## NASA Explorer Schools Pre-Algebra Unit

## Lesson 3 Student Workbook

# Solar System Math

## Comparing Planetary Travel Distances

*How far can humans travel in our solar system?*

Name: ______________________________ Date: ________________

# Pre-Lesson Activity - Part I

## Units of Measurement: Distance and Time

Think about units that are used to measure distance and units that are used to measure time. (Remember distance can be measured with *metric* units and *standard* units.) **List as many distance and time units of measurement as you can in the table below.**

| Distance Units | Time Units |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

## Units of Measurement: Speed

Speed is measured by ***distance traveled per unit time***. The unit for speed can vary based on the units of distance and time. For example: an automobile's speed is usually measured in *miles per hour* or *kilometers per hour*, whereas a track athlete's speed is often measured in *meters per second* or *miles per minute.*

| Match a unit from the 2nd column to each item below. | | Unit Choices |
|---|---|---|
| fingernail grows at a speed of | 0.1 ___________ | cm/minute |
| hair grows at a speed of | 1.25 ___________ | mi/hour |
| snail moves at a speed of | 15.6 ___________ | m/second |
| continental drift occurs at a speed of | 10 ___________ | cm/month |
| cheetah runs at a speed of | 70 ___________ | cm/year |
| airplane travels at a speed of | 250 ___________ | mm/day |

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# Distance, Time, & Speed: Equations

The relationship between distance, time, and speed is important. If we know two of the values, we can calculate the remaining value. For example...

*Speed is distance per time.* The word "per" can be thought of as meaning "divided by." A car's speed is often measured in *miles per hour*, that is miles divided by hours.

If a car travels 60 miles in 2 hours, then what is the speed of the car? In this example, we can use the two terms that we know (distance and time) to solve for the third term (speed).

60 miles ÷ 2 hours = 30 miles per hour

Distance ÷ Time = Speed

Write an equation for each of the three terms below. Each equation must include all three terms. Use the example above to help you get started.

Equation 1: Distance =

Equation 2: Time =

Equation 3: Speed =

Practice using these three equations with the three problems on pages 4-6.

Name: ______________________________ Date: ________________

# Distance, Time, & Speed: Problem I

**Problem I:** A car is traveling at 60 miles per hour. How many miles will it travel in 30 minutes?

**Step 1:** Identify the variable (the unknown) for which you are solving. ___________

**Step 2:** Decide which of the three equations to use to solve this problem.

| | | |
|---|---|---|
| Distance = Speed • Time | Time = $\frac{\text{Distance}}{\text{Speed}}$ | Speed = $\frac{\text{Distance}}{\text{Time}}$ |

**Step 3:** Identify the unit ratio to use to convert from one unit to another unit.

Unit Ratio: _____________

**Step 4:** Solve the problem.

| | |
|---|---|
| First, convert minutes to hours: | Then, solve the equation you chose in step 2: |

Name: ______________________________ Date: ____________

# Distance, Time, & Speed: Problem II

**Problem II:** A car is traveling at 30 miles per hour. How many minutes will it take for the car to travel 10 miles?

**Step 1:** Identify the variable (the unknown) for which you are solving. ___________

**Step 2:** Decide which of the three equations to use to solve this problem.

| | | |
|---|---|---|
| Distance = Speed • Time | Time = $\frac{\text{Distance}}{\text{Speed}}$ | Speed = $\frac{\text{Distance}}{\text{Time}}$ |

**Step 3:** Identify the unit ratio to use to convert from one unit to another unit.

Unit Ratio: ____________

**Step 4:** Solve the problem.

| | |
|---|---|
| First, solve the equation you chose in step 2: | Then, convert hours to minutes: |

Name: ______________________________ Date: ______________

# Distance, Time, & Speed: Problem III

**Problem III:** A car travels 100 miles in 4 hours. How fast is it traveling?

**Step 1:** Identify the variable (the unknown) for which you are solving. __________

**Step 2:** Decide which of the three equations to use to solve this problem.

| | | |
|---|---|---|
| Distance = Speed • Time | $\text{Time} = \dfrac{\text{Distance}}{\text{Speed}}$ | $\text{Speed} = \dfrac{\text{Distance}}{\text{Time}}$ |

**Step 3:** Identify the unit ratio to use to convert from one unit to another unit.
(Hint: *Do you need to convert units?*)

Unit Ratio: ____________

**Step 4:** Solve the problem.

| |
|---|
| Solve the equation you chose in step 2: |

Name: ______________________________________ Date:______________________.

# Pre-Lesson Activity - Part II

In this activity, you will calculate the sprinting speed and the jogging speed of a runner in miles per hour. Begin by measuring a distance for the runner to run.

Record the distance to be run: ___________________________

| Sprinting Times (in seconds) | Jogging Times (in seconds) |
|---|---|
| Time 1: | Time 1: |
| Time 2: | Time 2: |
| Time 3: | Time 3: |
| **Average Time:** | **Average Time:** |

Using the distance ran and the *average* time it took to run the distance, record the average sprinting speed and average jogging speed below. Round to the nearest tenth or whole number and remember to write your speed in the form of ***distance traveled per unit time***.

Avg sprinting speed: _______ = ____ __/__ Avg jogging speed: _______ = ____ __/__

Next, compare the average sprinting speed and the average jogging speed to the speed of a car by converting your answers to miles per hour. (Hint: *First, you may need to convert seconds to minutes or minutes to hours, etc using unit ratios.*) Round to 2 decimal places.

| |
|---|
| Sprinting speed converted to miles per hour is: _____ __/__ ≈ _____ mi/hr |
| Jogging speed converted to miles per hour is: _____ __/__ ≈ _____ mi/hr |

Name: ______________________________ Date: ____________________

# Transfer Orbits

## Student Reading

In order to complete your calculations of the distances from Earth to the planets and moons, you will need to understand the mechanics and the mathematics that scientists use to determine the trajectories (paths) of spacecraft.

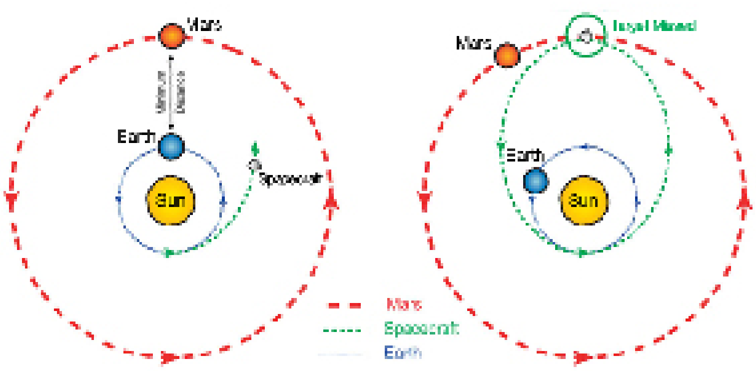
Normally, if we wanted to travel from point A to point B, we would follow the path of a straight line.

Point A ———————————————— Point B

**Mathematical Principle**

*The shortest distance between two points is a straight line.*

However, in space travel, vehicles do not always travel in straight lines. When we travel from Earth to another planet, we must consider the fact that Earth, as well as the planet we wish to reach, is orbiting the Sun and constantly moving along its orbital path. For example, if we waited for Earth and another planet to line up in a position where the distance between them was at a minimum, and then launched a crew vehicle in a straight line towards the planet, by the time the crew vehicle reached the location of the planet, the planet would have moved on its path around the Sun. The crew vehicle would miss the planet!

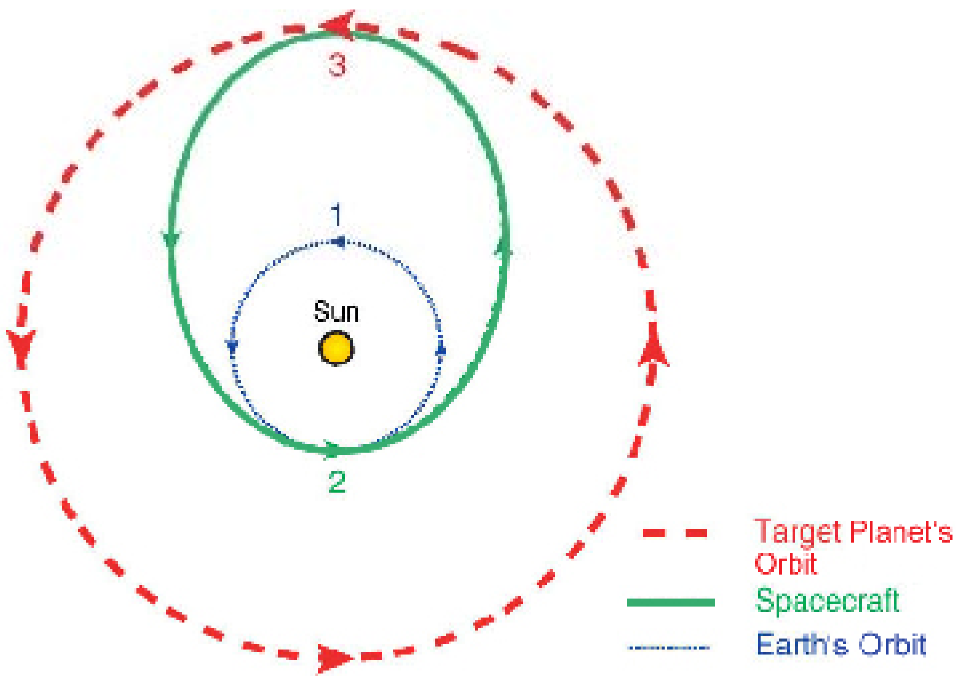



Have you ever played a game in which you needed to pass a ball to someone who was running? How did you pass the ball to the running target? Most likely you aimed the ball *in front* of the running person so that the ball and the person arrived at the same place at the same time. This idea is used when launching spacecraft. The vehicle is aimed *ahead* of the moving planet or moon so that the spacecraft and its destination are at the same place at the same time.

Name: ______________________________ Date: ____________________

There is another challenge with launching a crew vehicle directly at a planet or moon. The crew vehicle will have to constantly burn fuel to reach its destination. Fuel takes up a lot of space and adds a lot of mass to a spacecraft, plus fuel is expensive. Scientists and mathematicians found a way to use the gravity of Earth and other planets and moons to keep a spacecraft moving through the solar system without burning fuel at all times. This process allows a spacecraft to orbit a body, like Earth, and then use a small amount of fuel to break out of that orbit. The vehicle then continues moving at about the speed of the planet or the moon it was orbiting. For example, the Earth is moving around the Sun, so a spacecraft leaving the orbit of Earth would maintain the speed that Earth is moving as the spacecraft heads for its new destination.

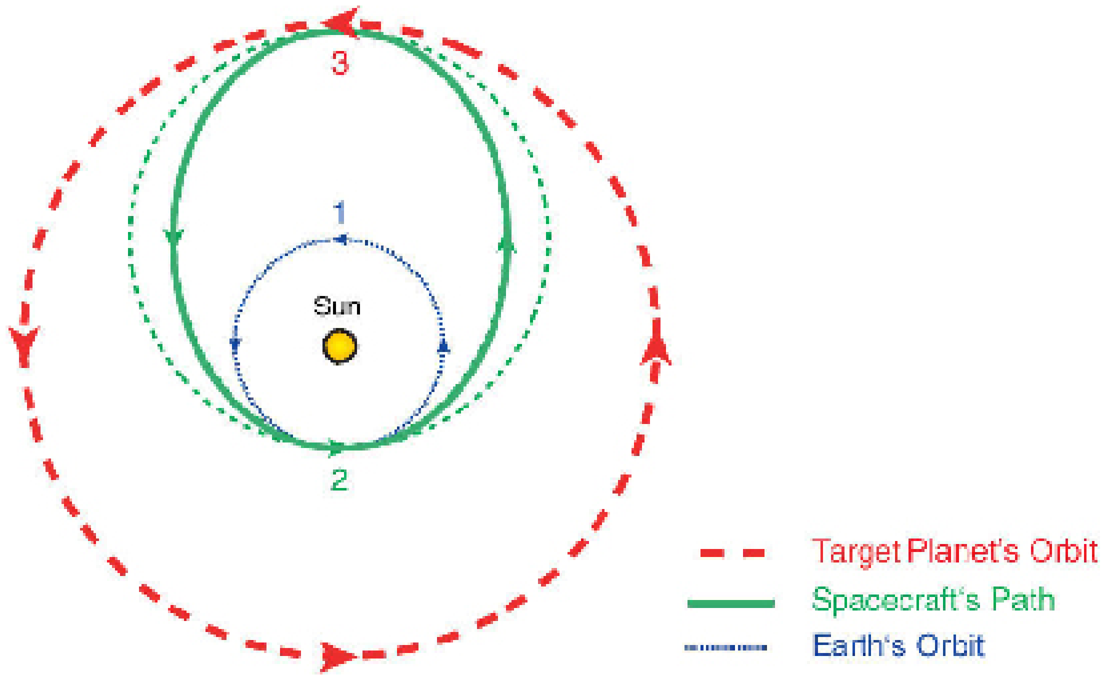
Spacecraft typically travel from Earth to another planet by moving from the orbit that the Earth is in to the orbit that the other planet is in. This allows spacecraft to use the gravity of Earth to reach the destination. This also saves fuel. The diagram below is useful in picturing how a spacecraft moves from one orbit to another.




The spacecraft starts on Earth at point 1. Once the spacecraft is launched, it follows the Earth's ········ orbit while orbiting the Earth. When the spacecraft reaches point 2, the spacecraft's engines fire. The spacecraft speeds up, and then leaves the Earth's orbit. It begins to follow the ▬▬▬ elliptical path, which will guide it to the planet we wish to reach. When the spacecraft reaches this targeted planet, it adjusts its speed to stay in the targeted planet's – – – – orbit. The spacecraft will continue to move around the Sun, following the orbital path of the target planet.

Name: ______________________________ Date:____________________

In order to calculate the distance from point 2 to point 3, we would need to be able to calculate half the circumference of the ▬▬▬ ellipse. The length of an *elliptical* path is not a simple calculation, so we will use a *circular* path instead. The circumference of the circular path will be *similar* to the elliptical path, and it will give us a good *estimate* of the distance the spacecraft will travel.




The radius of the ...... circular path is the average of the distance from the Earth's ········ orbit to the Sun and the target planet's – – – – orbit to the Sun. To find the average, we add the distance of those two planets from the Sun, and divide by two. Next, we use the formula for the circumference of a circle ($C = 2 \cdot \pi \cdot r$). The circumference divided by 2 will give the distance the spacecraft will travel from Earth to the target planet.

Name: ______________________________ Date: ____________________

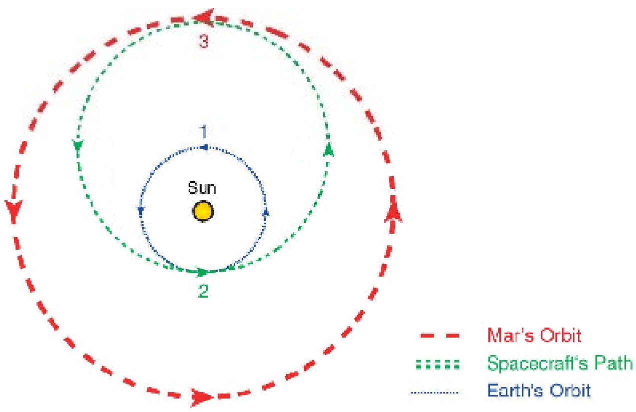
# Transfer Orbits: Sample Problem

Below is an example of using a transfer orbit to calculate the time it will take a spacecraft to travel from Earth to another planet.

**Question:** ***How many months will it take for a spacecraft to travel from Earth to Mars?***

We know that the average distance from Earth to the Sun is 1 AU.

We know that the average distance from Mars to the Sun is 1.5 AU.




Therefore the **radius of the ...... circle** is (1 AU + 1.5 AU) divided by 2, which equals 1.25 AU.

$$(1\text{ AU} + 1.5\text{ AU}) \div 2 = 1.25\text{ AU}$$

The **distance traveled from point 2 to point 3** along this ...... dotted circular path is one-half the circumference of the ...... circle. (Remember C = 2 • π • r)

$$\text{Distance from point 2 to point 3} = \frac{1}{2} \cdot 2 \cdot \pi \cdot 1.25\text{ AU}$$

$$= \frac{1}{\cancel{2}} \cdot \cancel{2} \cdot \pi \cdot 1.25\text{ AU}$$

$$= 1 \cdot \pi \cdot 1.25\text{ AU}$$

$$= \pi \cdot 1.25\text{ AU}$$

Name: ______________________________ Date:____________________

# Transfer Orbits: Sample Problem Continued

We will estimate the speed of the spacecraft at about the same as that of Earth's speed in its orbit. By using the circumference formula ($C = 2\,\pi\,r$), we see that the circumference of Earth's orbit is $2\,\pi$ AU since the radius of Earth's orbit is equal to 1 AU.

If we use this in the *speed* formula, then solving for speed we get:

$$\text{Speed} = \text{Distance} \div \text{Time}$$

$$\text{Speed of Earth's orbit} = \frac{2\,\pi\ \text{AU}}{1\ \text{year}}$$

We can then use the *time* formula to calculate how long it will take to travel from point 2 to point 3 (transfer orbit):

$$\text{Time} = \text{Distance} \div \text{Speed}$$

$$\text{Time to travel from point 2 to point 3} = \frac{\pi \bullet 1.25\ \text{AU}}{1} \div \frac{2\,\pi\ \text{AU}}{1\ \text{year}}$$

$$= \frac{\pi \bullet 1.25\ \text{AU}}{1} \bullet \frac{1\ \text{year}}{2\,\pi\ \text{AU}}$$

$$= \frac{\cancel{\pi} \bullet 1.25\ \cancel{\text{AU}}}{1} \bullet \frac{1\ \text{year}}{2\,\cancel{\pi}\ \cancel{\text{AU}}}$$

$$= \frac{1.25\ \text{years}}{2}$$

$$= 0.625\ \text{year}$$

Next, we *convert* (change) years to months:

$$0.625\ \text{year} = 0.625\ \cancel{\text{year}} \bullet \frac{12\ \text{months}}{1\ \cancel{\text{year}}}$$

$$= 7.5\ \text{months}$$

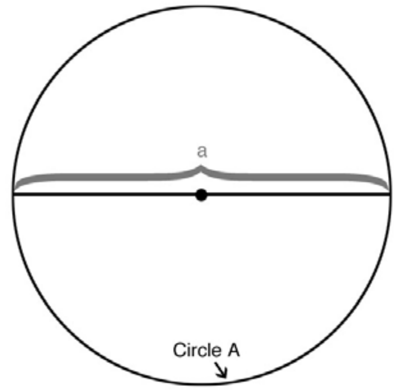
***Answer: The distance traveled from Earth to Mars is π • 1.25 AU, and the time to travel this distance is 7.5 months.***

Name: ______________________ Date: ______________

# Transfer Orbits: A Hands-on Proof

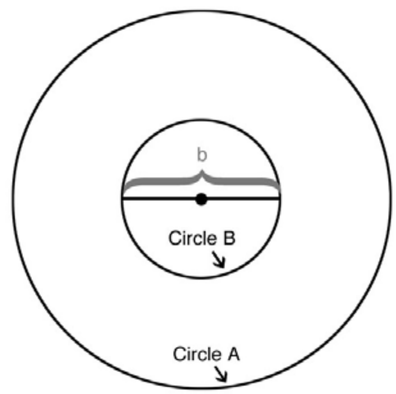
Using a ruler and a compass, draw a circle and measure its diameter (a).

Diameter of the first circle = a

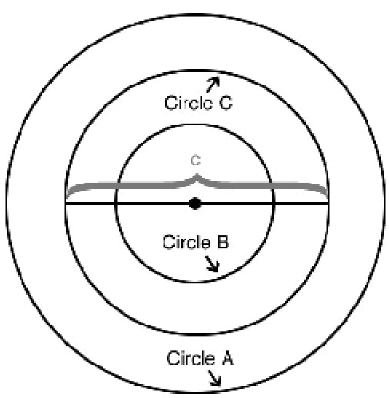



Using the same center, draw a smaller circle inside the first circle and measure its diameter (b).

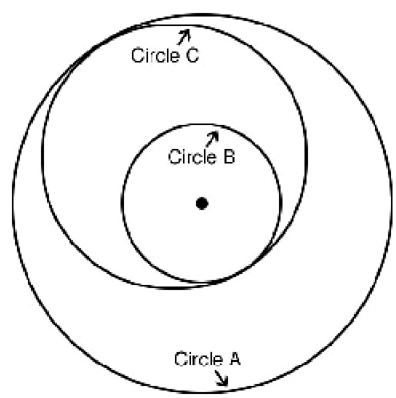
Diameter of the second circle = b




Add the two diameters together and divide by 2 to get a new value (c).




$$c = \frac{a + b}{2}$$




On a separate piece of paper draw a circle that has a diameter of c. **Cut out your new circle. See if the circle with diameter c will work as a transfer orbit from circle a to circle b.** Try it with different combinations and see what happens.

Name: Date: .

# Travel Distance Using Transfer Orbits

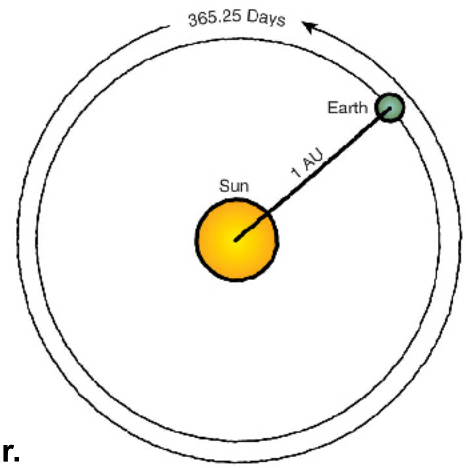
Calculate the distances for each planet and moon in the chart below. When necessary, round to the nearest tenth or hundredth AU (or nearest million km).

| *Earth = 1 AU (or 150,000,000 km)* | | *r = (1 AU + ? AU) ÷ 2* | *distance = π r* |
|---|---|---|---|
| **Destination** | **Distance from Sun in AU (or km)** | **Radius of Transfer Orbit** | **Distance Traveled from Earth to Planet** |
| Mercury | 0.4 AU (58,000,000 km) | 0.70 AU (104,000,000 km) | 2.20 AU (327,000,000 km) |
| Venus | | | |
| Mars | | | |
| Jupiter | | | |
| Saturn | | | |
| Uranus | | | |
| Neptune | | | |
| Pluto | | | |
| Moon* | 1.0 AU (150,000,000 km) | 0.0026 AU (384,000 km) | |
| Io & Europa | | | |
| Titan | | | |
| Triton | | | |

** Data for Earth's Moon not included in "What's the Difference" has been provided.*

Name: Date

# Crew Vehicle Speed




As the crew vehicle travels towards another planet or moon, *it will have the same speed at which Earth is orbiting the Sun.* You will now calculate Earth's speed in astronomical units per year and kilometers per year.

Remember: to solve for Earth's *speed,* you need to know the *distance* Earth travels in a given period of *time.*

## I. The crew vehicle's speed is ≈ __________ AU per year.

**Step 1: Distance** — The distance Earth travels in one year as it orbits the Sun is equal to the *circumference* of its orbital path. Calculate the *circumference* of the circular orbit in the picture above.

$$C = 2\pi r$$
$$= 2\pi \text{\_\_\_\_\_\_\_}$$
$$\approx \text{\_\_\_\_ AU}$$

**Step 2: Time —** How long does it take Earth to orbit the Sun? ______ days or _____ year

**Step 3: Speed** — Calculate the speed that Earth travels around the Sun in AU per year.

$$\text{Speed} = \text{Distance} \div \text{Time}$$
$$= \text{\_\_\_\_\_\_\_} \div \text{\_\_\_\_\_\_\_}$$
$$\approx \text{\_\_\_\_\_\_\_ per \_\_\_\_\_\_\_}$$

## II. The crew vehicle's speed is ≈ ____________________ km per year.

Earth travels around the Sun at a speed of 30 kilometers per second.
Use unit ratios to convert *30 kilometers per second* to *kilometers per year*.
**Step 1:** Convert seconds to years.

$$\frac{\text{\_\_\_\_\_\_\_\_\_\_ seconds}}{\text{1 year}} = \frac{\text{\_\_\_ seconds}}{\text{1 minute}} \cdot \frac{\text{\_\_\_ minutes}}{\text{1 hour}} \cdot \frac{\text{\_\_\_ hours}}{\text{1 day}} \cdot \frac{\text{\_\_\_\_\_ days}}{\text{1 year}}$$

**Step 2:** Convert 30 kilometers per second into kilometers per year.

$$\frac{\text{30 km}}{\text{1 sec}} = \frac{\text{30 km}}{\text{1 sec}} \cdot \frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ sec}}{\text{1 yr}}$$

$$= \frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ km}}{\text{1 yr}}$$

**Step 3:** Round your answer.

**≈ ____________________ ____ per ____**

Name: Date: .

# Travel Time

First, you calculated the *distance* the crew vehicle must travel to reach a planet or moon. Then you calculated the *speed* at which the crew vehicle will be traveling. Next, you will use the distance and the speed to calculate the *time* it will take for the crew vehicle to reach its destination.

Write the equation you will use to solve for time:

__________ = __________ ÷ __________

**Remember:** *You should use the same unit of measurement in your calculations.*

| **Example using astronomical units:** | **Example using kilometers:** |
|---|---|
| $\text{Travel time to Mercury} = \dfrac{\text{Travel distance to Mercury}}{\text{Speed of crew vehicle}}$<br>$= \dfrac{2.20\ \cancel{\text{AU}}}{6.28\ \cancel{\text{AU}}/\text{year}}$<br>$\approx 0.35$ year | $\text{Travel time to Mercury} = \dfrac{\text{Travel distance to Mercury}}{\text{Speed of crew vehicle}}$<br>$= \dfrac{327{,}000{,}000\ \cancel{\text{km}}}{947{,}000{,}000\ \cancel{\text{km}}/\text{year}}$<br>$\approx 0.35$ year |

Record your calculations for each planet and moon in the chart below. Round your final answer to 2 decimal places (hundredths), except for the Moon (thousandths).

| Destination | Calculation (choose *either* AU *or* km) | Travel Time in Years |
|---|---|---|
| Mercury | 2.20 ~~AU~~ ÷ 6.28 ~~AU~~/year = 0.3503 year<br>*or:* 327,000,000 ~~km~~ ÷ 947,000,000 ~~km~~/yr = 0.3453 yr | ≈ 0.35 years |
| Venus | | |
| Mars | | |
| Jupiter | | |
| Saturn | | |
| Uranus | | |
| Neptune | | |
| Pluto | | |
| Moon | | |
| Io & Europa | | |
| Titan | | |
| Triton | | |

Name: Date: .

# Synodic Period

A spacecraft is launched when Earth and the destination planet or moon are at their closest distance to each other. Likewise, the spacecraft will return to Earth when Earth and the destination planet or moon are once again nearest to each other. The length of time between these two alignments is called the ***synodic period***.

An ***orrery*** is a tool that shows the positions and motions of the planets and moons in the solar system.

Using the orrery in *What's the Difference*, you will determine the length of the synodic period between Earth and one other planet.

Kaptain Kobold 12-Apr-2006
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**Step 1:** Choose your destination planet.

My crew will travel from Earth to ____________________.

**Step 2:** Run the orrery and stop it on the date when Earth and your chosen planet are nearest to each other. (Use the fast, slow, & zoom features to help you.)

Date #1 (day-month-year): _____ _______________ __________

**Step 3:** Run the orrery again and stop it on the next date that Earth and your chosen planet are once again nearest to each other.

Date #2 (day-month-year): _____ _______________ __________

**Step 4:** Calculate the amount of time that passes between date #1 to date #2.

Synodic period ≈ _______________ years (round to one decimal point)

**Step 5:** Check your answer by looking up your planet's synodic period in *What's the Difference*. How accurate was your calculated estimate?

Name: Date: .

# Total Mission Length

The total length of a mission is based on three calculations: 1) the time it takes for the crew to reach their destination, 2) the time spent on the planet or moon conducting research, and 3) the time it takes the crew to return to Earth.

On page 16, you calculated the *travel time* from Earth to each destination. These times will need to be *doubled* to account for a round trip mission.

The *synodic period* represents the amount of time that the crew will remain on the planet or moon conducting research. This time will need to be *added* to the travel time.

**Example: Total Mission Length to Mercury**

Mission length = (travel time • 2) + synodic period

1.02 years = (0.35 years • 2) + 0.32 years

| Destination | Travel Time in Years (round trip) | Synodic Period in Years | Total Mission Length in Years |
|---|---|---|---|
| Mercury | 0.70 years | 0.32 years | 1.02 years |
| Venus | | 1.60 years | |
| Mars | | 2.14 years | |
| Jupiter | | 1.09 years | |
| Saturn | | 1.04 years | |
| Uranus | | 1.01 years | |
| Neptune | | 1.01 years | |
| Pluto | | 1.00 years | |
| Moon | | 0.08 years | |
| Io / Europa | | 1.09 years | |
| Titan | | 1.04 years | |
| Triton | | 1.01 years | |

Name: Date: .

# Percent of a Lifetime and Career

An average lifetime is considered to be 74 years, and the average length of a career is 40 years.

Using the total length of a mission to each planet and moon, calculate the percent of a lifetime and the percent of a career that each mission would require. Write the formulas that you will use below:

% of a lifetime = (__________________ ÷ __________________) • 100%

% of a career = (__________________ ÷ __________________) • 100%

Use the mission lengths you calculated on page 18. Round your lifetime and career calculations to the appropriate whole number value.

| Destination | Total Mission Length in Years | Percent of a Lifetime | Percent of a Career |
|---|---|---|---|
| Mercury | 1.02 years | 0.01 or 1% | 0.03 or 3% |
| Venus | | | |
| Mars | | | |
| Jupiter | | | |
| Saturn | | | |
| Uranus | | | |
| Neptune | | | |
| Pluto | | | |
| Moon | | | |
| Io / Europa | | | |
| Titan | | | |
| Triton | | | |

Think about the lengths of the missions to each planet and moon and how much of a lifetime or a career these missions would consume. Which planets and moons do you think should be ***eliminated*** as possible destinations?

____________________________________________________________

____________________________________________________________

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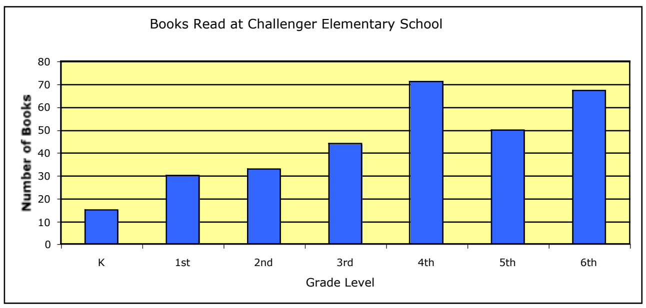
# Graphing Resource

## Student Guide

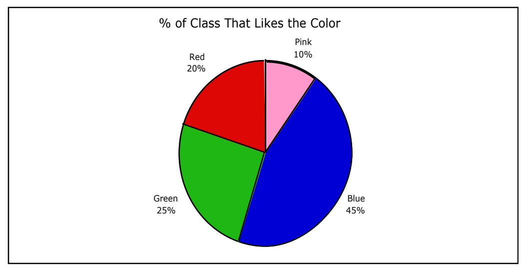
### Types of Graphs

There are several types of graphs that scientists and mathematicians use to analyze sets of numbers or data.

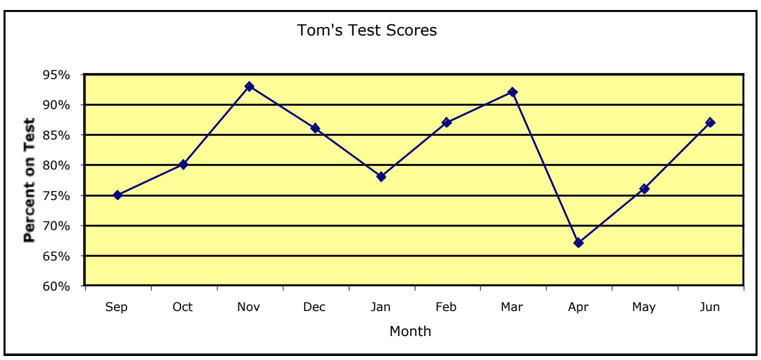
**Bar graphs** are often used to compare values.




**Pie graphs** are often used to compare percentages or parts of a whole.




**Line graphs** are often used to show rates of change.



Name: Date: .

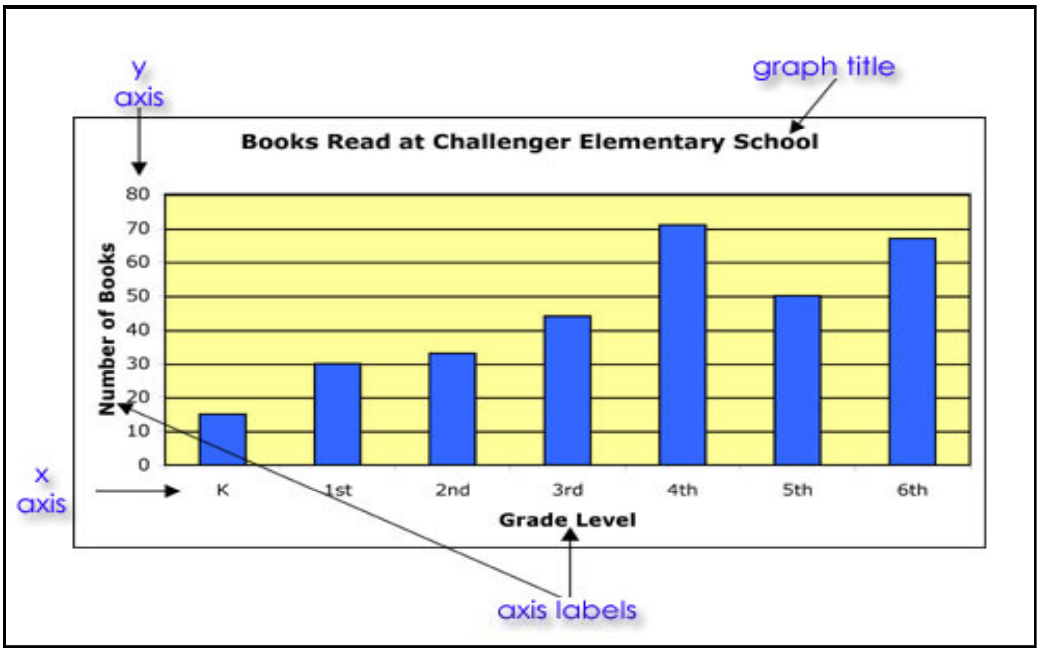
## Before You Begin

When you are planning to graph data, you need to answer some questions before you begin.

1. What type of graph will you use?
2. What unit of measurement will you use?
3. What scale will you use?
4. What will be the minimum and maximum values on your graph?
5. Will your graph start at 0?

## Making Bar Graphs and Line Graphs

Every graph needs a **title** and **labels** on the horizontal “x” axis (side-to-side) and the vertical “y” axis (up and down).




The **unit of measurement** you are using needs to be clearly shown (inches, kilograms, etc.). The unit for the bar graph above is “number of books” as is written in the vertical y-axis label.

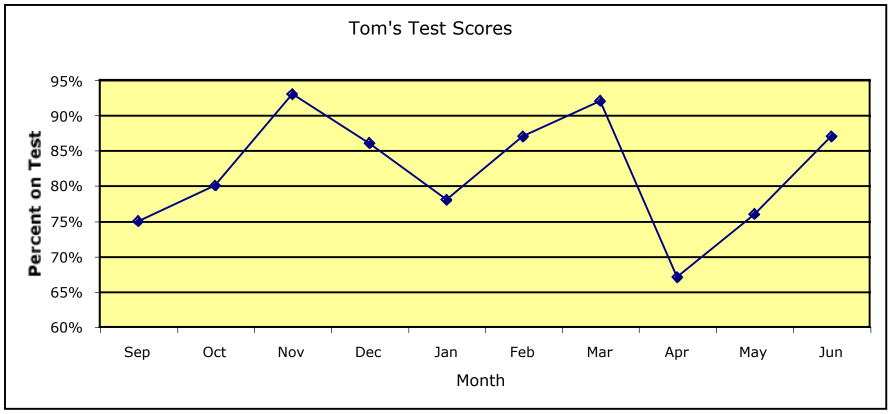
You also must choose a **scale** for your vertical y-axis. The vertical scale on the bar graph above goes from 0 to 80 in increments of 10.

Name: Date: .

The scale is determined by the data you are graphing. To determine the scale, look at the largest and smallest numbers you will be graphing.

For this line graph, the vertical y-axis goes from 60% to 95% in increments of 5%.

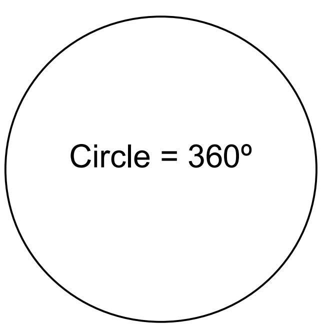
The unit of measurement for this graph is "percent." (%)




## Making a Pie Graph

A pie graph is shown using a circle, which has 360 degrees. To make an accurate pie graph you will need a compass or a similar instrument to trace a circle and a protractor to measure angles in degrees.

Start by making a circle. You will then have to multiply your fractions or percents (in decimal format) by 360 degrees to find out how many degrees you will need in each wedge. For example:




| Color | % of class that likes the color |
|---|---|
| Blue | 45% |
| Green | 25% |
| Red | 20% |
| Pink | 10% |
| **Total:** | **100%** |

The sum of your fractions should total to 100%.

Name: Date: .

To find out how many degrees of the pie graph will represent the number of students in the class who like the color blue, you would multiply 360 degrees by 0.45. The result of your calculation is 162 degrees. To find out how many degrees of the pie graph will represent the number of students in the class who like the color green, you would multiply 360 degrees by 0.25. The result of your calculation is 90 degrees.

To mark off the blue portion of the pie graph, start by drawing a radius of the circle (a line segment from the center of the circle to the circle itself). Then use the protractor to measure an angle of 162 degrees and draw the corresponding radius. The green portion will have an angle measure of 90 degrees, the red portion will have an angle measure of 72 degrees, and the pink portion will have an angle measure of 36 degrees. The sum of these angles will equal an angle measure of 360 degrees, the number of degrees in a circle.

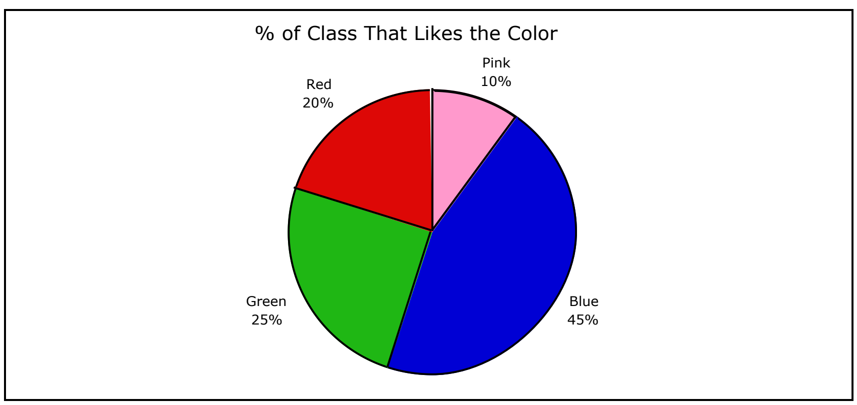
Pink = 36º

Blue = 162º

Green = 90º

Red = 72º

**Total = 360º**




When the portions have been drawn into the circle, you then need to **color** each portion, label each portion with both the **category** and the **percent or fraction**, and give the graph an overall **title**.

Name: Date: .

# Graphing the Mission Data

Based on the calculations you have made, you are going to graph one or more of the following aspects of a mission: (Place a √ next to the data you will be graphing.)

___ travel distances to each planet or moon

___ total mission length to each planet or moon

___ percentage of a lifetime that each mission would take

___ percentage of a career that each mission would take

First you need to plan your graph by answering the five questions below. Then you should create your graph on graph paper or chart paper. Be sure to give your graph a *title* and to *label* your x- and y-axis.

1. What type of graph will you use?

☐ bar graph ☐ pie graph ☐ line graph ☐ _______________
other

2. What unit of measurement will you use? ________________________________

3. What scale will you use? _____ to _____ in increments of _____

4. What will be the maximum and minimum data values on your graph?

Maximum value = _____ Minimum value = _____

5. Will your graph start at 0? If not, with what number will your graph begin?

______________________________________________________________

Name: Date: .

# All Things Considered

In this lesson you determined how much time a mission to each of the planets and moons would require based on the synodic period and the distance of the transfer orbit. In lessons 1 and 2, you analyzed other factors such as size, distance, mass, density, gravity, and composition.

What other factors should you consider? ______________________________

______________________________________________________________

| **Possible Destinations** | | | |
|---|---|---|---|
| Mercury | Venus | Moon | Mars |
| Jupiter | Io & Europa | Saturn | Titan |
| Uranus | Neptune | Triton | Pluto |

Use the grid below to help you consider what you have learned about the solar system. *Eliminate* (rule out) the planets and moons that would ***not*** be a good choice for a mission by listing them under the appropriate category.

| | | |
|---|---|---|
| Distance is too great; mission length is too long: | Not enough density; gaseous composition: | Too massive: |
| Microgravity or extreme gravity: | Environment too harsh: | Other factors: |

Now that you have eliminated some destinations, list the remaining planets and moons that you think are *good choices* for a future mission. (**Note:** *Just because you listed a planet or moon in the grid above, doesn't mean you can't still consider it for a mission.)*

______________________________________________________________

______________________________________________________________

Name: Date: .

# Lesson 3 Extension Problems

## Earth Speed

The following formulas can be used to calculate how fast Earth revolves around the Sun and how fast Earth rotates on its axis. Sketch a picture to help visualize the problem.

| | | | | |
|---|---|---|---|---|
| Circumference | = | $\pi$ | • | diameter |
| Speed | = | distance | ÷ | time |

**1. Speed of Earth's orbit around the Sun**

The average distance from Earth to the Sun is 150,000,000 km, and Earth completes one revolution (orbit) of the Sun in 365.25 days.

a) How fast does Earth orbit around the Sun in 1 second?

b) How many km does Earth travel around the Sun in 5 seconds?

**2. Speed of Earth on its axis**

Besides revolving around the Sun, Earth also rotates (spins) on its axis. If the diameter of Earth at the equator is 12,755 km and Earth takes 24 hours to rotate completely on its axis, then...

a) How fast is Earth spinning in km per second?

b) How many km does a point on the equator travel in 5 seconds?

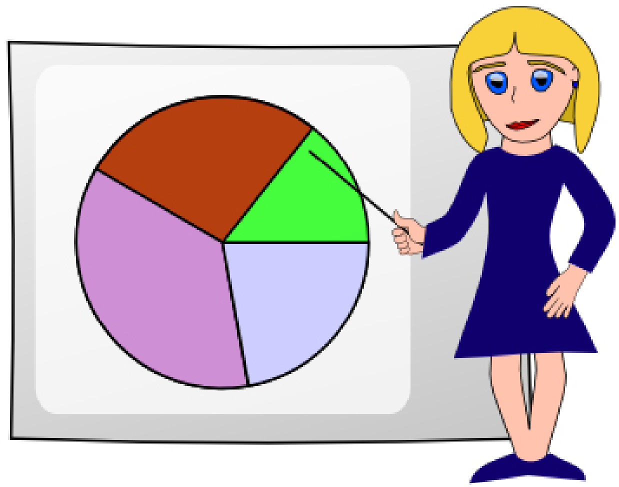
Name: Date: .

## Additional Ratio and Proportion Problems

The following are problems that will require multiple steps to obtain a solution. You will need to apply what you know about scale, ratio, and proportion to solve them. You may choose the units you work with, as long as they are appropriate. Be sure to include descriptions and pictures to explain how you solved the problem.

### 1. Percent of a Lifetime

Earlier in this lesson, you calculated the percent of a person's lifetime that a trip to a planet or moon would take. What about the percent of a person's lifetime that is spent on *other activities*?



Use the table on page 28 to record your answers for parts A through E below.

A. **Make a list of activities** that you do with most of your time each day. For example: sleeping, going to school, watching TV, etc. Include a category called "other" for all of the miscellaneous things that you do day-to-day.

B. **Estimate how many hours**, on average, you spend doing these activities each day. (The hours should total 24.)

C. **Calculate the fraction of each day** that is spent by each activity. For example, if you work 8 hours a day, then 8/24, or 1/3 of your day, is consumed by working.

D. **Convert each fraction to a decimal**. (Round to 2 decimal places.)

E. **Convert each decimal to a percent.** (The percents should total 100%.)

Name: Date: .

| A | B | C | D | E |
|---|---|---|---|---|
| **Activity** | **Hours per Day** | **Fraction** | **Decimal** | **Percent** |
| Working / School | 8 | $\frac{8}{24} = \frac{1}{3}$ | 0.33 | 33% |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Other | | | | |
| **Totals:** | | | | |

F. If you apply the daily percentages spent on these activities to a lifetime, then you can determine how much time would be spent on these activities throughout your life.

For example, if you work for an average of 33% of every day and you live 74 years, then you would spend 24.42 years of your life working!

**Calculate the number of years** you would spend doing each activity on your list based on a 74-year lifetime. (Round answers to 2 decimal places.)

| Activity | Percent | # Days in a Lifetime | # of Years in a Lifetime |
|---|---|---|---|
| Working | 33% | 8,919.41 days | 24.42 years |
| | | | |
| | | | |
| | | | |
| | | | |
| Other | | | |
| **Totals:** | | | |

Name: Date: .

G. **Create a pie chart** that illustrates what percent of an average day is occupied by these activities. Give your chart a title and appropriate labels.

1. What do you spend most of your day doing?

2. What do you spend the least amount of time doing?

3. Are there any activities you think you should spend more or less time on?

   I should spend more time ________________ because ________________

   ________________________________________________________________.

   I should spend less time ________________ because ________________

   ________________________________________________________________.

Name: Date: .

## 2. Travel Time—Part 1

The distance from Los Angeles, California to New York City, New York is 4,548 kilometers. For each problem, you will need to:


- Decide which units of time are appropriate for your answer.

- Use the approximated unit ratio:

$$\frac{1 \text{ mile}}{1.6 \text{ kilometers}}$$

A. The average speed of a marathon runner is approximately 12 km per hour. If a marathon runner could run the entire distance from Los Angeles to New York City at a constant speed of 12 km/hour without stopping, how long would it take?

Write your estimate below, and then calculate the actual t**ime** it would take to run between the two cities.

Estimated time: ____________

Actual time: ____________

B. The average walking speed of a human is 6 km per hour. If a human could walk the entire distance from Los Angeles to New York City at a constant speed of 6 km/hour without stopping, how long would it take?

Write your estimate below, and then calculate the actual time it would take to walk between the two cities.

Estimated time: ____________

Actual time: ____________

Name: Date: .

C. The average biking speed of a human is 24 km per hour. If a human could ride a bike the entire distance from Los Angeles to New York City at a constant speed of 24 km/hour without stopping, how long would it take?


Write your estimate below, and then calculate the actual time it would take to walk between the two cities.

Estimated time: _________

Actual time: ____________

D. The average speed limit for cars across the United States is approximately 65 **miles** per hour. If a human could drive the entire distance from Los Angeles to New York City at a constant speed of 65 **miles**/hour without stopping, how long would it take?

Write your estimate below, and then calculate the actual time it would take to walk between the two cities.

Estimated time: _________

Actual time: ____________

E. A 747 airplane travels at an average speed of 907 km per hour. If a 747 airplane could fly the entire distance from Los Angeles to New York City at a constant speed of 907 km/hour without stopping, how long would it take? (*You can check your answer by going online and checking the length of flights from LAX to JFK airports.*)

Write your estimate below, and then calculate the actual time it would take to walk between the two cities.

Estimated time: _________

Actual time: ____________

Name: Date: .

F. When the space shuttle is in orbit, it travels approximately 28,000 km per hr. If the space shuttle could fly the entire distance from Los Angeles to New York City at a constant speed of 28,000 km/hour without stopping, how long would it take?

Write your estimate below, and then calculate the actual time it would take to walk between the two cities.

Estimated time: ____________

Actual time: ____________

## 3. Travel Time—Part 2

In Travel Time—Part 1, travel times were calculated assuming that humans could run, walk, bike, or drive nonstop for days at a time. In reality, people get tired and have to take breaks to sleep and eat. Furthermore, the harder your body works, the more time it needs to rest and the more food it needs to eat.

**Step 1:** Choose running, walking, biking, or driving.

**Step 2:** Plan realistic amounts of time that would be needed for breaks, sleeping, and eating.

**Step 3:** Calculate how long you think the trip would actually take.