HUMAN

Accelerator

Thomas Jefferson National Accelerator Facility - Office of Science Education
http://education.jlab.org/

Human Accelerator

HOW EASY IS IT TO WORK TOGETHER AS A TEAM?

1. Stand side by side, shoulder to shoulder with your class. Your class is now a linear accelerator that will help deliver the electron beam to its target.

2. The first person in the line will act as the injector. Every other person in the line is a cavity. The last person in line will hit the target with the electrons.

3. Cup your hand that is closest to the injector in the upward direction and the other hand downward.

4. As the electrons that make up the beam are injected you will transfer them along the accelerator by bringing your hands together and then moving them back to their original position as a leader calls “in...out...in...out...” in constant rhythm. When your hands come together, or in, you will transfer the electrons from one hand to the other. When your hands go out you will transfer them to the next cavity in line.

5. You must continue to do your job **even if you don’t have any electrons** so that the accelerator may continue operating.

6. Do not pick up any lost electrons.

7. After the beam has been delivered to its target, use the **Human Accelerator Data Chart** on the next page to record your data.

Human Accelerator Data Chart

Beam Type	Number of balls **Injected**	Number of balls **Delivered**	Fraction Delivered	Percent Delivered
Pulsed Beam				
Continuous Beam (slow cadence)				
Continuous Beam (fast cadence)				
Eyes Shut				
Other				

HOW DO I CONVERT A FRACTION INTO A PERCENT?

Write the fraction as a division problem.

$\frac{7}{12} = 12\overline{)7}$

12 doesn't go into 7, so make the 7 look larger by adding a decimal point and some zeros.

$12\overline{)7.000}$

Bring the decimal point up and divide like you usually do.

$$\begin{array}{r} .583 \\ 12\overline{)7.000} \\ -60 \\ \hline 100 \\ -96 \\ \hline 40 \\ -36 \\ \hline 4 \end{array}$$

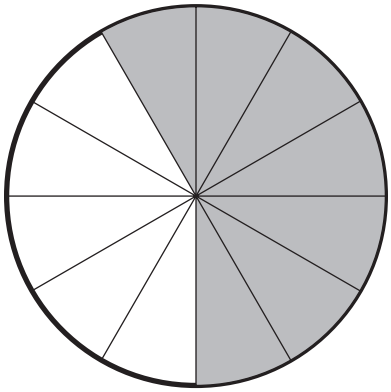
This problem will go on forever. Stop dividing when you think you have gone far enough.

Convert your decimal answer to a percent by multiplying by 100.

$$\begin{array}{r} .583 \\ \times\ 100 \\ \hline 58.3\% \end{array}$$

LET'S MAKE SOME GRAPHS!

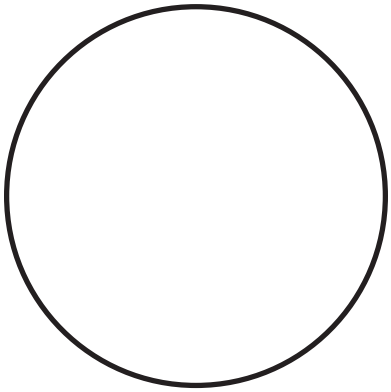
Example



Fraction Delivered = 7/12

Percent Delivered = 58%

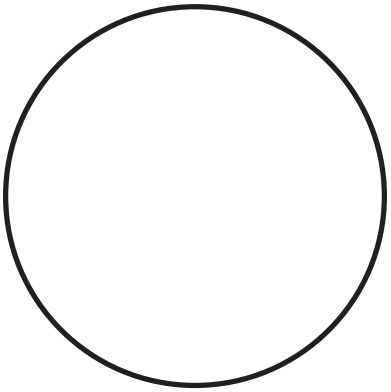
Pulsed Beam



Fraction Delivered = ____

Percent Delivered = ____

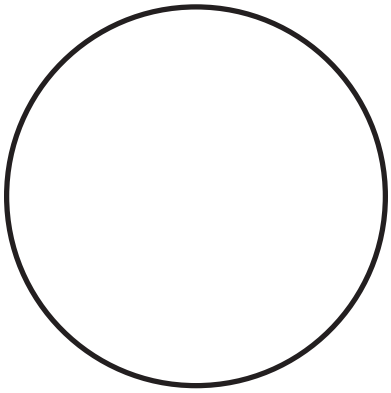
Continuous Beam (slow cadence)



Fraction Delivered = ____

Percent Delivered = ____

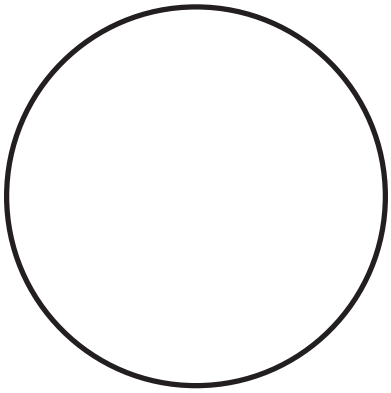
Continuous Beam (fast cadence)



Fraction Delivered = ____

Percent Delivered = ____

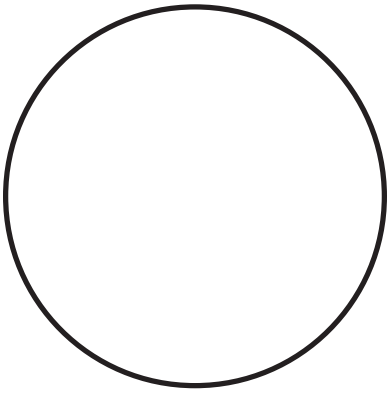
Eyes Shut



Fraction Delivered = ____

Percent Delivered = ____

Other



Fraction Delivered = ____

Percent Delivered = ____

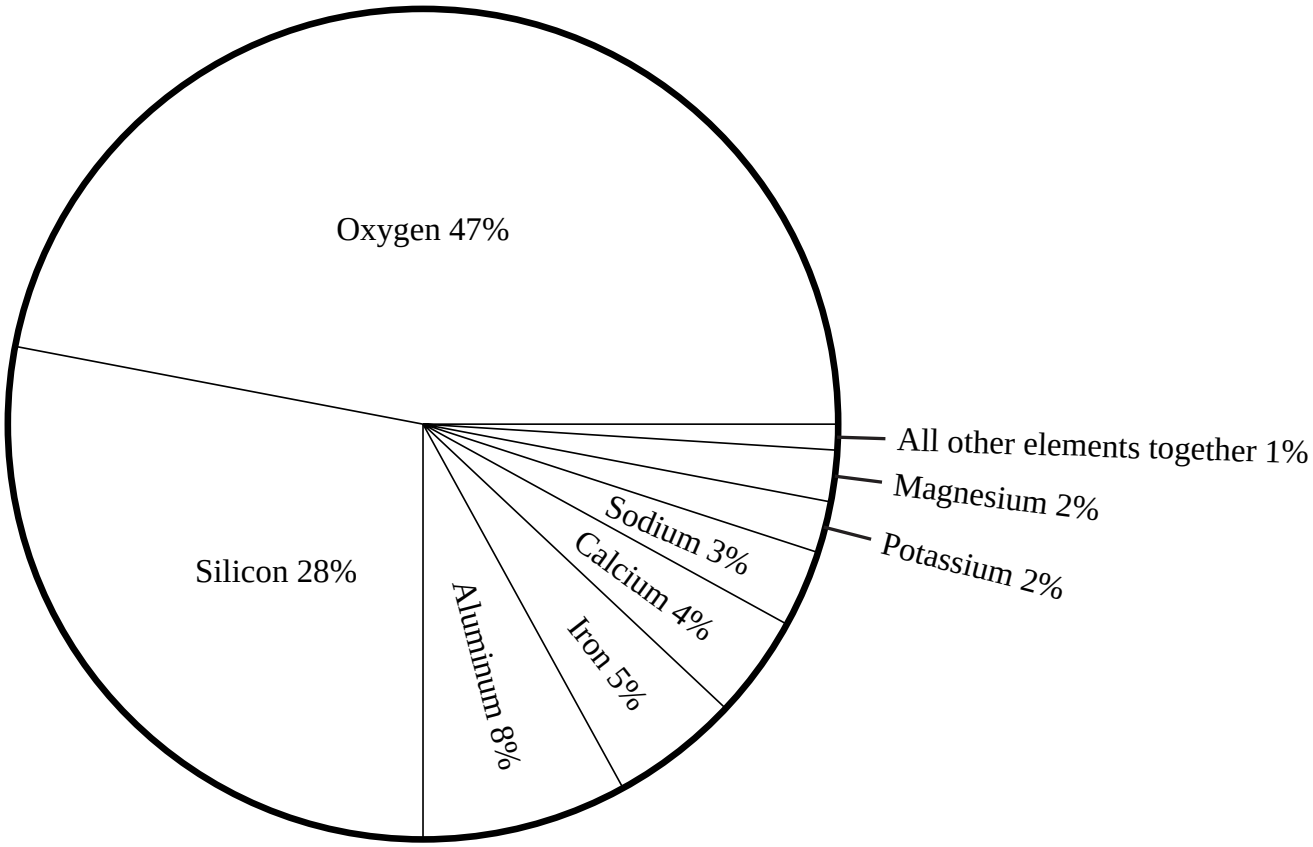
Reading About Materials in the Earth's Crust

IN THE HUMAN ACCELERATOR ACTIVITY YOU DID AT THE LAB, YOU USED PIE GRAPHS TO SEE THE PERCENTAGE OF TENNIS BALLS THAT ARRIVED AT THE TARGET. USE THE PIE GRAPH BELOW TO HELP YOU UNDERSTAND THE FOLLOWING PASSAGE.

Directions: Read the following passage about minerals and the materials that make up the earth's crust. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

The earth's crust is made up of a number of different materials. Solid __1__ that are found in the crust are minerals. There are hundreds of different minerals. Each __2__ has its own properties. Scientists identify minerals by testing their __3__. One property is magnetism; magnetite has __4__ properties. The shape of crystals can identify minerals such as salt, which has __5__ that look like cubes. The color, shine and hardness of minerals are other properties used to classify and __6__ minerals in the crust.

The __7__ chart below shows the elements that make up most minerals. The graph shows that __8__ makes up 47% of the minerals in the crust. Both potassium and magnesium make up __9__ of the crust. The graph also gives us information about other elements, such as carbon. Carbon makes up __10__ 1% of the crust.



Directions: Use the context of the passage and the graph to select the best word for each blank.

1.	a. minerals	b. materials	c. crusts	d. numbers
2.	a. mineral	b. material	c. property	d. layer
3.	a. minerals	b. materials	c. properties	d. scientists
4.	a. magnetic	b. quality	c. properties	d. identify
5.	a. properties	b. saltiness	c. minerals	d. crystals
6.	a. push	b. mine	c. identify	d. clarify
7.	a. line	b. bar	c. percentage	d. pie
8.	a. silicon	b. aluminum	c. oxygen	d. iron
9.	a. 4%	b. 3%	c. over 8%	d. 2%
10.	a. more than	b. less than	c. equal to	d. unknown

Human Accelerator Data Chart

Beam Type	Number of balls **Injected**	Number of balls **Delivered**	Fraction Delivered	Percent Delivered
Pulsed Beam	20	10	$^{10}/_{20}$	50%
Continuous Beam (slow cadence)				
Continuous Beam (fast cadence)				
Eyes Shut				
Other				

HOW DO I CONVERT A FRACTION INTO A PERCENT?

Write the fraction as a division problem.

$\frac{7}{12} = 12\overline{)7}$

12 doesn't go into 7, so make the 7 look larger by adding a decimal point and some zeros.

$12\overline{)7.000}$

Bring the decimal point up and divide like you usually do.

```
   .583
12)7.000
 -60
  100
  -96
    40
   -36
     4
```

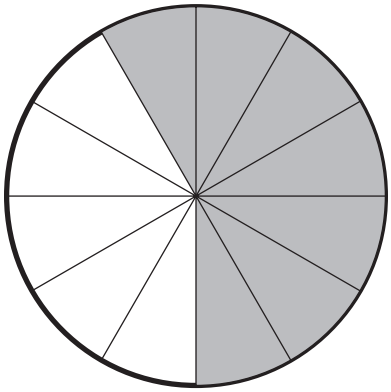
This problem will go on forever. Stop dividing when you think you have gone far enough.

Convert your decimal answer to a percent by multiplying by 100.

```
  .583
x 100
------
58.3%
```

LET'S MAKE SOME GRAPHS!

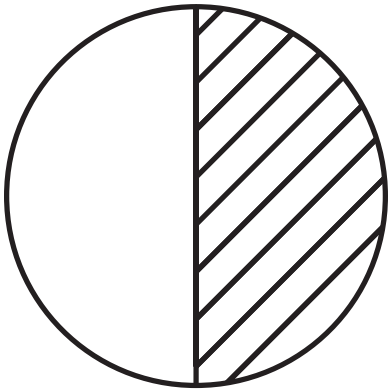
Example



Fraction Delivered = 7/12

Percent Delivered = 58%

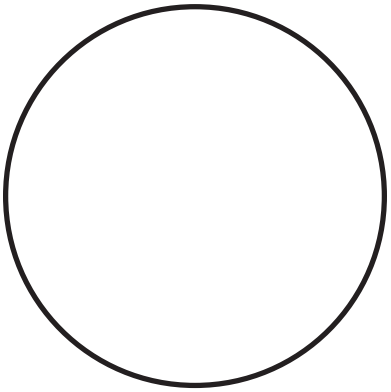
Pulsed Beam



Fraction Delivered = 10/20

Percent Delivered = 50%

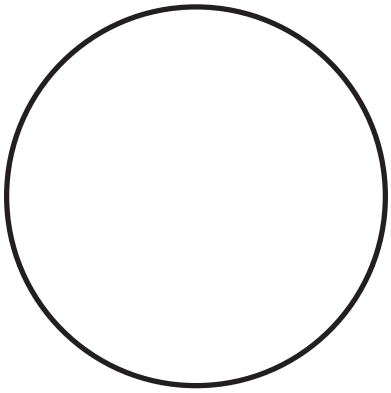
Continuous Beam
(slow cadence)



Fraction Delivered = ____

Percent Delivered = ____

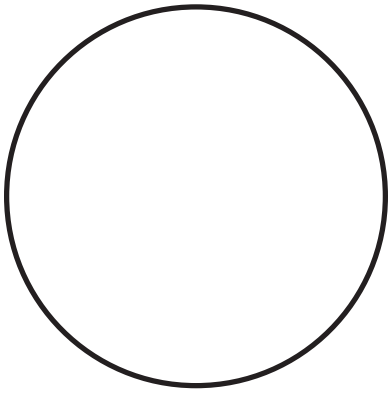
Continuous Beam
(fast cadence)



Fraction Delivered = ____

Percent Delivered = ____

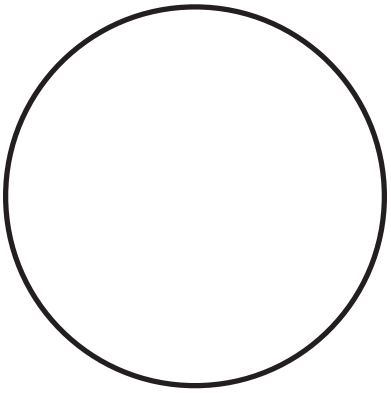
Eyes Shut



Fraction Delivered = ____

Percent Delivered = ____

Other



Fraction Delivered = ____

Percent Delivered = ____

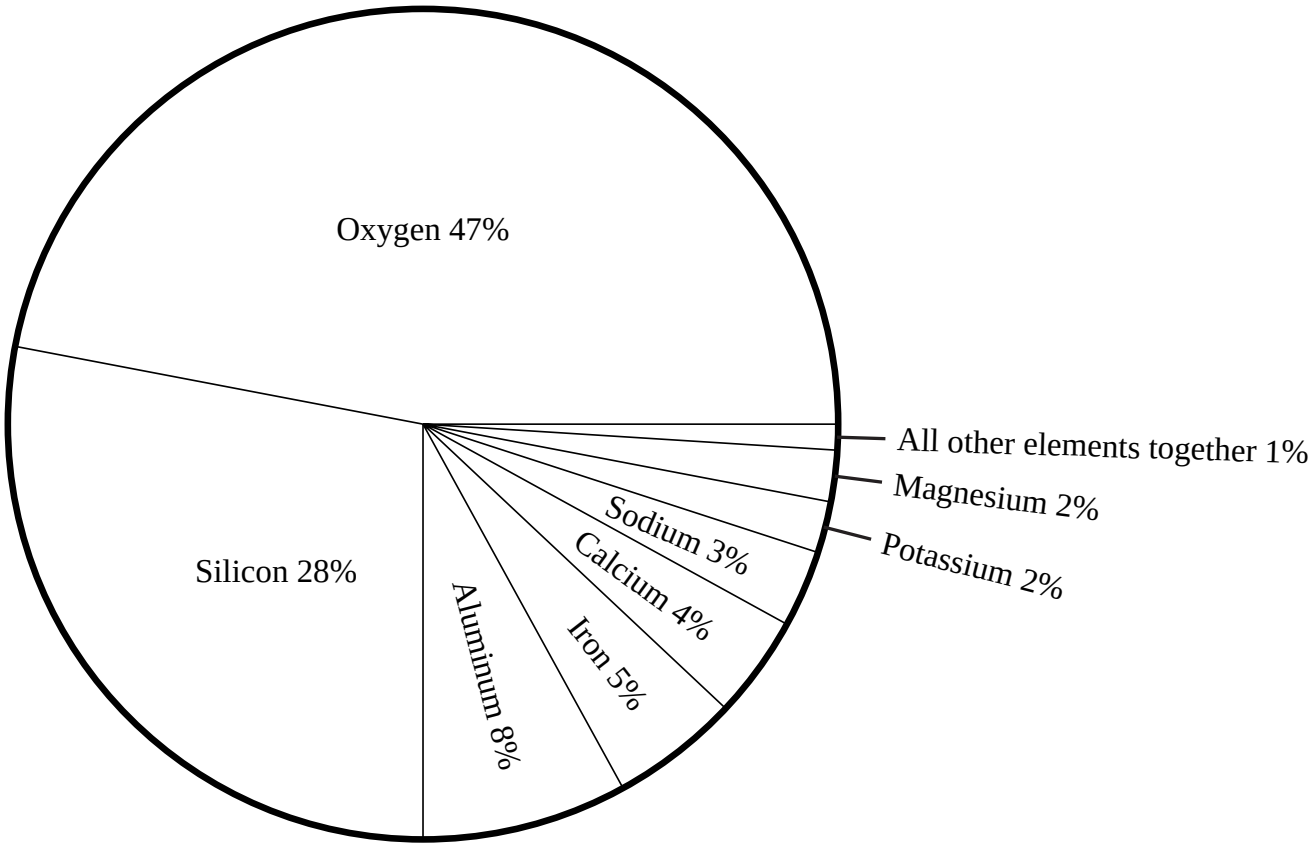
Reading About Materials in the Earth's Crust

IN THE HUMAN ACCELERATOR ACTIVITY YOU DID AT THE LAB, YOU USED PIE GRAPHS TO SEE THE PERCENTAGE OF TENNIS BALLS THAT ARRIVED AT THE TARGET. USE THE PIE GRAPH BELOW TO HELP YOU UNDERSTAND THE FOLLOWING PASSAGE.

Directions: Read the following passage about minerals and the materials that make up the earth's crust. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

The earth's crust is made up of a number of different materials. Solid __1__ that are found in the crust are minerals. There are hundreds of different minerals. Each __2__ has its own properties. Scientists identify minerals by testing their __3__. One property is magnetism; magnetite has __4__ properties. The shape of crystals can identify minerals such as salt, which has __5__ that look like cubes. The color, shine and hardness of minerals are other properties used to classify and __6__ minerals in the crust.

The __7__ chart below shows the elements that make up most minerals. The graph shows that __8__ makes up 47% of the minerals in the crust. Both potassium and magnesium make up __9__ of the crust. The graph also gives us information about other elements, such as carbon. Carbon makes up __10__ 1% of the crust.



Directions: Use the context of the passage and the graph to select the best word for each blank.

1.	a. minerals	**b. materials**	c. crusts	d. numbers
2.	**a. mineral**	b. material	c. property	d. layer
3.	a. minerals	b. materials	**c. properties**	d. scientists
4.	**a. magnetic**	b. quality	c. properties	d. identify
5.	a. properties	b. saltiness	c. minerals	**d. crystals**
6.	a. push	b. mine	**c. identify**	d. clarify
7.	a. line	b. bar	c. percentage	**d. pie**
8.	a. silicon	b. aluminum	**c. oxygen**	d. iron
9.	a. 4%	b. 3%	c. over 8%	**d. 2%**
10.	a. more than	**b. less than**	c. equal to	d. unknown

Human Accelerator

This is an activity in which students simulate Jefferson Lab's accelerator by passing tennis balls down a straight line.

Objectives:

In this activity students will:

- cooperate with their partners to complete a task
- pass tennis balls down a line of students to simulate a linear accelerator
- record the number of tennis balls that successfully made it to the end of the line
- calculate the fraction of tennis balls that successfully made it to the end of the line
- use division and multiplication to convert each fraction into a percent
- create a pie graph for each fraction

Questions to Ask:

1. Which method of passing the tennis balls was the most difficult?
2. What are some ways your team worked well together?
3. Where are some places you use percents?

Travel Book Activities:

- Reading About Materials in the Earth's Crust

Virginia State Standards of Learning

Math 6.1 Number and Number Sense

- by writing the equivalence relationship between fractions and percents

Math 6.4 Number and Number Sense

- by comparing fractions and percents using pie graphs

Science 6.1 Plan and Conduct Investigations

- by recording precise and approximate measurements
- by devising methods to test the validity of predictions and inferences
- by manipulating one variable over time with repeated trials
- by collecting, recording and analyzing data
- by organizing and communicating data through graphical representations
- by analyzing alternative scientific explanations
- by basing conclusions on scientific evidence

Science 6.2 Demonstrate Scientific Reasoning and Logic

- by basing conclusions on scientific evidence

LS.1 Plan and Conduct Investigations

- by organizing data into tables showing repeated trials
- by defining variables
- by constructing models to illustrate and explain phenomena
- by identifying sources of experimental error
- by identifying independent variables, dependent variables and constants
- by controlling variables with repeated trials to test the hypotheses

PS.1 Plan and Conduct Investigations

- by recording and interpreting data from circle graphs
- by identifying independent and dependent variables, constants, controls and repeated trials
- by analyzing data to form valid conclusions

Human Accelerator
Teacher Overview and Materials List

Background:

Scientist at Jefferson Lab study atoms using a machine called an electron accelerator. Jefferson Lab's accelerator produces a beam of fast moving electrons by passing them through hollow metal devices called cavities. An alternating sequence of electrical charges is created on thMaterials for Human Acceleratore surface of the cavities and these charges accelerate the electrons. The cavities are arranged in two long, straight sections called Linear Accelerators. In this activity, students pass tennis balls down a line like Jefferson Lab's cavities ‘pass’ electrons down the Linear Accelerators.

Minimum Materials Needed for Each Student Group:

~20 tennis balls

2 containers to hold the tennis balls

Materials for Human Accelerator