Name:

Skill Sheet 30 Measuring the Moon's Diameter

In this skill sheet you will explore how to measure the size of the moon's diameter using simple tools and calculations.

1. Tools to measure the moon's diameter

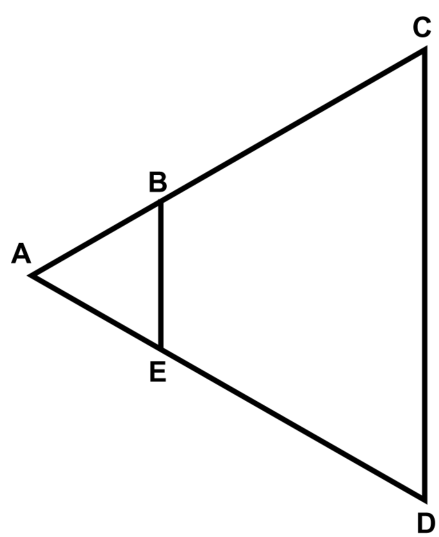
Here are the materials you will need to measure the moon's diameter:

- A 3-meter piece of string
- A metric tape measure
- A small metric ruler
- Tape
- Scissors
- Marker
- One-centimeter semi-circle card (Cut out from the bottom of the last page)

2. Proportions and Geometry

The method you will use to measure the moon's diameter depends on the properties of similar triangles. The following exercise demonstrates these properties.

Below is a large triangle. A line drawn from one side to the other of the large triangle results in a smaller triangle inside the larger one. The ends of each line are labeled with letters.



1. Make the following measurements of the lines on the triangle:
   Distance AC: ____________________ cm
   Distance AD: ____________________ cm
   Distance AB: ____________________ cm
   Distance AE: ____________________ cm
   Distance BE: ____________________ cm
   Distance CD: ____________________ cm

2. How is the distance from AB related to AC?

---

3. How is the distance from BE related to CD?

---

4. Based on your measurements and your answers to questions (2) and (3), come up with a statement that explains the properties of similar triangles.

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3. Finding the diameter of the moon

Now, you are ready to use your supplies to find the diameter of the moon. Follow these steps carefully and answer the questions as you go.

1. Locate a place where you can see the moon from a window. This is possible at night or early in the morning.
2. Use scissors to carefully cut out the semi-circle card found on the next page.
3. Tape this card to the window when you can see the full (or gibbous) moon through the window.
4. Tape one end of the 3-meter piece of string to the card directly underneath the semi-circle.
5. Now, slowly move backward from the window while holding on to the string. Watch your step! As you move backward, pay attention to the moon. You want to move back far enough so that the bottom half of the moon "sits" in the semi-circle cutout. You want the semi-circle to be the same size as the lower half to the moon.
6. When the lower half of the moon is the same size as the semi-circle cut out, stop moving backward and hold the sting up to the side of one of your eyes. Have a friend carefully mark the string at this distance.
7. Now, measure the distance from the window to the mark on the string to the nearest millimeter. Convert this distance to meters. Write the string distance in Table 1.

Table 1:Finding the moon's diameter data

Semi-circle diameter	0.01 meter
String distance	
Diameter of the moon	???
Distance from Earth to the moon	384, 400, 000 meters

4. Finding the moon's diameter

1. You have three out of four measurements in Table 1. The only measurement you need is the moon's diameter. You can find the moon's diameter using proportions. Which calculation will help you?

a. $\frac{\text{semi-circle diameter}}{\text{moon diameter}} = \frac{\text{distance to semi-circle}}{\text{distance from Earth to the moon}}$	b. $\frac{\text{semi-circle diameter}}{\text{distance to semi-circle}} = \frac{\text{moon diameter}}{\text{distance from Earth to the moon}}$
c. $\frac{\text{moon diameter}}{\text{semi-circle diameter}} = \frac{\text{distance to semi-circle}}{\text{distance from Earth to the moon}}$	d. $\frac{\text{moon diameter}}{\text{semi-circle diameter}} = \frac{\text{distance from Earth to the moon}}{\text{distance to semi-circle}}$

2. Use the proportion that you selected in question (1) to calculate the moon's diameter.

____

____

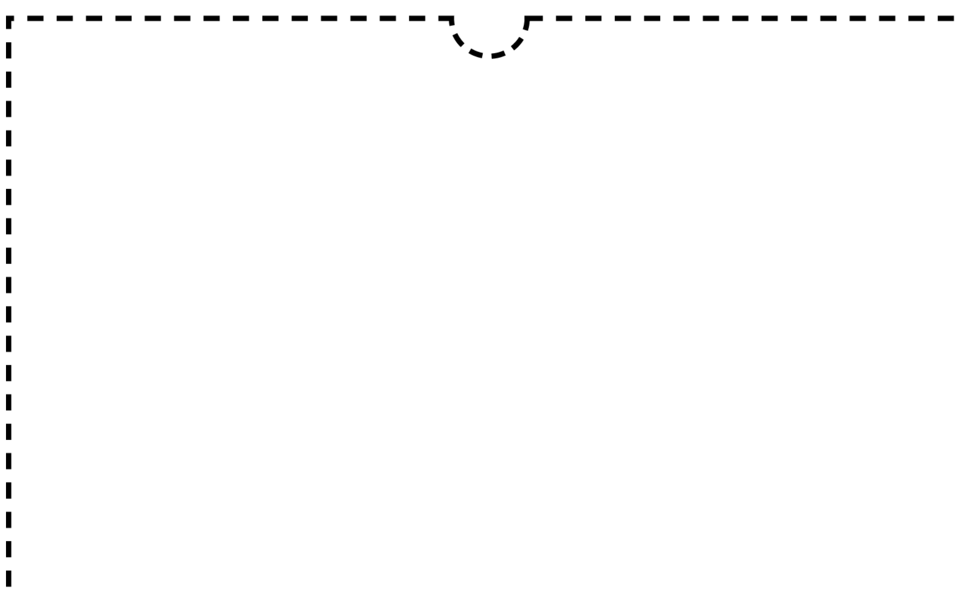
3. How is performing this calculation like the exercise you did in part 2?

____

____

____

Diameter = 1 cm



Semi-circle card
(cut out along dotted lines)

Name:

Skill Sheet 31-A Gravity Problems

An easy way to solve problems is to set them up as proportions. In this skill sheet, you will practice using proportions and learn more about the force of gravity on different planets.

1. Comparing the force of gravity on the planets

Table 1 lists the force of gravity on each planet in our solar system. We can see more clearly how these values compare to each other using proportions. First, we assume that Earth's gravity is equal to "1." Then, we set up the proportion where "x" equals the force of gravity on another planet (in this case, Mercury) as compared to Earth.

$$\frac{1}{\text{Earth gravity}} = \frac{x}{\text{Mercury gravity}}$$

$$\frac{1}{9.8\ \text{N}} = \frac{x}{3.7\ \text{N}}$$

$$(1 \times 3.7\ \text{N}) = (9.8\ \text{N} \times x)$$

$$\frac{3.7\ \text{N}}{9.8\ \text{N}} = x$$

$$0.38 = x$$

Therefore, Mercury's force of gravity is a little more than a third of Earth's gravity.

Now, calculate the proportions for the remaining planets.

Table 1: The force of gravity on planet in our solar system

Planet	Force of gravity in Newtons (N)	Value compared to Earth's gravity
Mercury	3.7	0.38
Venus	8.9	
Earth	9.8	1
Mars	3.7	
Jupiter	23.1	
Saturn	9.0	
Uranus	8.7	
Neptune	11.0	
Pluto	0.6	

2. How much does it weigh on another planet?

Use Table 1 to solve the following problems.

1. A cat weighs 8.5 pounds on Earth. How much would this cat weigh on Neptune?

---

2. A baby elephant weighs 250 pounds on Earth. How much would this elephant weigh on Saturn? Give you answer in Newtons (4.48 Newtons = 1 pound).

---

3. On Pluto, a baby would weigh 2.7 Newtons. How much would this baby weigh on Earth? Give your answer in Newtons and pounds.

---

4. Imagine that it is possible to travel to each planet in our solar system. After a space “cruise,” a tourist returns to Earth. One of the ways he recorded his travels was to weigh himself on each planet he visited. Use the list of these weights on each planet to figure out the order of the planets he visited. On Earth he weighs 720 Newtons. List of weights: 655 N; 1,697 N; 792 N; 44 N; and 661 N.

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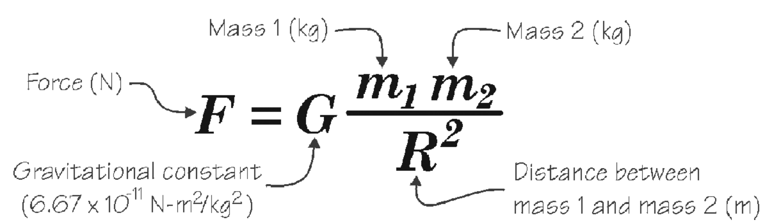
3. Using the Universal Law of Gravitation

Use the equation for Universal Gravitation to solve the following problems. The first problem is done for you.

Equation of Universal Gravitation:



1. What is the force of gravity between Pluto and Earth? The mass of Earth is 6.0×10^{24} kg. The mass of Pluto is 1.3×10^{22} kg. The distance between these two planets is 5.76×10^{12} meters.

$$\text{Force of gravity between Earth and Pluto} = \left(\frac{6.67 \times 10^{-11}\text{N-m}^2}{\text{kg}^2}\right)\frac{(6.0 \times 10^{24}) \times (1.3 \times 10^{22})}{(5.76 \times 10^{12})^2}$$

$$\text{Force of gravity} = \frac{52.0 \times 10^{35}}{33.2 \times 10^{24}} = 1.57 \times 10^{11}\text{N}$$

2. What is the force of gravity between Jupiter and Saturn? The mass of Jupiter is 6.4×10^{24} kg. The mass of Saturn is 5.7×10^{26} kg. The distance between Jupiter and Saturn is 6.52×10^{11} m.

Name:

Skill Sheet 31-B Touring the Solar System

What would a tour of our solar system be like? How long would it take? How much food would you have to bring on your tour? In this skill sheet, you will calculate the travel distances and times for a tour of the solar system. You mode of transportation will be an airplane travelling at 250 meters per second or 570 miles per hour.

1. Planets on the tour

Starting from Earth, the tour itinerary is: Earth to Mars to Saturn to Neptune to Venus and then back to Earth The distances between each planet of the tour is provided in Table 1. The airplane travels at 250 meters per second or 900 kilometers per hour. Using this rate and the speed formula, find out how long it will take to travel each leg of the itinerary. An example for how to calculate how many hours it will take to travel from Earth to Mars is provided below. For the table, calculate the time in days and years as well.

Example: How many days will it take to travel from Earth to Mars? The distance from Earth to Mars is 78 million kilometers.

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$\text{time to travel from Earth to Mars} = \frac{78 \text{ million km}}{900\frac{\text{km}}{\text{hour}}}$$

$$\text{time to travel from Earth to Mars} = 86{,}666 \text{ hours}$$

$$86{,}666 \text{ hours} \times \frac{1 \text{ day}}{24 \text{ hours}} = 3{,}611 \text{ days}$$

Table 1: Solar System Trip

Legs of the trip	Distance travelled for each leg (km)	Hours travelled	Days travelled	Years travelled
Earth to Mars	78,000,000			
Mars to Saturn	1,202,000,000			
Saturn to Neptune	3,070,000,000			
Neptune to Venus	4,392,000,000			
Venus to Earth	42,000,000			

2. Provisions for the trip

A trip through the solar system is a science fiction fantasy. Answer the following questions as if such a journey were possible.

1. It is recommended that a person drink eight glasses of water each day. To keep yourself hydrated on your trip. How many glasses of water would you need to drink on the leg from Earth to Mars?

2. An average person needs 2,000 food calories per day. How many food calories will you need for the leg of the journey from Neptune to Venus?

3. Proteins and carbohydrates provide 4 calories per gram. Fat provides 9 calories per gram. Given this information, would it be more efficient to pack the plane full of foods that are high in fat or high in protein for the journey? Explain your answer.

4. You decide that you want to celebrate Thanksgiving each year of your travel. How many frozen turkeys will you need for the entire journey?

3. Planning your trip for each planet

In the student text, there is a table that lists the properties of the nine planets. Use this table to answer the following questions.

1. On which planet, would there be the most opportunities to visit a moon?

2. Which planets would require high-tech clothing to endure high temperatures? Which planets would require high-tech clothing to endure cold temperatures?

3. Which planet has the longest day?

4. Which has the shortest day?

5. On which planet would you have the most weight? How much would you weigh in Newtons?

6. On which planet would you have the least weight? How much would you weigh in Newtons? Use proportions to answer this question.

7. Which planet would take the longest time to travel around?

8. Which planet would require your spaceship to orbit with the fastest orbital speed? Explain your answer.

Name:

Skill Sheet 32-A Comparing Sizes of Stars

In this skill sheet, you will explore the sizes of stars. In the process, you will get a better understanding of the scale of the universe as you develop your understanding of stars.

1. How big is the sun in our solar system?

The sun is our closest star. It is very big compared to the size of the planets in the solar system. How big is it?

1. The diameter of the sun is 1,390,000 kilometers.
   a Write this number using scientific notation.

   b Given the diameter, what is the *radius* of the sun?

   c Find the volume of the sun using the following formula where **r** equals the radius. Write this value using scientific notation.

$$\text{volume of a sphere} = \frac{4}{3}\pi r^3$$

2. Solar size units

In this section, we will use the diameter of the sun to represent a unit of 1. We will call this unit the sun size unit.

$$\text{diameter of the sun} = 1{,}392{,}000\text{ km} = 1\text{ sun size unit} = 1\text{ SSU}$$

We can compare the size of other objects to the sun using the sun size unit.

1. How many sun size units is the diameter of our solar system. The diameter of our solar system is about 12 billion kilometers (12,000,000,000).

2. The diameter of Uranus is 51,200 kilometers. How many sun size units is this diameter?

3. The diameter of the Milky Way galaxy is over 50,000 light years across. One light year is equivalent to 9.6×10^{12} km. How many sun size units is this distance?

3. Comparing the sun to other stars

Using proportions, find the diameters of other stars in units of sun size units. The actual diameters of these stars are provided for you in the first column of Table 1. First, write these values in scientific notation in the second column. Then, convert these to diameters in terms of sun size units (SSU) in the third column of Table 1.

Table 1:Comparing the sun to other stars

The solar system	Diameter in kilometers	Diameter in scientific notation (km)	Diameter of planet in SSU
Sun	1,392,000	1.4×10^6	1
Aldebaran	50,112,000		
Rigel	69,600,000		
Betelgeuse	556,800,000		
Castor A	2,784,000		
Canus Major (a white dwarf)	13,920		
Neutron Star	14		
Antares	696,000,000		

4. Comparing the diameters of the stars

Now, you will compare the sizes of the stars using common objects such as marbles.

1. Use the information from Table 1, to list the stars in order from smallest diameter to largest diameter in Table 2.
2. To compare the sizes of the stars in centimeters, let's assume that the scale is 1 cm = 1 SSU. Determine the scale size of each star, in centimeters, and record your answers in Table 2. The first three are done for you.
3. In the third column of the table, list a common object that could be used to represent each star for comparison. The first three are done for you.

Table 2:Comparing the sun to other stars

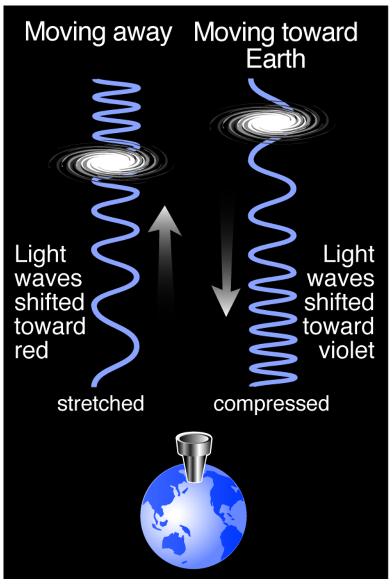
Star	Diameter (cm)	Common object
Neutron Star	.000001	Width of a human hair
Canus Major	.01	Poppy seed
Sun	1	Marble

Name:

Skill Sheet 32-B Doppler Shift

Doppler shift is an important tool used by astronomers to study the motion of objects, such as stars and galaxies, in space. For example, if an object is moving toward Earth, the light waves it emits are compressed, shifting them toward the blue end (shorter wavelengths, higher frequencies) of the visible spectrum. If an object is moving away from Earth, the light waves it emits are stretched, shifting them toward the red end (longer wavelengths, lower frequencies) of the visible spectrum. In this skill sheet, you will practice solving problems that involve doppler shift.

1. Understanding Doppler shift

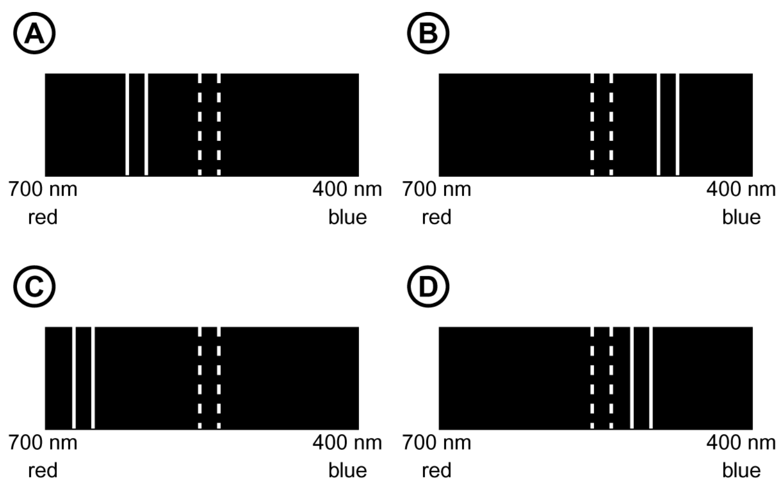


You have learned that astronomers use a spectrometer to determine which elements are found in stars and other objects in space. When burned, each element on the periodic table produces a characteristic set of spectral lines. When an object in space is moving very fast, its spectral lines show the characteristic patterns for the elements it contains. However, these lines are *shifted.*

If the object is moving away from Earth, its spectral lines are shifted toward the red end of the spectrum. If the object is moving toward Earth, its spectral lines are shifted toward the blue end of the spectrum.

1. The graphic to the right shows two spectral lines from an object that is not moving. Use an arrow to indicate the direction that the spectrum would appear to shift if the object was moving toward you.

2. The graphic to the right shows the spectral lines emitted by four moving objects. The spectral lines for when the object is stationary are shown as dotted lines on each spectrum. The faster a star is moving, the greater the shift in wavelength. Use the graphic to help you answer the following questions.



   a. Which of the spectra show an object that is moving toward you?
   b. Which of the spectra show an object that is moving away from you?
   c. Which of the spectra show an object that is moving the fastest away from you?
   d. Which of the spectra show an object that is moving the fastest toward you?

2. Problem solving

By analyzing the shift in wavelength, you can also determine the speed at which a star is moving. The faster a star is moving, the larger the shift in wavelength. The following proportion is used to help you calculate the speed of a moving star. The speed of light is a constant value equal to 3×10^8 m/sec. The first problem is done for you.

$$\frac{\text{The speed of a star}}{\text{The speed of light}} = \frac{\text{The difference in wavelength}}{\text{The stationary value for wavelength}}$$

1. The spectral lines emitted by a distant galaxy are analyzed. One of the lines for hydrogen has shifted from 450 nm to 498 nm. Is this galaxy moving away from or toward Earth? What is the speed of galaxy?

$$\frac{\text{The speed of a star}}{3 \times 10^8 \text{m/sec}} = \frac{498 \text{ nm} - 450 \text{ nm}}{450 \text{ nm}}$$

$$\text{The speed of a star} = \frac{48 \text{ nm}}{450 \text{ nm}} \times 3 \times 10^8 \text{m/sec} = 0.11 \times 3 \times 10^8 \text{m/sec} = 3.3 \times 10^7 \text{m/sec}$$

The galaxy is moving away from Earth at a speed of 33 million meters per second.

2. One of the spectral lines for a star has shifted from 535 nm to 545 nm. What is the speed of this star? Is the star moving away from or toward Earth?

3. One of the spectral lines for a star has shifted from 560 nm to 544 nm. What is the speed of the star? Is it moving away from or toward Earth?

4. An astronomer has determined that two galaxies are moving away from Earth. A spectral line for galaxy A is red shifted from 501 nm to 510 nm. The same line for galaxy B is red shifted from 525 nm to 540 nm. Which galaxy is moving the fastest? Justify your answer.

5. Does the fact that both galaxies in the question above are moving away from Earth support or refute the Big Bang theory? Explain your answer.

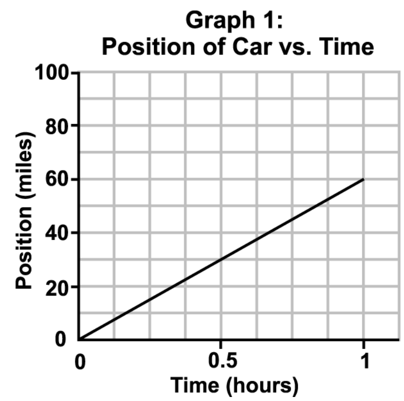
Name: ____________________

Skill Builder — Calculating Slope

How do you use a graph to make predictions? One way is to find a mathematical relationship between the variables by finding the slope of the line. This skill sheet will help you master calculating slope and making predictions from graphs.

1. What is slope?

You are going on a road trip. Graph 1 shows how the position of your car changes with time. On this graph, the starting point of the trip is represented by the point (0,0).



1. What information is represented on the *y* (vertical) axis of the graph?

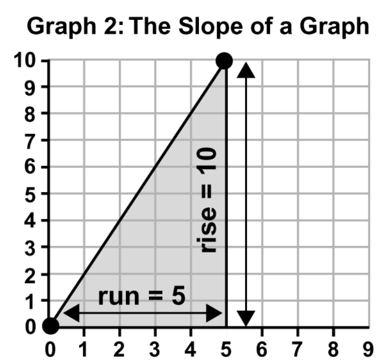
2. What information is represented on the *x* (horizontal) axis of the graph?

3. What does the line in the graph tell you about your road trip? For example, is your speed changing or staying the same?

Since the line in the graph is straight with no curves, it is *linear*. We can also describe what this line looks like by its *slope*. Slope tells how steep a line is. Slope is calculated by finding the ratio of the "rise" of the line (its vertical change) to the "run" of the line (its horizontal change).

2. Slope equals rise over run

The slope of the graph to the right can be determined by first choosing two points along the line. The two points chosen for this graph are (0,0) and (5,10). The format for writing pairs of point is: (*x, y*).



The next step is to make a right triangle. The line segment between the two chosen points is the hypotenuse of the triangle. The sides of the triangle are formed as shown on the graph.

The height or "rise" of the triangle is 10. The length of the base or "run" of the triangle is 5.

Calculate the slope of the line using the equation:

$$\text{slope of a line} = \frac{\text{rise}}{\text{run}}$$

1. What is the slope of the line in Graph 2?

2. Is the point (2.5, 5) on the line in Graph 2? How do you know?

3. Calculating slope using an equation for a line

Two points on a line can be represented as: (x_1, y_1) and (x_2, y_2). The equation for calculating the slope using these two points is:

$$\text{slope of line} = \frac{y_2 - y_1}{x_2 - x_1}$$

The slope of a line is the rate of change. By knowing the rate of change of a line (the slope), you can write an equation for a line that will help you make predictions if you are given a value for either **x** or **y**.

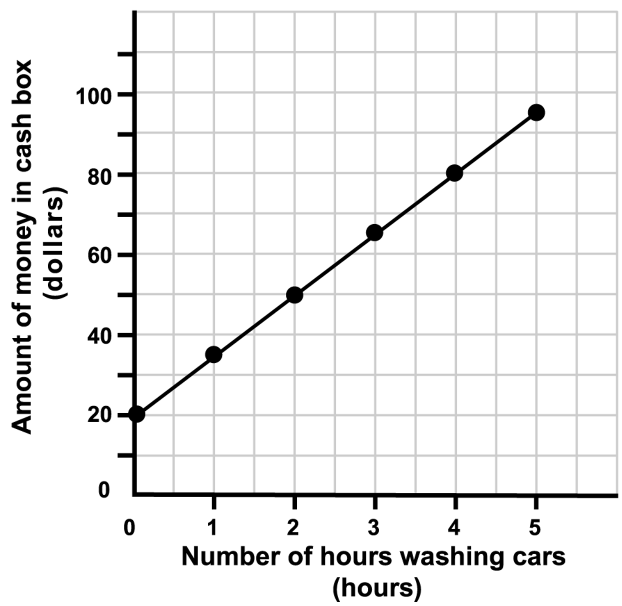
The equation for a line is:

$$y = m(x) + b$$

where:

m = slope of the line

b = y-intercept (the y value when x is equal to zero)



1. Chose two points on the line in Graph 3. Calculate the slope of the line.

2. The y-intercept of a line is the **y** value when the *x* value is equal to zero. What is the y-intercept of the line in Graph 3?

3. You now know the the value for slope (m), and the y intercept (b). Write the equation for the line in Graph 3.

4. A friend wants to have a car wash next weekend, but she only wants to wash cars for 3 hours. Use the graph to predict how much money would be in the cash box (if they start with $20 for making change) after three hours of washing cars. Hint: You know the x value, the slope, and the y-intercept. You need to calculate the y value.

5. Use the equation for the line to predict how much the car wash will earn washing cars if you work for five hours per day for eight Saturdays. The class trip costs $500.00. Will you earn enough money from washing cars to pay for the class trip?

4. Practice with calculating slope

Make a graph of the data below using the grid provided. Be sure to label the *x*-axis and the *y*-axis.

Road Trip Data

x Time (hours)	*y* Distance traveled (kilometers)
0	0
1	10
2	20
3	30
4	40
5	50
6	60

Title: ____________________

y label: ____________________

x label: ____________________

1. What is the slope of the line for the road trip data set?

2. What is the *y*-intercept of this data set?

3. Write the equation of the line for this data set.

5. Additional questions

1. You know that the slope of a line is equal to 3 and the y-intercept is equal to 1.
   a. Write the equation for this line.

   b. Using this equation for the line, come up with five pairs of coordinates (x and y values) that work in this equation.

2. Two points on a line are: (2, 8) and (6, 10). What is the slope of this line?

3. You have been give two equations for calculating slope. How are these two equations similar?

$$\text{slope of a line} = \frac{\text{rise}}{\text{run}}$$

$$\text{slope of a line} = \frac{y_2 - y_1}{x_2 - x_1}$$

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Skill Builder — Dimensional Analysis

SB

Dimensional analysis is used to solve problems that involve converting between different units of measurement. Before trying this skill builder, read the section on dimensional analysis in the reference section of your textbook.

1. Choosing a conversion factor

Circle the conversion factor you would choose to solve the following problems.

1. How many inches are in 6 meters?

$$\frac{\text{1 meter}}{\text{39.4 inches}} \quad \text{OR} \quad \frac{\text{39.4 inches}}{\text{1 meter}}$$

2. How many liters are in 10 U.S. gallons?

$$\frac{\text{1 gallon}}{\text{3.79 liters}} \quad \text{OR} \quad \frac{\text{3.79 liters}}{\text{1 gallon}}$$

3. 100 kilometers is equal to how many miles?

$$\frac{\text{1 kilometer}}{\text{0.624 miles}} \quad \text{OR} \quad \frac{\text{0.624 miles}}{\text{1 kilometer}}$$

4. 1,000,000 grams is equal to how many kilograms?

$$\frac{\text{0.001 kilogram}}{\text{1 gram}} \quad \text{OR} \quad \frac{\text{1 gram}}{\text{0.001 kilogran}}$$

2. Solving problems

Use dimensional analysis to solve each of the following problems:

1. A grocery store just received a shipment of 200 cartons of eggs. Each carton holds one dozen eggs. If 12 eggs = 1 dozen, how many eggs did the store receive?

2. A marathon is 26.2 miles long. How many kilometers is a marathon? (1 mile = 1.61 km)

3. The speed limit on many interstate highways in the United States is 65 miles per hour. How many kilometers per hour is that? (1 mile = 1.61 km)

4. Ashley is going on a trip to London. She has saved $100.00 in spending money. When she arrives in England, she goes to a bank to change her money into pounds. She is told that the exchange rate is 1 British pound = 1.43 American dollars. The bank charges a fee of 4 pounds to change the money from dollars to pounds. How much money, in British pounds, will Ashley have if she changes all of her dollars to pounds?

5. Although it is widely believed that Germany's Autobahn highway has no speed limit whatsoever, much of the highway has regulated speed limits of 130 km/hr or less, and in some places speed is limited to just 60 km/hr.
   a. How many miles per hour is 130 km/hr? (1 mile = 1.61 km)

   b. How many miles per hour is 60 km/hr?

6. In England, a person's weight is commonly given in stones. One English stone is equal to 14 pounds. If an English friend tells you he weighs eleven stones, what is his weight in pounds?