Pre Algebra Study Guide

From Simple Studies, https://simplestudies.edublogs.org & @simplestudiesinc on Instagram

Solving Linear Equations in One Variable

Solving Two-Step Equations with Rational Coefficients

- The goal of solving an equation is to **isolate** the variable, or get a variable alone on one side of the equation.
- A two-step equation contains two operations. To solve a two-step equation use the **inverse operations** and **properties of equality** to isolate the variable. Addition and subtraction are inverse operations. Multiplication and division are inverse operations.

$$5y - 4 = 31$$
$$\underline{\quad +4 \quad +4 \quad}$$ Addition Property of Equality
$$\frac{5y}{5} = \frac{35}{5}$$ Division Property of Equality
$$y=7$$

- To solve an equation when the coefficient of the variable is a fraction:

$$\frac{2}{5}x + 6 = -4$$
$$\underline{\quad -6 \quad -6 \quad}$$ Subtraction Property of Equality
$$2/5x= -10$$
$$(5/2)\ 2/5x = -10\ (5/2)$$ Multiply both sides by reciprocal
$$X = -25$$

Solving Multi-Step Equations

To solve an equation, isolate the variable.

- If the equation has parentheses, use the Distributive Property.
- Combine like terms on each side of the equation, as needed.
- Use the properties of equality and inverse operations to isolate the variable.
- Check your solution.

$$5\ (2x + 3) = 55$$
$$5\ (2x) + 5(3) = 55$$
$$10x + 15 = 55$$
$$\underline{\quad -15 \quad -15 \quad}$$
$$\frac{10x}{10} = \frac{40}{10}$$
$$x=4$$

Solving Equations with Variables on Both Sides

To solve an equation, you need to isolate the variable.

- If the equation has parentheses, use the Distributive Property
- If there are like terms on the same side of the equation, combine like terms.
- Collect all the variables onto one side of the equation using inverse operations.
- Collect all the constants on the other side by using inverse operations

$$
\begin{array}{l}
2x + 7 = -1x - 2 \\
+1x \qquad +1x \\
\hline
3x + 7 = -2 \\
\quad -7 \quad -7 \\
\hline
3x = -9 \\
\frac{3x}{3} = \frac{-9}{3} \\
x = -3
\end{array}
$$

Solutions of One Variable Equations

When solving an equation with variables on both sides, you can find:

- One Solution- When you solve the equation, the solution will be a variable equal to a number (x=*a*, with *a* being a constant)
- Infinitely many solutions- When you solve the equation, the variable will cancel itself out, and your solution will be a true statement, where an answer equals itself (*a*=*a*, with *a* being a constant) and the solution will make the equation true.

$$
\begin{array}{l}
-2(x + 3) = -2x - 6 \\
-2x - 6 =n -2x - 6 \\
+2x \qquad +2x \\
\hline
-6 = -6
\end{array}
$$

- No solution- When solving an equation, the variable cancels out, but you get a false statement where two numbers are not equal (*a*=*b*, with *a* and *b* both representing two different constants). The equation has no true number solution.

$$
\begin{array}{l}
2x + 3 = 2x + 7 \\
-2x \qquad -2x \\
\hline
3 = 7
\end{array}
$$

Solving Equations Containing Fractions by Clearing the Fraction

Clearing the Fraction:

If an equation contains fractions, you should clear the fraction using the steps below:

1. Find the Least Common Denominator (LCD) of the fractions.
2. Multiple **every term** on both sides of the equation by the LCD
3. Simplify the fractions
4. Solve the equation

$$\frac{1}{2}x + \frac{3}{4} = 5 \qquad \text{LCD} = 4$$

$$4\left(\frac{1}{2}x + \frac{3}{4}\right) = 5(4)$$

$$2x + 3 = 20$$

$$\underline{\quad -3 \quad -3}$$

$$\frac{2x}{2} = \frac{17}{2}$$

$$x = 8.5$$

Solving Linear Equations by Solving Proportions

- Linear equations made up of the equivalent rational expressions are solved the same way we normally solve proportions.
- When there is more than one term in the numerator or/and denominator, put the expression with more than one term in parentheses so that you remember to use the distributive property when transforming the equation.

$$\frac{(5 + 2x)}{(3x - 1)} = \frac{6}{7}$$

$$6(3x - 1) = 7(5 + 2x)$$

$$18x - 6 = 35 + 14x$$

$$\underline{-14x \qquad\quad -14x}$$

$$4x - 6 = 35$$

$$\underline{\quad +6 \quad +6}$$

$$\frac{4x}{4} = \frac{41}{4}$$

$$x = 41/4$$

Applications of Linear Equations

1. The sum of thirteen and twice a number is seven less than six times a number. What is the number?

   Let x= the number

$$
\begin{array}{l}
2x + 13 = 6x - 7 \\
-2x \qquad\quad -2x \\
\hline
13 = 4x - 7 \\
+7 \qquad +7 \\
\hline
\dfrac{20 = 4x}{4 \qquad 4} \\
x = 5
\end{array}
$$

The number equals 5.

2. The sum of four consecutive integers is -26. What are the integers?

   Let x= 1st integer

   Let x+1= 2nd integer

   Let x+2= 3rd integer

   Let x+3= 4th integer

$$
\begin{array}{l}
X + (x+1) + (x+2) + (x+3) = -26 \\
4x + 6 + -26 \\
\quad -6 \quad -6 \\
\hline
4x = -32 \\
\hline
4 \qquad 4 \\
x = 8
\end{array}
$$

The integers are -8, -7, -6, and -5.

Linear Equations in Two Variables

The Coordinate Plane

Two perpendicular number lines separate a plane into four regions called **quadrants.** The quadrants are numbered with Roman numerals, in the counterclockwise direction.

- The x-axis is the horizontal number line, and the y-axis is the vertical number line.
- The origin is the intersection between the x and y axes, represented by the ordered pair (0,0).
- Points being located on a plane are denoted using ordered pairs (x,y). The first number in an ordered pair represents the x-coordinate. The second is the y-coordinate.
    - A plane that has been set up in this way is referred to as a coordinate plane.
- When you're graphing on the coordinate plane, first find the x-coordinate, then the y-coordinate. These directions start at the origin.

	Positive	Negative
x-axis	right	left
y-axis	up	down

- When graphing an equation, you are creating a picture/graph of the ordered pairs that are solutions to the equations (using the rule). Graphs show you how many solutions there are to the equation. Some graphs form lines when multiple solutions are plotted.
- The graph of the line represents a **linear relationship** between the two variables, x and y.
- **Steps to draw a graph:**
    1. Create a table of values to represent the relationship or equation.
    2. Graph ordered pairs (from table)
    3. Determine if relationship is proportional or non-proportional

Slope as a Rate of Change- From Graphs

- In a linear relationship, the rate of change on a graph is the slope of the line. This term is used to describe the steepness of a line. It is the ratio of rise over run, (vertical change over horizontal change).
- We can measure the steepness of a line comparing how much the y-variable changes over the x-variable change

$$\text{slope} = \frac{\text{Rise}}{\text{run}} \qquad \frac{y2-y1}{x2-x1}$$

- Slope (rate of change) can be positive or negative.
  - Positive: line slants upward left to right
  - Negative: line slants downward from left to right
  - Horizontal lines have a **slope of zero**.
  - Vertical lines have an **undefined slope** (the slope cannot be determined).

Sketching Graphs of Linear Equations in y=mx+b

- This is called slope intercept form.
- M represents the slope and the b represents the y-intercept of the line.
- A linear equation has an infinite number of solutions. The solutions are all the ordered pairs that make the equation true.
  - You can create a table of values and graph the ordered pairs to determine the line**.** **(m= rise/run)**

Rewriting Equations in Slope Intercept Form

- It is easy to graph an equation written in slope-intercept form. In order to graph an equation not written in slope intercept form, isolate the y on one side of the equation by using the properties of equality.

Slope as a Rate of Change- From Two Points

- To find slope from 2 points, use the Slope Formula:
  - The slope of a line passing through points (x1, y1) and (x2, y2) is the ratio of the difference in the y-coordinates to the difference in the x-coordinates.

Rate of Change from a Table

- The slope is a rate that describes how a quantity is in relation to another quantity. In a linear relationship, the rate of change between any two ordered pairs is constant. This is called the **constant rate of change.**
- You can determine if a relationship is linear from a table of values, without graphing the line, by determining if there is a constant rate of change between the ordered pairs in the table.

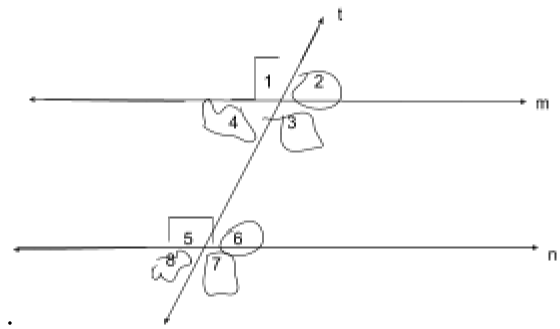
Linear Equations in Slope- Intercept Form

- Linear relationships can be written in the form y=mx+b (slope intercept form).
  - M, the coefficient of x, represents the slope.
  - The constant, b, is the y-value of the y-intercept (0, b).
  - When an equation in slope-intercept form applies to a real-world situation, the slope represents the rate of change, and the y-intercept represents the initial value.

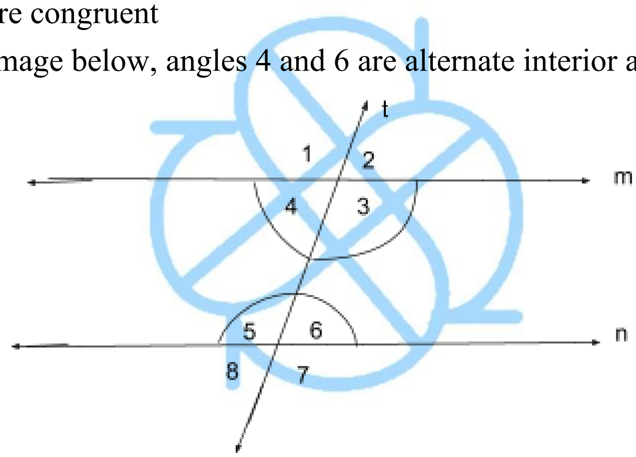
Angle Relationships

Angle Relationships in Parallel Lines Crossed by a Transversal

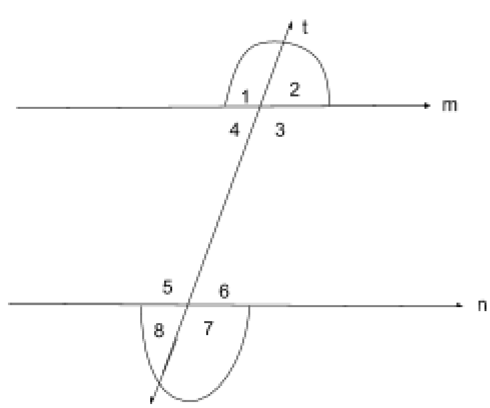
- Corresponding Angles: pairs of angles in the same relative position on different parallels.
    - They are congruent



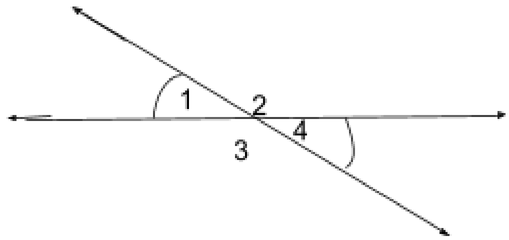
- Alternate Interior Angles: pairs of angles on opposite sides of the transversal inside the parallel; they are congruent
    - In the image below, angles 4 and 6 are alternate interior angles, and so are 3 and 4



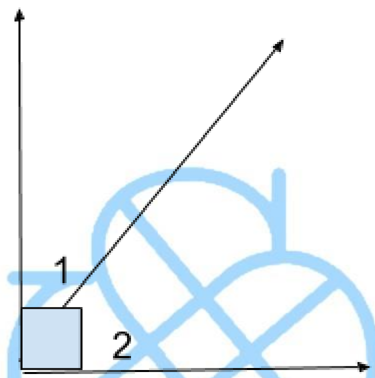
- Alternate Exterior Angles: pairs of angles on opposite sides of the transversal outside the parallel lines; they are congruent.
    - In the image below, angles 2 and 8 are alternate exterior angles, and so are 1 and 7



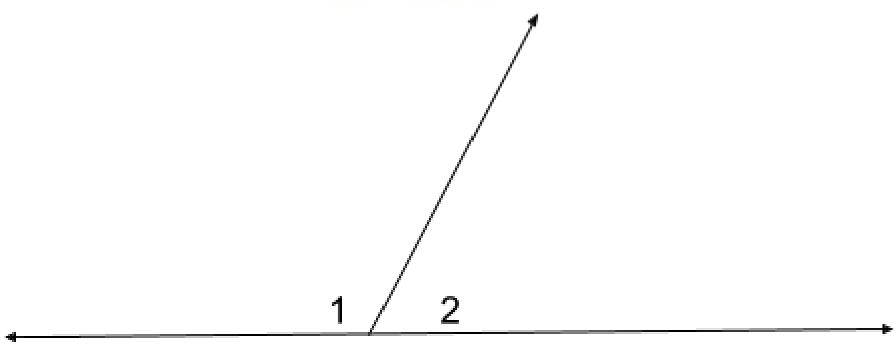
- Vertical Angles: Pairs of congruent angles. Formed when 2 lines intersect. T%he have sides that are opposite rays and share a vertex.



- Complementary Angles: Two angles whose sum is 90 degrees.
    - m∠1 + m∠2 = 90 degrees

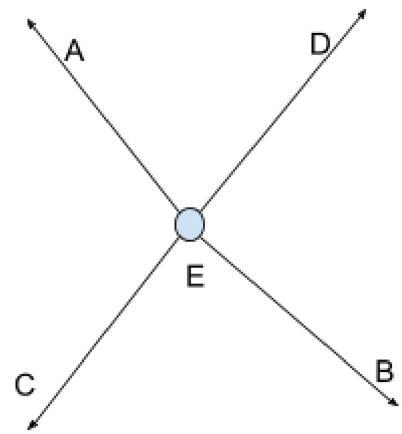


- Supplementary Angles: Two angles whose sum is 180 degrees.
    - If they are adjacent, they form a linear pair
    - m∠1+ m∠2 = 180 degrees



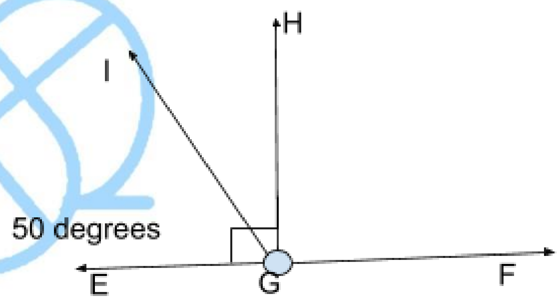
Angle Relationships in Basic Diagrams

Example 1:



- Which angle is vertical to ∠AEC?
  - ∠DEB
- Which angle is vertical to ∠CEB?
  - ∠AED
- Name an angle that is supplementary to ∠AEC
  - ∠CEB
- If the m∠DEB is 35 degrees, what is m∠AEC?
  - 35 degrees
- If the m∠DEB is 35 degrees, what is the m∠AED?
  - 145 degrees

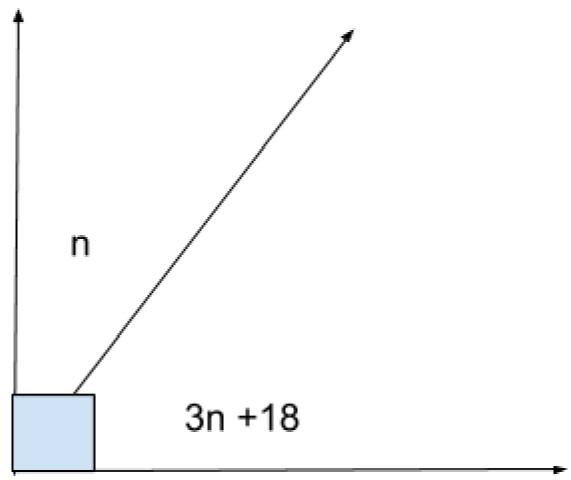
Example 2:



- Find the measure of ∠IGH.
  - 90 - 50 = 40 degrees
- Find the measure of ∠IGF.
  - 180 - 50 = 130 degrees
- Which angle is complementary to ∠EGI?
  - ∠HGI

Using Equations to Determine Angle Measurements

- What is the angle relationship?
  - Complementary
- Write and solve an equation based on the relationship between the angles.

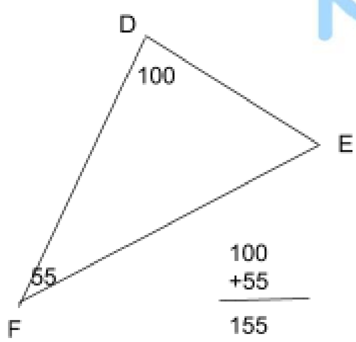


N +3n + 18= 90
4n + 18= 90
-18 -18
4n = 72
4 4
n=18
degrees

  - m∠n = 18 degrees ; m∠(3n+18) = 72 degrees

Angle Relationships in Triangles

- Triangle Sum Theorem: The sum of the three interior angles of a triangle equals 180°.
  - For triangle ABC: ∠A + ∠B + ∠C = 180 degrees
  - Example: Find ∠E

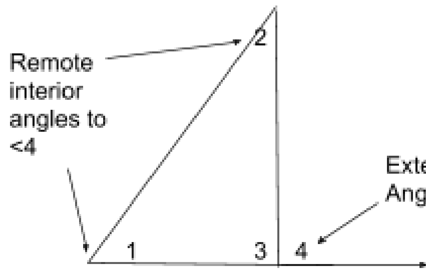


100
+55
155
degrees

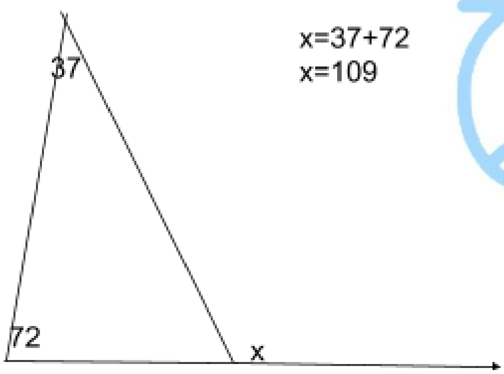
180
-155
25 degrees

    - m∠E = 25 degrees

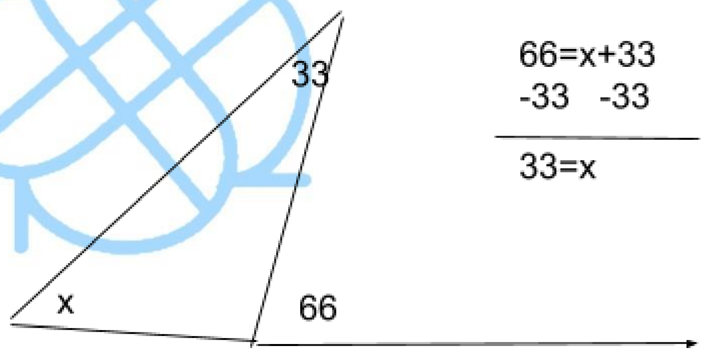
- Exterior Angle of a Triangle Theorem:
    - An **exterior angle** of a triangle is formed by one side of the triangle and the extension of an adjacent side.
    - An exterior angle of a triangle has two remote interior angles.
        - A **remote interior angle** is an angle inside the triangle that is not adjacent to the exterior angle.



    - Exterior Angle Theorem: The measure of an exterior angle is equal to the sum of its two remote interior angles.
        - In the diagram above: m∠1+ m∠2= m∠4



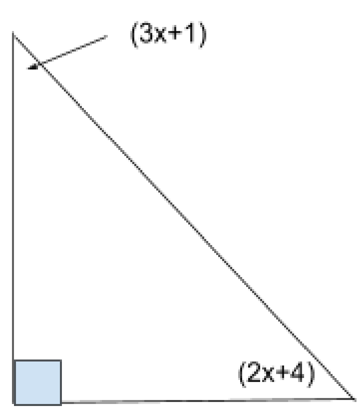
x=37+72
x=109



66=x+33
-33 -33

33=x

Finding Angle Measures (in triangles) using Equations



- Find x (in the pic on the right)

3x+1+2x+4+90+180
5x+95+180
-95 -95

5x=85
5 5
x=75

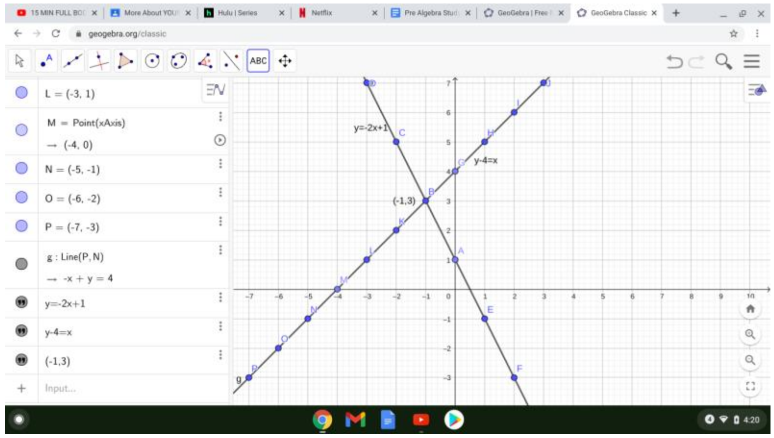
3x +1
3(17)+1
m<=52

2x+4
2(17)+1
38 degrees

Solving Systems of Equations

Solving a System of Equations by Graphing

- A system of linear equations contains two or more equations. The solution of such a system is an ordered pair (solution to both equations).
- To solve a system of linear equations, graph both lines on the same coordinate plane, and the point of intersection between the two lines is the solution.
- Steps on Solving a System of Linear Equations using the Graphing Method:
    1. Graph and label one equation on the coordinate plane.
    2. Graph and label the other equation on the same coordinate plane.
    3. The point where the lines intersect is the solution. Write the coordinates on the graph.
    4. CHECK the solution in both equations algebraically. The solution must satisfy both equations.
- Ex. $y = -2x + 1$ and $y - 4 = x$
    1. Rearrange the 2nd equation to isolate y → $y = x + 4$
    2. Graph both equations

3. 

4. Find the coordinates for the point of intersection of the two lines

Systems of Equations with One solution, No solution, or Infinitely many Solutions

- If lines intersect once, there is one solution (an ordered pair) to the system
- If the lines are parallel, there is no solution to the system because the lines will never intersect. The slope is the same of both lines
- If the lines are the same, there are infinitely many solutions to the system.
  - Lines are the same if they have the same equation when written in slope-intercept form.

Applied Systems of Equations using Graphing

- You can model and solve many real-world problems in which you are given two different relationships between two unknown quantities by using systems of linear equations.
  - Define the variables (x,y)
    - Let x = __ ; Let y = __
  - Write 2 linear equations using the information given in the problem
    - Rewrite the equations in slope-intercept form, if needed.
  - Graph the equations on the same axes. State the slope and y-intercept, and label each line with its equation
  - Write the coordinates of the solution. Interpret the solution based on the problem

Solving a System of Equations by Substitution

- Solve one of the equations for either x or y (isolate one of the variables)
- Substitute the expression from step 1 into the other equation in place of the isolated variable. Now the second equation only has one variable.
- Solve that second equation to find the value of that one variable.
- Take this value and substitute it into one of the original equations to find the value of the second variable.

1) $2y+3x=16$
2) $y=2x-6$

$2(2x-6)+3x=16$
$4x-12+3x=16$
$7x-12=16$
$+12 \quad +12$
$7x=28$
$\frac{7x}{7}=\frac{28}{7}$
$x=4$

Find y

$y=2x-6$
$y=2(4)-6$
$y=8-6$
$y=2$

(4,2)

Checks

$2y+3x=16$	$y=2x-6$
$2(2)+3(4)=16$	$2=2(4)-6$
$4+12=16$	$2=8-6$
$16=16$	$2=2$

- Write the solution as an ordered pair and check solution

Solving a System of Equations using Elimination

- If the two equations are in standard form (Ax+By=C), and each has coefficients that are additive inverses for one of the variables, the equations can be added together by combining like terms to eliminate the variable.
- Then substitute that value into the original equations to find the value of the other variable. State your solution by writing your solution as an ordered pair (unless there is no solution or infinitely many solutions).

Solving a System of Equations by Elimination with Multiplication

1. Write both equations in standard form
2. Compare the coefficients of the x-terms.
    a. Ask yourself, "What number can I multiply one of the equations by to get the additive inverse of the other term?"
3. Write an equation equivalent to the second equation by multiplying each term by the number you found above.
4. Now solve by elimination → Add the equations together and solve for one variable.
5. Substitute the value you found for y into either one of the original equations.

Exponents

Introduction to Exponents

- A product of repeated factors can be expressed in **exponential form**.
- There are two parts to an expression in exponential form: the base and the exponent. To evaluate a power means to simplify it to find its value as a singular number
- *Note that the parentheses means the base includes the negative sign; no parentheses would mean that the negative is not part of the base.
- *Note that fractions that are raised to a power must be in parentheses, meaning the numerator and denominator are both raised to that power.

Expanded Form

4^4= (4)(4)(4)(4)

Exponential Form

(-3)(-3)(-3)(-3)=(-3)^4

Evaluate the Expression

-2^4= -16

Multiplication of Numbers in Exponential Form

- To multiply powers with the same base, keep the base and add the exponents. If there are coefficients, multiply them.
    - Ex. $3^2 + 3^7 = 3^{(2+7)} = 3^9$

Raising a Power to a Power

- To multiply a power raised to a power, keep the base and multiply the exponents.

(3^4)^5= 3^4(5)= 3^20

- To raise a product to a power, raise each factor to the power.

(2x)^3= 2^3x^3

Division of Numbers in Exponential Form - Simplifying Fractions

- To divide powers with the same base, keep the base and subtract the exponents. If there are coefficients, divide the coefficients.

$$\frac{7^\wedge 9}{7^\wedge 6} = 7^\wedge 3$$

Zero and Negative Exponents

- To simplify an exponential expression means to write it using the fewest number of bases possible with only positive exponents.
- When you multiply or divide exponential expressions, you may end up with negative or zero exponents. They must be further simplified so the final expression contains only positive exponents.
- Zero Power Definition: Any base with an exponent of 0 equals 1 (0^0 is undefined)
    - Ex. $5^0 = 1$
- Negative Exponents: Any base raised to a negative exponent is equal to the reciprocal of the base raised to the positive exponent.
    - Ex. $2^{-3} = \frac{1}{2^3}$

Scientific Notation

Scientific Notation is a shorthand way of expressing a very large or very small number as the product of a factor and an integer power of 10.

- The factor must be between 1 and 10.

$$89{,}000{,}000 \longrightarrow 8.9 \times 10^{7}$$

$$0.00000432 \longrightarrow 4.32 \times 10^{-6}$$

Multiplying Numbers in Scientific Notation

1. Multiply the first numbers (coefficients)
2. Add the exponents of the powers of 10 (Product of Powers Property)
3. Be sure your answer is in scientific notation

$$(4 \times 10^{4})(2 \times 10^{6})$$

$$(4)(2) \times 10^{4+6}$$

$$8 \times 10^{10}$$

Diving Numbers in Scientific Notation

1. Divide the first numbers (coefficients)
2. Subtract the exponents of the powers of 10
3. Be sure your answer is in scientific notation

$$\frac{8 \times 10^{8}}{2 \times 10^{3}} \qquad 8/2 \times 10^{8-3}$$

$$4 \times 10^{5}$$

Statistics (Bivariate Data)

Intro to Scatter Plots

- A **scatter plot** is a graph that shows the relationship between two sets of data (bivariable data). The data is graphed on a coordinate plane.
- A scatter plot can be used to determine if an association exists between two variables.
  - The general shape of all the points in a scatter plot can describe the association.
  - To determine the type of association, look at the points on a scatter plot to see if they are grouped closely together.
    - If they are grouped together, this represents clustering.
    - If all the points are clustered in a line, the scatter plot shows a linear relationship.
    - If the points are not clustered in a line, then the scatter plot shows a non-linear relationship.
    - If there is an outlier, one data point that is far away from all the other points, you do not need to consider it when looking for an association.
- Positive association- an x increases, a y increases
- Negative association- As x increases, y decreases
- No association- The points show no pattern

Scatter Plots and Line of Best Fit

- **Bivariable data** are used to explore the relationship between two variables and can be graphed on a scatter plot
  - If there's a linear association in the scatter plot, then a line can be used to represent the relationship between the two variables.
- A **line of best fit** is a straight line that comes closest to most of the points on a scatter plot. The data points should be clustered close to the line with almost an equal number of points above and below the line. The line of best fit will not fit all the data points exactly.
  - A nonlinear association cannot be modeled with a straight line.

Two Way Tables

- A scatter plot represents two sets of quantitative data, such as distance, time, or height,
  - Quantitative data can be written with numerical measurements.
- Now we will look at another way to analyze data. A **two-way table** represents frequencies for two sets of categorical or qualitative data, such as gender, sport, color, or subject. The rows indicate one category, and the columns represent another.

Two-Way Frequency Tables

- A **relative frequency table** shows percentages so that the data can be compared.
- Useful when there's a lot of data.
- Relative frequency can be calculated for the whole table, the row categories, and/or the column categories.

$$\text{Relative Frequency} = \frac{\text{Number of the item}}{\text{Total number of items (whole table or row or column)}}$$

Transformations

Intro to Rigid Transformations

- A **transformation** is a change in the position, size, or orientation of a figure.
    - The original figure is called the **preimage**.
    - The resulting (new) figure is called the **image**.
    - A transformation maps the preimage to the image.
- **Rigid Transformations:** the preimage and the image are congruent, which means they are the same size and shape.
- **Arrow notation** is used to describe a transformation, and **prime notation** is used to label the image.
- **Reflection** - A transformation across a line, called the line of reflection.
    - Each point and its image are the same distance from the line of reflection.
        - (Orientation changes!)
- **Rotation** - A transformation about a point P, called the center of rotation.
    - Each point and its image are the same distance from P.
- **Translation** - A transformation in which all points of a figure move the same distance in the same direction.

Translations

- A translation is a transformation that slides a figure of fixed distance in a given direction.
- In a translation, all of the points move the same distance in the same direction.
- A translation is called a rigid transformation because the image is congruent to the pre-image (which means same size and shape).
- In a translation of triangle ABC to triangle A'B'C, the distances from the pre-image points to the image points are equal, and the segments representing these distances are parallel.
    - The preimage and the image are congruent since line segments are the same length (same size) and corresponding angles have the same measure (same shape) in the preimage and image.

- Properties preserved under a translation from the pre-image to the image:
    1. Distance
    2. Angle measures
    3. Parallelism
    4. Orientation

Reflections

- A reflection is a rigid transformation in which a figure is reflected or flipped across a line called the line of reflection.
- Each point of the preimage and image is equally distant from the line of reflection.
    - The preimage and the image are congruent because in a rigid transformation, the position of a figure changes but size and shape are preserved.
- After a reflection, the image is a mirror image of the pre-image; therefore, the orientation is changed.

Rotations

- A rotation is a rigid transformation that turns a figure about a fixed point called the center of rotation a given number of degrees called the angle of rotation.
- The preimage and image are the same shape and size but the figures may be turned in different directions.
- A rotation maps a line to line, a ray to ray, a segment to segment, and an angle to angle. A rotation preserves lengths and segments, and a rotation preserves measures of a corresponding angle.

Dilations on the Coordinate Plane

- A dilation is a transformation in which a figure is enlarged or reduced by a scale factor with respect to a fixed point (often the origin).
- The preimage and the image are similar but not congruent.

Congruent vs. Similar Figures

- **Congruent Figures**: Two figures are congruent if one can be obtained from the other by a sequence of rotations, reflections and translations (rigid transformations).
- **Similar figures**: Two figures are similar to each other if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations.
  - They have the same shape but different sizes.

Similar Triangles- Angle-Angle Criterion and Scale Factor/Side Lengths

- Two triangles are similar if they have congruent corresponding angles and proportional corresponding sides.
- If two triangles are congruent, their corresponding angles and corresponding sides will be congruent.

Angle-Angle (AA) Similarity Postulate

- If two triangles have two pairs of corresponding angles, then they are similar triangles.

Similar Triangles- Scale Factor and Side Lengths

- If we don't have info about corresponding angles (two pairs), we need to examine the ratios of the corresponding side lengths. This will help us prove the triangles are similar.
  - If the ratios of corresponding side lengths are equal, then the triangles are similar, meaning the lengths of the triangles were dilated by the same scale factor.
    - If two triangles are similar, comparing the ratios of corresponding sides will produce a constant scale factor.

Area, Surface Area and Volume

Volumes of Prisms and Cylinders

- **Volume** is the amount of 3-dimensional space that a substance (solid, liquid, or gas) occupies, measured in cubic units.
- When working with pi, leaving your answer in terms of pi is the exact answer. If the problem asks you to round your answer, write the full calculator display before you round to the indicated place value.

Volume of a Sphere

- Volume of a Sphere = $\frac{4}{3}\pi r^3$

Perfect Square Roots

- When you multiply a number by itself, you are squaring that number or raising it to the second power.
    - For example 3^2 (3 x 3= 9).
- The square root of a number is one of its two equal factors.
    - Every positive number has both a positive and negative square root.
    - A radical sign is used to indicate the principal square root.
    - A negative sign in front of the radical means to find the negative square root.
    - If there is a plus/minus sign in front of the radical, you need to find both square roots.

Simplifying Square Roots

- Ex. $\sqrt{16}+\sqrt{25}=4+5=9$

Simplifying Cubed Roots

- Ex. $\sqrt[3]{125}+10=5+10=15$

Solving Equations with Square Roots

- Ex. $\sqrt{x^2} \pm \sqrt{16} \rightarrow x = \pm 4$

Sources

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