s)(r^2 - s^2)}{(r + s)(r - s)^2}$
 $= \frac{(\cancel{r - s})(\cancel{r - s})(r + s) \cdot 1}{(\cancel{r + s})(\cancel{r - s})(\cancel{r - s})}$
 $= 1$

2. $\frac{m^2 - n^2}{r + s} \div \frac{m - n}{r + s}$
 $= \frac{m^2 - n^2}{r + s} \cdot \frac{r + s}{m - n}$
 $= \frac{(m + n)(\cancel{m - n})(\cancel{r + s})}{(\cancel{r + s})(\cancel{m - n})}$
 $= m + n$

3. $\frac{4x^2 + 9x + 2}{x^2 + x - 2} \cdot \frac{x^2 - 1}{3x^2 + x - 2}$
 $= \frac{(4x + 1)(\cancel{x + 2})(\cancel{x + 1})(\cancel{x - 1})}{(\cancel{x + 2})(\cancel{x - 1})(3x - 2)(\cancel{x + 1})}$
 $= \frac{4x + 1}{3x - 2}$

4. $\frac{3x + 12}{2x - 8} \div \frac{(x + 4)^2}{(x - 4)^2}$
 $= \frac{3x + 12}{2x - 8} \cdot \frac{(x - 4)^2}{(x + 4)^2}$
 $= \frac{3(\cancel{x + 4})(\cancel{x - 4})(x - 4)}{2(\cancel{x - 4})(\cancel{x + 4})(x + 4)}$
 $= \frac{3(x - 4)}{2(x + 4)}$

5. $\frac{a^2 - a - 2}{a^2 - a - 6} \div \frac{a^2 - 2a}{2a + a^2}$
 $= \frac{a^2 - a - 2}{a^2 - a - 6} \cdot \frac{2a + a^2}{a^2 - 2a}$
 $= \frac{(\cancel{a - 2})(a + 1)(\cancel{a})(\cancel{2 + a})}{(a - 3)(\cancel{a + 2})(\cancel{a})(\cancel{a - 2})}$
 $= \frac{a + 1}{a - 3}$

6. $\frac{x^2 - y^2}{x^3 - y^3} \cdot \frac{x^2 + xy + y^2}{x^2 + 2xy + y^2}$
 $= \frac{(x + y)(x - y)(x^2 + xy + y^2)}{(x - y)(x^2 + xy + y^2)(x + y)(x + y)}$
 $= \frac{1}{x + y} \cdot \frac{(x + y)(x - y)(x^2 + xy + y^2)}{(x + y)(x - y)(x^2 + xy + y^2)}$
 $= \frac{1}{x + y} \cdot 1$ Removing a factor of 1
 $= \frac{1}{x + y}$

23. Add and Subtract Rational Expressions

1. $\frac{a - 3b}{a + b} + \frac{a + 5b}{a + b} = \frac{2a + 2b}{a + b}$
 $= \frac{2(\cancel{a + b})}{1 \cdot (\cancel{a + b})}$
 $= 2$

2. $\frac{x^2 - 5}{3x^2 - 5x - 2} + \frac{x + 1}{3x - 6}$
 $= \frac{x^2 - 5}{(3x + 1)(x - 2)} + \frac{x + 1}{3(x - 2)}$
 $= \frac{x^2 - 5}{(3x + 1)(x - 2)} \cdot \frac{3}{3} + \frac{x + 1}{3(x - 2)} \cdot \frac{3x + 1}{3x + 1}$
 $= \frac{3(x^2 - 5) + (x + 1)(3x + 1)}{3(3x + 1)(x - 2)}$
 $= \frac{3x^2 - 15 + 3x^2 + 4x + 1}{3(3x + 1)(x - 2)}$
 $= \frac{6x^2 + 4x - 14}{3(3x + 1)(x - 2)}$

$$\begin{aligned}
 3. \quad & \frac{a^2 + 1}{a^2 - 1} - \frac{a - 1}{a + 1} \\
 &= \frac{a^2 + 1}{(a + 1)(a - 1)} - \frac{a - 1}{a + 1}, \text{ LCD is } (a + 1)(a - 1) \\
 &= \frac{a^2 + 1 - (a - 1)(a - 1)}{(a + 1)(a - 1)} \\
 &= \frac{a^2 + 1 - a^2 + 2a - 1}{(a + 1)(a - 1)} \\
 &= \frac{2a}{(a + 1)(a - 1)}
 \end{aligned}$$

$$\begin{aligned}
 4. \quad & \frac{9x + 2}{3x^2 - 2x - 8} + \frac{7}{3x^2 + x - 4} \\
 &= \frac{9x + 2}{(3x + 4)(x - 2)} + \frac{7}{(3x + 4)(x - 1)}, \\
 & \quad \text{LCD is } (3x + 4)(x - 2)(x - 1) \\
 &= \frac{9x + 2}{(3x + 4)(x - 2)} \cdot \frac{x - 1}{x - 1} + \frac{7}{(3x + 4)(x - 1)} \cdot \frac{x - 2}{x - 2} \\
 &= \frac{9x^2 - 7x - 2}{(3x + 4)(x - 2)(x - 1)} + \frac{7x - 14}{(3x + 4)(x - 1)(x - 2)} \\
 &= \frac{9x^2 - 16}{(3x + 4)(x - 2)(x - 1)} \\
 &= \frac{\cancel{(3x + 4)}(3x - 4)}{\cancel{(3x + 4)}(x - 2)(x - 1)} \\
 &= \frac{3x - 4}{(x - 2)(x - 1)}
 \end{aligned}$$

$$\begin{aligned}
 5. \quad & \frac{y}{y^2 - y - 20} - \frac{2}{y + 4} \\
 &= \frac{y}{(y + 4)(y - 5)} - \frac{2}{y + 4}, \text{ LCD is } (y + 4)(y - 5) \\
 &= \frac{y}{(y + 4)(y - 5)} - \frac{2}{y + 4} \cdot \frac{y - 5}{y - 5} \\
 &= \frac{y}{(y + 4)(y - 5)} - \frac{2y - 10}{(y + 4)(y - 5)} \\
 &= \frac{y - (2y - 10)}{(y + 4)(y - 5)} \\
 &= \frac{y - 2y + 10}{(y + 4)(y - 5)} \\
 &= \frac{-y + 10}{(y + 4)(y - 5)}
 \end{aligned}$$

$$\begin{aligned}
 6. \quad & \frac{3y}{y^2 - 7y + 10} - \frac{2y}{y^2 - 8y + 15} \\
 &= \frac{3y}{(y - 2)(y - 5)} - \frac{2y}{(y - 5)(y - 3)}, \\
 & \quad \text{LCD is } (y - 2)(y - 5)(y - 3) \\
 &= \frac{3y(y - 3) - 2y(y - 2)}{(y - 2)(y - 5)(y - 3)} \\
 &= \frac{3y^2 - 9y - 2y^2 + 4y}{(y - 2)(y - 5)(y - 3)} \\
 &= \frac{y^2 - 5y}{(y - 2)(y - 5)(y - 3)} \\
 &= \frac{y\cancel{(y - 5)}}{(y - 2)\cancel{(y - 5)}(y - 3)} \\
 &= \frac{y}{(y - 2)(y - 3)}
 \end{aligned}$$

24. Simplify Complex Rational Expressions

$$\begin{aligned}
 1. \quad & \frac{\frac{x}{y} - \frac{y}{x}}{\frac{1}{y} + \frac{1}{x}} = \frac{\frac{x}{y} - \frac{y}{x}}{\frac{1}{y} + \frac{1}{x}} \cdot \frac{xy}{xy}, \text{ LCM is } xy \\
 &= \frac{\left(\frac{x}{y} - \frac{y}{x}\right)(xy)}{\left(\frac{1}{y} + \frac{1}{x}\right)(xy)} \\
 &= \frac{x^2 - y^2}{x + y} \\
 &= \frac{(x + y)(x - y)}{\cancel{(x + y)} \cdot 1} \\
 &= x - y
 \end{aligned}$$

$$\begin{aligned}
 2. \quad & \frac{\frac{a - b}{b}}{a^2 - b^2} = \frac{a - b}{b} \cdot \frac{ab}{a^2 - b^2} \\
 &= \frac{a - b}{b} \cdot \frac{ab}{(a + b)(a - b)} \\
 &= \frac{\cancel{a} \cancel{b} (a - b)}{\cancel{b} (a + b) \cancel{(a - b)}} \\
 &= \frac{a}{a + b}
 \end{aligned}$$

$$\begin{aligned}
 3. \quad \frac{w + \frac{8}{w^2}}{1 + \frac{2}{w}} &= \frac{w \cdot \frac{w^2}{w^2} + \frac{8}{w^2}}{1 \cdot \frac{w}{w} + \frac{2}{w}} \\
 &= \frac{\frac{w^3 + 8}{w^2}}{\frac{w + 2}{w}} \\
 &= \frac{w^3 + 8}{w^2} \cdot \frac{w}{w + 2} \\
 &= \frac{(w+2)(w^2 - 2w + 4)\cancel{w}}{\cancel{w} \cdot w(w+2)} \\
 &= \frac{w^2 - 2w + 4}{w}
 \end{aligned}$$

$$\begin{aligned}
 4. \quad \frac{\frac{x^2 - y^2}{xy}}{\frac{x - y}{y}} &= \frac{x^2 - y^2}{xy} \cdot \frac{y}{x - y} \\
 &= \frac{(x + y)\cancel{(x - y)}\cancel{y}}{xy\cancel{(x - y)}} \\
 &= \frac{x + y}{x}
 \end{aligned}$$

$$\begin{aligned}
 5. \quad \frac{\frac{a}{1} - \frac{b}{1}}{\frac{1}{a} - \frac{1}{b}} &= \frac{a^2 - b^2}{b - a} \quad \text{Multiplying by } \frac{ab}{ab} \\
 &= \frac{(a + b)(a - b)}{b - a} \\
 &= \frac{(a + b)\cancel{(a - b)}}{-1 \cdot \cancel{(a - b)}} \\
 &= -a - b
 \end{aligned}$$

$$11. \quad \sqrt{x^2 - 4x + 4} = \sqrt{(x - 2)^2} = x - 2$$

$$12. \quad \sqrt{2x^3y}\sqrt{12xy} = \sqrt{24x^4y^2} = \sqrt{4x^4y^2 \cdot 6} = 2x^2y\sqrt{6}$$

$$13. \quad \sqrt[3]{3x^2y}\sqrt[3]{36x} = \sqrt[3]{108x^3y} = \sqrt[3]{27x^3 \cdot 4y} = 3x\sqrt[3]{4y}$$

$$\begin{aligned}
 14. \quad 5\sqrt{2} + 3\sqrt{32} &= 5\sqrt{2} + 3\sqrt{16 \cdot 2} \\
 &= 5\sqrt{2} + 3 \cdot 4\sqrt{2} \\
 &= 5\sqrt{2} + 12\sqrt{2} \\
 &= (5 + 12)\sqrt{2} \\
 &= 17\sqrt{2}
 \end{aligned}$$

$$15. \quad 7\sqrt{12} - 2\sqrt{3} = 7 \cdot 2\sqrt{3} - 2\sqrt{3} = 14\sqrt{3} - 2\sqrt{3} = 12\sqrt{3}$$

$$\begin{aligned}
 16. \quad 2\sqrt{32} + 3\sqrt{8} - 4\sqrt{18} &= 2 \cdot 4\sqrt{2} + 3 \cdot 2\sqrt{2} - 4 \cdot 3\sqrt{2} = \\
 &= 8\sqrt{2} + 6\sqrt{2} - 12\sqrt{2} = 2\sqrt{2}
 \end{aligned}$$

$$\begin{aligned}
 17. \quad 6\sqrt{20} - 4\sqrt{45} + \sqrt{80} &= 6\sqrt{4 \cdot 5} - 4\sqrt{9 \cdot 5} + \sqrt{16 \cdot 5} \\
 &= 6 \cdot 2\sqrt{5} - 4 \cdot 3\sqrt{5} + 4\sqrt{5} \\
 &= 12\sqrt{5} - 12\sqrt{5} + 4\sqrt{5} \\
 &= (12 - 12 + 4)\sqrt{5} \\
 &= 4\sqrt{5}
 \end{aligned}$$

$$\begin{aligned}
 18. \quad (2 + \sqrt{3})(5 + 2\sqrt{3}) &= 2 \cdot 5 + 2 \cdot 2\sqrt{3} + \sqrt{3} \cdot 5 + \sqrt{3} \cdot 2\sqrt{3} \\
 &= 10 + 4\sqrt{3} + 5\sqrt{3} + 3 \cdot 2 \\
 &= 10 + 9\sqrt{3} + 6 \\
 &= 16 + 9\sqrt{3}
 \end{aligned}$$

$$\begin{aligned}
 19. \quad (\sqrt{8} + 2\sqrt{5})(\sqrt{8} - 2\sqrt{5}) &= (\sqrt{8})^2 - (2\sqrt{5})^2 \\
 &= 8 - 4 \cdot 5 \\
 &= 8 - 20 \\
 &= -12
 \end{aligned}$$

$$\begin{aligned}
 20. \quad (1 + \sqrt{3})^2 &= 1^2 + 2 \cdot 1 \cdot \sqrt{3} + (\sqrt{3})^2 \\
 &= 1 + 2\sqrt{3} + 3 \\
 &= 4 + 2\sqrt{3}
 \end{aligned}$$

25. Simplify Radical Expressions

$$1. \quad \sqrt{(-21)^2} = |-21| = 21$$

$$2. \quad \sqrt{9y^2} = \sqrt{(3y)^2} = |3y| = 3y$$

$$3. \quad \sqrt{(a - 2)^2} = a - 2$$

$$4. \quad \sqrt[3]{-27x^3} = \sqrt[3]{(-3x)^3} = -3x$$

$$5. \quad \sqrt[4]{81x^8} = \sqrt[4]{(3x^2)^4} = 3x^2$$

$$6. \quad \sqrt[5]{32} = \sqrt[5]{2^5} = 2$$

$$7. \quad \sqrt[4]{48x^6y^4} = \sqrt[4]{16x^4y^4 \cdot 3x^2} = 2xy\sqrt[4]{3x^2} = 2xy\sqrt[4]{3x^2}$$

$$8. \quad \sqrt{15}\sqrt{35} = \sqrt{15 \cdot 35} = \sqrt{3 \cdot 5 \cdot 5 \cdot 7} = \sqrt{5^2 \cdot 3 \cdot 7} = \sqrt{5^2} \cdot \sqrt{3 \cdot 7} = 5\sqrt{21}$$

$$9. \quad \frac{\sqrt{40xy}}{\sqrt{8x}} = \sqrt{\frac{40xy}{8x}} = \sqrt{5y}$$

$$10. \quad \frac{\sqrt[3]{3x^2}}{\sqrt[3]{24x^5}} = \sqrt[3]{\frac{3x^2}{24x^5}} = \sqrt[3]{\frac{1}{8x^3}} = \frac{1}{2x}$$

26. Rationalizing Denominators

$$1. \quad \frac{4}{\sqrt{11}} = \frac{4}{\sqrt{11}} \cdot \frac{\sqrt{11}}{\sqrt{11}} = \frac{4\sqrt{11}}{11}$$

$$2. \quad \sqrt{\frac{3}{7}} = \sqrt{\frac{3}{7} \cdot \frac{7}{7}} = \sqrt{\frac{21}{49}} = \frac{\sqrt{21}}{\sqrt{49}} = \frac{\sqrt{21}}{7}$$

$$3. \quad \frac{\sqrt[3]{7}}{\sqrt[3]{2}} = \frac{\sqrt[3]{7}}{\sqrt[3]{2}} \cdot \frac{\sqrt[3]{4}}{\sqrt[3]{4}} = \frac{\sqrt[3]{28}}{\sqrt[3]{8}} = \frac{\sqrt[3]{28}}{2}$$

$$\begin{aligned}
 4. \quad \sqrt[3]{\frac{16}{9}} &= \sqrt[3]{\frac{16}{9} \cdot \frac{3}{3}} = \sqrt[3]{\frac{48}{27}} = \frac{\sqrt[3]{48}}{\sqrt[3]{27}} = \\
 &= \frac{\sqrt[3]{8 \cdot 6}}{3} = \frac{2\sqrt[3]{6}}{3}
 \end{aligned}$$

$$\begin{aligned} 5. \quad \frac{3}{\sqrt{30}-4} &= \frac{3}{\sqrt{30}-4} \cdot \frac{\sqrt{30}+4}{\sqrt{30}+4} \\ &= \frac{3\sqrt{30}+12}{(\sqrt{30})^2-4^2} \\ &= \frac{3\sqrt{30}+12}{30-16} \\ &= \frac{3\sqrt{30}+12}{14} \end{aligned}$$

$$\begin{aligned} 6. \quad \frac{4}{\sqrt{7}-\sqrt{3}} &= \frac{4}{\sqrt{7}-\sqrt{3}} \cdot \frac{\sqrt{7}+\sqrt{3}}{\sqrt{7}+\sqrt{3}} \\ &= \frac{4\sqrt{7}+4\sqrt{3}}{(\sqrt{7})^2-(\sqrt{3})^2} \\ &= \frac{4\sqrt{7}+4\sqrt{3}}{7-3} \\ &= \frac{4\sqrt{7}+4\sqrt{3}}{4} = \frac{4(\sqrt{7}+\sqrt{3})}{4} \\ &= \sqrt{7}+\sqrt{3} \end{aligned}$$

$$\begin{aligned} 7. \quad \frac{6}{\sqrt{m}-\sqrt{n}} &= \frac{6}{\sqrt{m}-\sqrt{n}} \cdot \frac{\sqrt{m}+\sqrt{n}}{\sqrt{m}+\sqrt{n}} \\ &= \frac{6(\sqrt{m}+\sqrt{n})}{(\sqrt{m})^2-(\sqrt{n})^2} \\ &= \frac{6\sqrt{m}+6\sqrt{n}}{m-n} \end{aligned}$$

$$\begin{aligned} 8. \quad \frac{1-\sqrt{2}}{\sqrt{3}-\sqrt{6}} &= \frac{1-\sqrt{2}}{\sqrt{3}-\sqrt{6}} \cdot \frac{\sqrt{3}+\sqrt{6}}{\sqrt{3}+\sqrt{6}} \\ &= \frac{\sqrt{3}+\sqrt{6}-\sqrt{6}-\sqrt{12}}{3-6} \\ &= \frac{\sqrt{3}+\sqrt{6}-\sqrt{6}-2\sqrt{3}}{3-6} \\ &= \frac{-\sqrt{3}}{-3} = \frac{\sqrt{3}}{3} \end{aligned}$$

27. Rational Exponents

1. $y^{5/6} = \sqrt[6]{y^5}$

2. $x^{2/3} = \sqrt[3]{x^2}$

3. $16^{3/4} = (16^{1/4})^3 = (\sqrt[4]{16})^3 = 2^3 = 8$

4. $4^{7/2} = (\sqrt{4})^7 = 2^7 = 128$

5. $125^{-1/3} = \frac{1}{125^{1/3}} = \frac{1}{\sqrt[3]{125}} = \frac{1}{5}$

6. $32^{-4/5} = (\sqrt[5]{32})^{-4} = 2^{-4} = \frac{1}{16}$

7. $\sqrt[12]{y^4} = y^{4/12} = y^{1/3}$

8. $\sqrt{x^5} = x^{5/2}$

9. $x^{1/2} \cdot x^{2/3} = x^{1/2+2/3} = x^{3/6+4/6} = x^{7/6} = \sqrt[6]{x^7} = x^{\sqrt[6]{x}}$

10. $(a-2)^{9/4}(a-2)^{-1/4} = (a-2)^{9/4+(-1/4)} = (a-2)^{8/4} = (a-2)^2$

11. $(m^{1/2}n^{5/2})^{2/3} = m^{\frac{1}{2} \cdot \frac{2}{3}} n^{\frac{5}{2} \cdot \frac{2}{3}} = m^{1/3} n^{5/3} = \sqrt[3]{m} \sqrt[3]{n^5} = \sqrt[3]{mn^5} = n \sqrt[3]{mn^2}$

28. The Pythagorean Theorem

1. $a^2 + b^2 = c^2$

$8^2 + 15^2 = c^2$

$64 + 225 = c^2$

$289 = c^2$

$17 = c$

2. $a^2 + b^2 = c^2$

$4^2 + 4^2 = c^2$

$16 + 16 = c^2$

$32 = c^2$

$\sqrt{32} = c$

$5.657 \approx c$

3. $a^2 + b^2 = c^2$

$5^2 + b^2 = 13^2$

$25 + b^2 = 169$

$b^2 = 144$

$b = 12$

4. $a^2 + b^2 = c^2$

$a^2 + 12^2 = 13^2$

$a^2 + 144 = 169$

$a^2 = 25$

$a = 5$

5. $a^2 + b^2 = c^2$

$(\sqrt{5})^2 + b^2 = 6^2$

$5 + b^2 = 36$

$b^2 = 31$

$b = \sqrt{31} \approx 5.568$

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Chapter 1

Graphs, Functions, and Models

Exercise Set 1.1

1. Point A is located 5 units to the left of the y -axis and 4 units up from the x -axis, so its coordinates are $(-5, 4)$.

Point B is located 2 units to the right of the y -axis and 2 units down from the x -axis, so its coordinates are $(2, -2)$.

Point C is located 0 units to the right or left of the y -axis and 5 units down from the x -axis, so its coordinates are $(0, -5)$.

Point D is located 3 units to the right of the y -axis and 5 units up from the x -axis, so its coordinates are $(3, 5)$.

Point E is located 5 units to the left of the y -axis and 4 units down from the x -axis, so its coordinates are $(-5, -4)$.

Point F is located 3 units to the right of the y -axis and 0 units up or down from the x -axis, so its coordinates are $(3, 0)$.

2. G: $(2, 1)$; H: $(0, 0)$; I: $(4, -3)$; J: $(-4, 0)$; K: $(-2, 3)$; L: $(0, 5)$

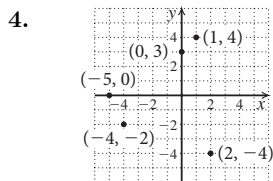
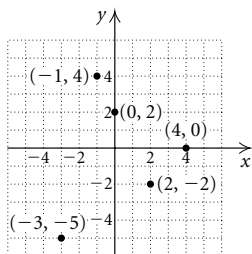
3. To graph $(4, 0)$ we move from the origin 4 units to the right of the y -axis. Since the second coordinate is 0, we do not move up or down from the x -axis.

To graph $(-3, -5)$ we move from the origin 3 units to the left of the y -axis. Then we move 5 units down from the x -axis.

To graph $(-1, 4)$ we move from the origin 1 unit to the left of the y -axis. Then we move 4 units up from the x -axis.

To graph $(0, 2)$ we do not move to the right or the left of the y -axis since the first coordinate is 0. From the origin we move 2 units up.

To graph $(2, -2)$ we move from the origin 2 units to the right of the y -axis. Then we move 2 units down from the x -axis.



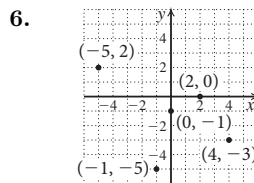
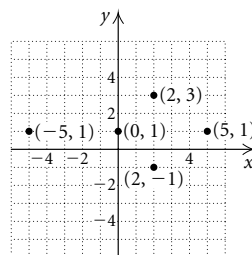
5. To graph $(-5, 1)$ we move from the origin 5 units to the left of the y -axis. Then we move 1 unit up from the x -axis.

To graph $(5, 1)$ we move from the origin 5 units to the right of the y -axis. Then we move 1 unit up from the x -axis.

To graph $(2, 3)$ we move from the origin 2 units to the right of the y -axis. Then we move 3 units up from the x -axis.

To graph $(2, -1)$ we move from the origin 2 units to the right of the y -axis. Then we move 1 unit down from the x -axis.

To graph $(0, 1)$ we do not move to the right or the left of the y -axis since the first coordinate is 0. From the origin we move 1 unit up.



7. The first coordinate represents the year and the corresponding second coordinate represents the number of cities served by Southwest Airlines. The ordered pairs are $(1971, 3)$, $(1981, 15)$, $(1991, 32)$, $(2001, 59)$, $(2011, 72)$, and $(2014, 96)$.

8. The first coordinate represents the year and the second coordinate represents the percent of Marines who are women. The ordered pairs are $(1960, 1\%)$, $(1970, 0.9\%)$, $(1980, 3.6\%)$, $(1990, 4.9\%)$, $(2000, 6.1\%)$, $(2011, 6.8\%)$, and $(2014, 7.6\%)$.

9. To determine whether $(-1, -9)$ is a solution, substitute -1 for x and -9 for y .

$$\begin{array}{r|l}
 y = 7x - 2 & \\
 -9 \stackrel{?}{=} 7(-1) - 2 & \\
 -9 & -7 - 2 \\
 -9 & -9 \qquad \text{TRUE}
 \end{array}$$

The equation $-9 = -9$ is true, so $(-1, -9)$ is a solution.

To determine whether $(0, 2)$ is a solution, substitute 0 for x and 2 for y .

$$\begin{array}{r|l} y = 7x - 2 & \\ \hline 2 \text{ ? } 7 \cdot 0 - 2 & \\ \hline 0 - 2 & \\ 2 \text{ | } -2 & \text{FALSE} \end{array}$$

The equation $2 = -2$ is false, so $(0, 2)$ is not a solution.

10. For $(\frac{1}{2}, 8)$:

$$\begin{array}{r|l} y = -4x + 10 & \\ \hline 8 \text{ ? } -4 \cdot \frac{1}{2} + 10 & \\ \hline -2 + 10 & \\ 8 \text{ | } 8 & \text{TRUE} \end{array}$$

$(\frac{1}{2}, 8)$ is a solution.

For $(-1, 6)$:

$$\begin{array}{r|l} y = -4x + 10 & \\ \hline 6 \text{ ? } -4(-1) + 10 & \\ \hline 4 + 10 & \\ 6 \text{ | } 14 & \text{FALSE} \end{array}$$

$(-1, 6)$ is not a solution.

11. To determine whether $(\frac{2}{3}, \frac{3}{4})$ is a solution, substitute $\frac{2}{3}$ for x and $\frac{3}{4}$ for y .

$$\begin{array}{r|l} 6x - 4y = 1 & \\ \hline 6 \cdot \frac{2}{3} - 4 \cdot \frac{3}{4} \text{ ? } 1 & \\ \hline 4 - 3 & \\ 1 \text{ | } 1 & \text{TRUE} \end{array}$$

The equation $1 = 1$ is true, so $(\frac{2}{3}, \frac{3}{4})$ is a solution.

To determine whether $(1, \frac{3}{2})$ is a solution, substitute 1 for x and $\frac{3}{2}$ for y .

$$\begin{array}{r|l} 6x - 4y = 1 & \\ \hline 6 \cdot 1 - 4 \cdot \frac{3}{2} \text{ ? } 1 & \\ \hline 6 - 6 & \\ 0 \text{ | } 1 & \text{FALSE} \end{array}$$

The equation $0 = 1$ is false, so $(1, \frac{3}{2})$ is not a solution.

12. For $(1.5, 2.6)$:

$$\begin{array}{r|l} x^2 + y^2 = 9 & \\ \hline (1.5)^2 + (2.6)^2 \text{ ? } 9 & \\ \hline 2.25 + 6.76 & \\ 9.01 \text{ | } 9 & \text{FALSE} \end{array}$$

$(1.5, 2.6)$ is not a solution.

For $(-3, 0)$:

$$\begin{array}{r|l} x^2 + y^2 = 9 & \\ \hline (-3)^2 + 0^2 \text{ ? } 9 & \\ \hline 9 + 0 & \\ 9 \text{ | } 9 & \text{TRUE} \end{array}$$

$(-3, 0)$ is a solution.

13. To determine whether $(-\frac{1}{2}, -\frac{4}{5})$ is a solution, substitute $-\frac{1}{2}$ for a and $-\frac{4}{5}$ for b .

$$\begin{array}{r|l} 2a + 5b = 3 & \\ \hline 2(-\frac{1}{2}) + 5(-\frac{4}{5}) \text{ ? } 3 & \\ \hline -1 - 4 & \\ -5 \text{ | } 3 & \text{FALSE} \end{array}$$

The equation $-5 = 3$ is false, so $(-\frac{1}{2}, -\frac{4}{5})$ is not a solution.

To determine whether $(0, \frac{3}{5})$ is a solution, substitute 0 for a and $\frac{3}{5}$ for b .

$$\begin{array}{r|l} 2a + 5b = 3 & \\ \hline 2 \cdot 0 + 5 \cdot \frac{3}{5} \text{ ? } 3 & \\ \hline 0 + 3 & \\ 3 \text{ | } 3 & \text{TRUE} \end{array}$$

The equation $3 = 3$ is true, so $(0, \frac{3}{5})$ is a solution.

14. For $(0, \frac{3}{2})$:

$$\begin{array}{r|l} 3m + 4n = 6 & \\ \hline 3 \cdot 0 + 4 \cdot \frac{3}{2} \text{ ? } 6 & \\ \hline 0 + 6 & \\ 6 \text{ | } 6 & \text{TRUE} \end{array}$$

$(0, \frac{3}{2})$ is a solution.

For $(\frac{2}{3}, 1)$:

$$\begin{array}{r|l} 3m + 4n = 6 & \\ \hline 3 \cdot \frac{2}{3} + 4 \cdot 1 \text{ ? } 6 & \\ \hline 2 + 4 & \\ 6 \text{ | } 6 & \text{TRUE} \end{array}$$

The equation $6 = 6$ is true, so $(\frac{2}{3}, 1)$ is a solution.

15. To determine whether $(-0.75, 2.75)$ is a solution, substitute -0.75 for x and 2.75 for y .

$$\begin{array}{r|l} x^2 - y^2 = 3 & \\ \hline (-0.75)^2 - (2.75)^2 \text{ ? } 3 & \\ \hline 0.5625 - 7.5625 & \\ -7 \text{ | } 3 & \text{FALSE} \end{array}$$

The equation $-7 = 3$ is false, so $(-0.75, 2.75)$ is not a solution.

To determine whether $(2, -1)$ is a solution, substitute 2 for x and -1 for y .

$$\begin{array}{r|l} x^2 - y^2 = 3 & \\ \hline 2^2 - (-1)^2 \stackrel{?}{=} 3 & \\ 4 - 1 & \\ \hline 3 & 3 \text{ TRUE} \end{array}$$

The equation $3 = 3$ is true, so $(2, -1)$ is a solution.

16. For $(2, -4)$:

$$\begin{array}{r|l} 5x + 2y^2 = 70 & \\ \hline 5 \cdot 2 + 2(-4)^2 \stackrel{?}{=} 70 & \\ 10 + 2 \cdot 16 & \\ \hline 10 + 32 & \\ \hline 42 & 70 \text{ FALSE} \end{array}$$

$(2, -4)$ is not a solution.

For $(4, -5)$:

$$\begin{array}{r|l} 5x + 2y^2 = 70 & \\ \hline 5 \cdot 4 + 2(-5)^2 \stackrel{?}{=} 70 & \\ 20 + 2 \cdot 25 & \\ \hline 20 + 50 & \\ \hline 70 & 70 \text{ TRUE} \end{array}$$

$(4, -5)$ is a solution.

17. Graph $5x - 3y = -15$.

To find the x -intercept we replace y with 0 and solve for x .

$$\begin{aligned} 5x - 3 \cdot 0 &= -15 \\ 5x &= -15 \\ x &= -3 \end{aligned}$$

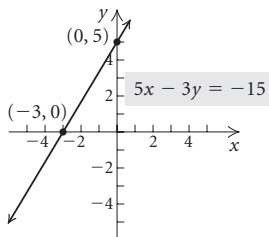
The x -intercept is $(-3, 0)$.

To find the y -intercept we replace x with 0 and solve for y .

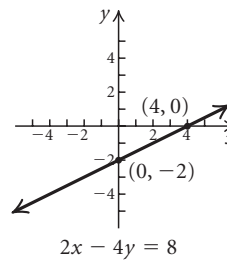
$$\begin{aligned} 5 \cdot 0 - 3y &= -15 \\ -3y &= -15 \\ y &= 5 \end{aligned}$$

The y -intercept is $(0, 5)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



18.



19. Graph $2x + y = 4$.

To find the x -intercept we replace y with 0 and solve for x .

$$\begin{aligned} 2x + 0 &= 4 \\ 2x &= 4 \\ x &= 2 \end{aligned}$$

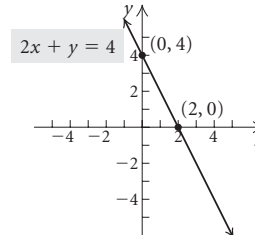
The x -intercept is $(2, 0)$.

To find the y -intercept we replace x with 0 and solve for y .

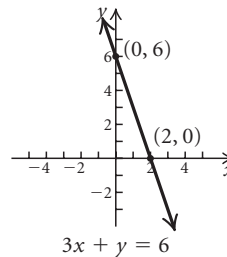
$$\begin{aligned} 2 \cdot 0 + y &= 4 \\ y &= 4 \end{aligned}$$

The y -intercept is $(0, 4)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



20.



21. Graph $4y - 3x = 12$.

To find the x -intercept we replace y with 0 and solve for x .

$$\begin{aligned} 4 \cdot 0 - 3x &= 12 \\ -3x &= 12 \\ x &= -4 \end{aligned}$$

The x -intercept is $(-4, 0)$.

To find the y -intercept we replace x with 0 and solve for y .

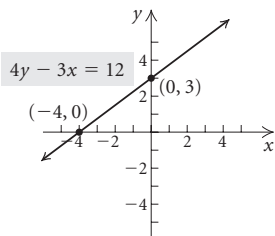
$$4y - 3 \cdot 0 = 12$$

$$4y = 12$$

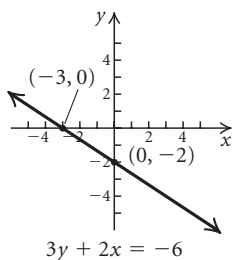
$$y = 3$$

The y -intercept is $(0, 3)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



22.



23. Graph $y = 3x + 5$.

We choose some values for x and find the corresponding y -values.

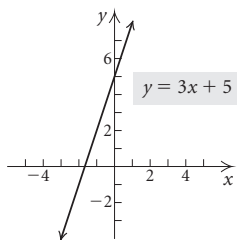
When $x = -3$, $y = 3x + 5 = 3(-3) + 5 = -9 + 5 = -4$.

When $x = -1$, $y = 3x + 5 = 3(-1) + 5 = -3 + 5 = 2$.

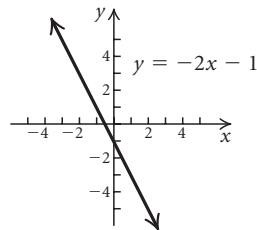
When $x = 0$, $y = 3x + 5 = 3 \cdot 0 + 5 = 0 + 5 = 5$

We list these points in a table, plot them, and draw the graph.

x	y	(x, y)
-3	-4	$(-3, -4)$
-1	2	$(-1, 2)$
0	5	$(0, 5)$



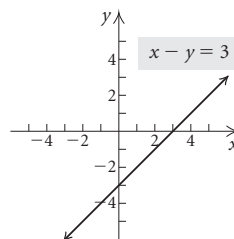
24.



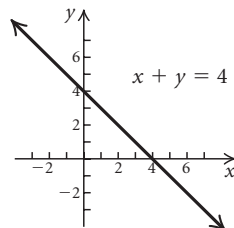
25. Graph $x - y = 3$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-2	-5	$(-2, -5)$
0	-3	$(0, -3)$
3	0	$(3, 0)$



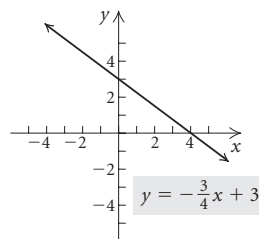
26.



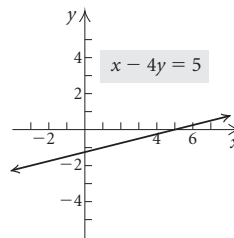
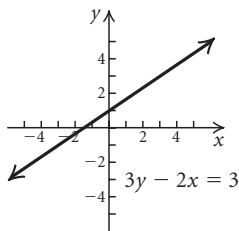
27. Graph $y = -\frac{3}{4}x + 3$.

By choosing multiples of 4 for x , we can avoid fraction values for y . Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-4	6	$(-4, 6)$
0	3	$(0, 3)$
4	0	$(4, 0)$



28.



29. Graph $5x - 2y = 8$.

We could solve for y first.

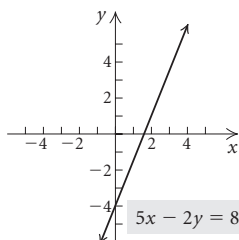
$$5x - 2y = 8$$

$$-2y = -5x + 8 \quad \text{Subtracting } 5x \text{ on both sides}$$

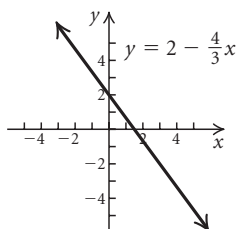
$$y = \frac{5}{2}x - 4 \quad \text{Multiplying by } -\frac{1}{2} \text{ on both sides}$$

By choosing multiples of 2 for x we can avoid fraction values for y . Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
0	-4	(0, -4)
2	1	(2, 1)
4	6	(4, 6)



30.

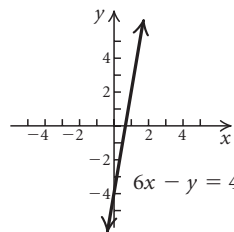


31. Graph $x - 4y = 5$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-3	-2	(-3, -2)
1	-1	(1, -1)
5	0	(5, 0)

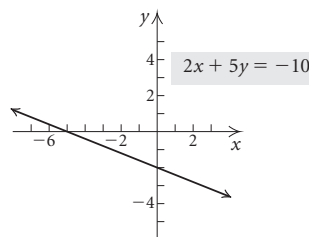
32.



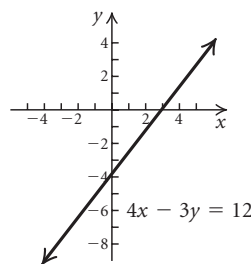
33. Graph $2x + 5y = -10$.

In this case, it is convenient to find the intercepts along with a third point on the graph. Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-5	0	(-5, 0)
0	-2	(0, -2)
5	-4	(5, -4)



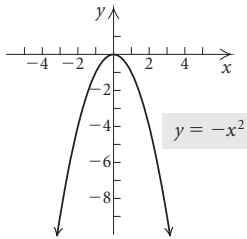
34.



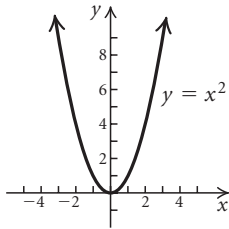
35. Graph $y = -x^2$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-2	-4	$(-2, -4)$
-1	-1	$(-1, -1)$
0	0	$(0, 0)$
1	-1	$(1, -1)$
2	-4	$(2, -4)$



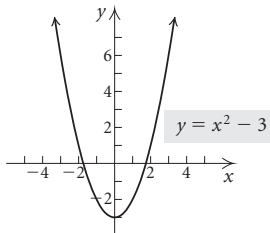
36.



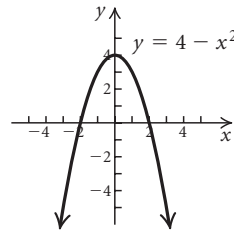
37. Graph $y = x^2 - 3$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-3	6	$(-3, 6)$
-1	-2	$(-1, -2)$
0	-3	$(0, -3)$
1	-2	$(1, -2)$
3	6	$(3, 6)$



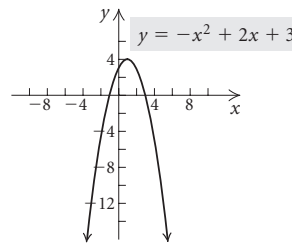
38.



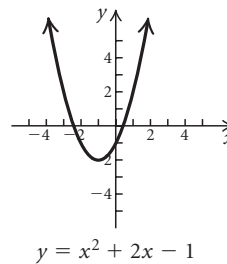
39. Graph $y = -x^2 + 2x + 3$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-2	-5	$(-2, -5)$
-1	0	$(-1, 0)$
0	3	$(0, 3)$
1	4	$(1, 4)$
2	3	$(2, 3)$
3	0	$(3, 0)$
4	-5	$(4, -5)$



40.



41. Graph (b) is the graph of $y = 3 - x$.

42. Graph (d) is the graph of $2x - y = 6$.

43. Graph (a) is the graph of $y = x^2 + 2x + 1$.

44. Graph (c) is the graph of $y = 8 - x^2$.