

Earth Day 2023 – Plastic Straws Activity *Teacher Notes and Solutions*

From *Parade Magazine*, April 15, 2018, page 8:

Problem #1: Plastic Pollution

That plastic straw in your morning iced coffee or lunch-time soda? It's not so innocent.

How many straws do Americans use every day? **500 million** The number should astound you.

Many end up in the ocean (along with plastic bags), where sea life accidentally consumes them. Nearly 90 percent of the debris in oceans is plastic.

To comprehend this number of **500** million straws per day, let's investigate this in some kind of context.

Note: use a calculator to do your calculations. We suggest that students store each intermediate answer into a different variable and make note of that variable on their paper with the solutions.

Do not round any intermediate answers, but round only final answers to three decimal places.

Exercise 1. If we connected these straws for one day and could place them along the equator, how far would they wrap around the earth at the equator?

- a. Discuss in your groups what information you would need to know in order to be able to solve this problem.

Possible questions:

What straw length should we use?

For this problem we will use an "average" length of $7\frac{3}{4}$ in.

What is the radius, diameter, or circumference of the earth?

The earth is not a perfect sphere. The rotation of the earth causes it to bulge at the equator. The diameter from pole to pole is 7899.86 miles, while the diameter at the equator is 7926 miles.

For this reason, the earth is called an "oblate spheroid", a sphere that experiences flattening at the poles.

We will use the equatorial diameter in our calculations.

- b. Ask your teacher for the information that you decide in part a.
- c. Solve the problem.

Solution.

$$(500,000,000) \cdot (7.75) = 3,875,000,000 \text{ in} \rightarrow A$$

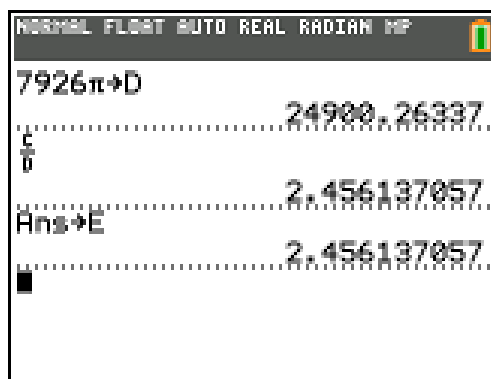
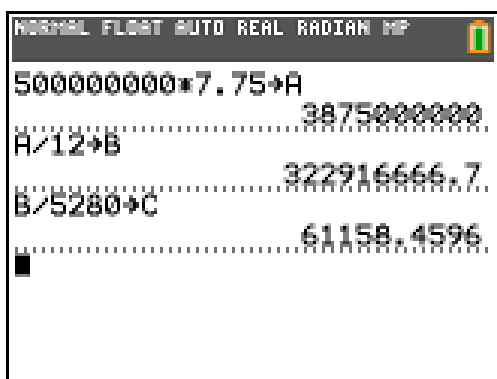
$$\text{Convert to feet: } A/12 = 322,916,666.7 \text{ ft} \rightarrow B$$

$$\text{Convert to miles: } B/5280 = 61,158.4596 \text{ miles} \rightarrow C$$

$$\text{Circumference at the equator: } 7926 \cdot \pi = 24,900.26337 \text{ miles} \rightarrow D$$

One day's supply of straws will wrap around the earth at the equator how many times?:

$$\frac{C}{D} = \frac{61158.4596}{24900.26337} = 2.456137057 \rightarrow E \doteq \underline{\underline{2.456 \text{ times}}} \text{ (almost two and a half times!)}$$

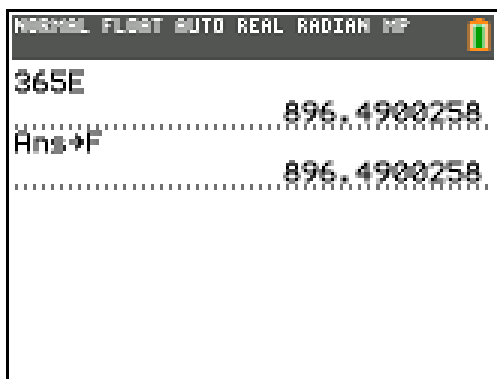


Exercise 2. If we connected these straws for the entire year and could place them along the equator, how far would they wrap around the earth at the equator?

Solution.

$$365 \cdot E = 896.4900258 \rightarrow F$$

One year's worth of straws will wrap around the earth at the equator 896.490 times!



Exercise 3. If we connected these straws for the entire year and could place them on a straight line from the earth to the moon, how far would they make it to the moon?

- Discuss in your groups what information you would need to know in order to be able to solve this problem.

Possible questions:

What is the distance from the earth to the moon?

At its perigee (closest distance), the moon is 225,623 miles to the earth.

At its apogee (farthest distance), the moon is 252,088 miles to the earth.

On average, the moon and earth are 238,855 miles apart. We will use this number in our calculations.

How Far is the Moon?

By Tim Sharp, Reference Editor | October 27, 2017 09:03am ET

The moon's orbit around Earth is elliptical. At perigee — its closest approach — the moon comes as close as 225,623 miles (363,104 kilometers). At apogee — the farthest away it gets — the moon is 252,088 miles (405,696 km) from Earth. On average, the distance from Earth to the moon is about 238,855 miles (384,400 km). According to [NASA](#), "That means 30 Earth-sized planets could fit in between Earth and the moon."

Today, the moon is moving away from Earth at a rate of about 1.5 inches (4 cm) per year.

The [moon](#) is in synchronous rotation with Earth. In other words, the moon rotates on its axis in about the same amount of time it takes to revolve around Earth — 27 days 8 hours, which is called sidereal month. So we always see the same side of the moon; there is no "dark side of the moon." Instead, scientists refer to the side of the moon facing away from the planet as the "far side of the moon." The far side can be spotted by missions such as NASA's DSCOVR satellite, which captured a [video](#) of the moon "photobombing" Earth.

A [lunar month](#), also called a synodic month, is the time it takes for the moon to complete a lunar cycle — full moon to full moon. A lunar month is about 29 days 13 hours.

<https://www.space.com/18145-how-far-is-the-moon.html>

- b. Ask your teacher for the information that you decide in part a.
- c. Solve the problem.

Solution.

We will use information found in exercise 1.

Length of straws in miles is stored in C = 61158.4596.

Divide this number by the average distance to the moon, 238,855.

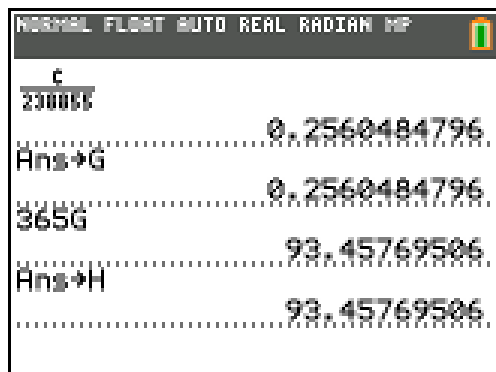
$$\frac{C}{238855} = \frac{61158.4596}{238855} = 0.2560484769 \rightarrow G$$

The length of straws in one day will go a little more than a quarter of the way, 0.256, from the earth to the moon.

For one year:

$$365 \cdot G = 93.45769506 \rightarrow H$$

The length of straws in one year can travel the distance from the earth to the moon almost 93.5 times (93.458).



Exercise 4. If all these straws were made of plastic, what would be the volume of the plastic used to make the straws for one year?

- a. Discuss in your groups what information you would need to know in order to be able to solve this problem.

Possible questions:

Dimensions of the straw?

Length of a straw?

Outside diameter of a straw?

Thickness of the straw material?

We will use an “average” straw’s dimensions.

The straw is $7\frac{3}{4}$ in long.

The outside diameter of the straw is $\frac{3}{16}$ in.

The thickness of the straw material we will use is 0.01 inches.

- b. Ask your teacher for the information that you decide in part a.

- c. Solve the problem.

Solution.

One way to visualize the volume of plastic contained in one straw is to cut the straw along a vertical line and flatten it to be a very thin rectangular solid.

C of straw



7.75 in

We need to calculate the volume of this very thin rectangular solid. To do so, we need to first calculate the circumference of the outside of the straw.

$$\text{Circumference} = \pi \cdot \text{diameter} = \pi \cdot \frac{3}{16}$$

$$\text{Circumference} = 0.5890486225 \text{ in} \rightarrow I$$

Volume of plastic needed for one day’s worth of straws:

$$V = l \cdot w \cdot h = (7.75)(I)(0.01)$$

$$V = 0.0456512682 \text{ cu in} \rightarrow J$$

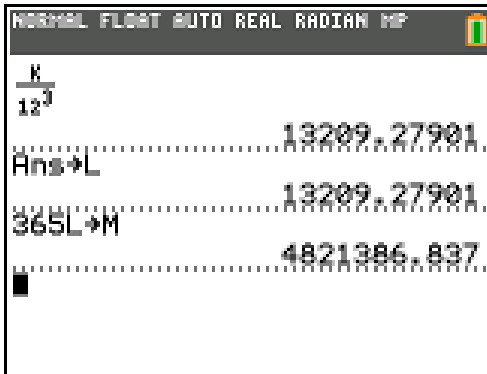
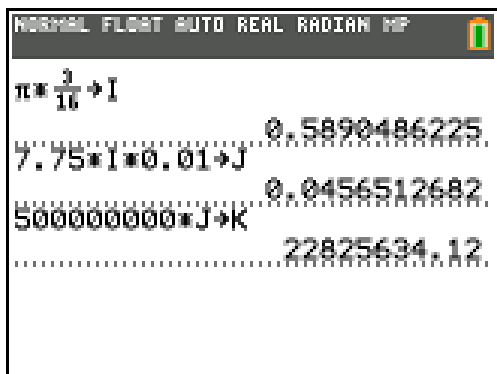
$$\text{Volume of all straws: } V = 500,000,000 \cdot J = 22,825,634.12 \text{ cu in} \rightarrow K$$

Convert to cubic feet:

$$\frac{K}{12^3} = 13209.27901 \text{ cu ft} \rightarrow L$$

Volume of plastic needed for one year’s worth of straws:

$$365 \cdot L = 4,821,386.837 \text{ cu ft} \rightarrow M$$



- d. To try to comprehend what this volume of plastic for one year means, let's put it into context of something we can visualize.

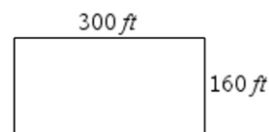
If we were to cover a football field with this plastic from goal line to goal line, and the width of the football field, what would be the depth of the plastic?

Note: a football field is 160 feet wide.

Solution.

Calculate the area of the football field in sq ft:

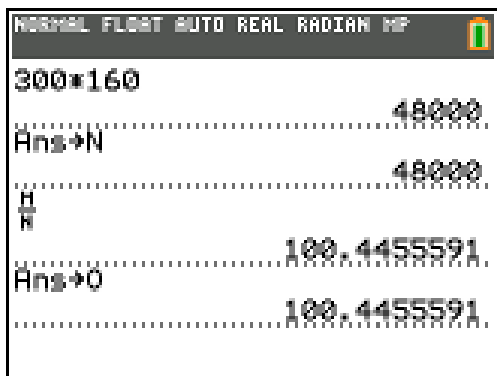
$$(300)(160) = 48,000 \text{ sq ft} \rightarrow N$$



Divide the volume by the area to find the height (depth) of the plastic:

$$\frac{M}{N} = \frac{4,821,385.839}{48,000} = 100.4455591 \rightarrow O$$

The depth of plastic on a football field would be almost 100.5 feet (100.446 ft).



Background information

Are Plastic Drinking Straws Harmful to the Environment?

Plastic straws rarely come out as a major problem in global discussions of environmental destruction, maybe due to their small size. The production cost of straws is low, enabling their mass production. In many countries, straws are offered freely after purchasing soft drinks. Plastic straws are therefore one of the most used plastics, and resultantly among the worst pollutants in the world. The easy availability of plastic straws has become the straw's main undoing, as people dispose of used straws in the knowledge that obtaining another straw is virtually free and within arm's reach. According to some estimates, as much as 3 million pounds of plastics straws are used in the United States each day.

Environmental Effects of Plastic Straws

One destructive characteristic of the humble plastic straw is its light weight and small size. The inadequate disposal of plastic straws has found its way to the beaches, and due to their small size, plastic straws are often ingested by marine animals. Environmentalists have shown that the death of many marine animals is attributed to complications caused by ingesting plastic straws. The other damaging characteristic of the plastic straws is their composition, as they are made of non-biodegradable material. The environmental effects of straws can also be seen in their production. While plastic straws made out of silicone exists, most plastic straws are manufactured from polypropylene, a hydrocarbon and a fossil fuel byproduct. The production of polypropylene results in the emission of toxic pollutants into the environment. Like other plastic pollutants, plastic straws become eyesores after being dumped into landfills.

Could a Ban Be the Answer?

The most effective way of dealing with the environmental pollution caused by plastic straws is the reuse, recycling, or instituting a ban on the use of plastic straws. Being plastics, the straws can be molded into new items. Many organizations around the world convert used straws into new commodities. In Africa, local communities collect used plastic straws and use them to make mats and bags. Another remedy for environmental pollution caused by plastic straws is placing a ban on their production and use. Activists around the world are lobbying governments to ban plastic straws to save the environment. A few countries in the world such as Rwanda, Macedonia, China, Kenya and the state of California have already banned the use of plastic bags and are expected to expand the ban also to include plastic straws and bottles. Users are also encouraged to boycott the use of the plastic straws which is seen as unnecessary. As expected, such measures face stiff opposition from straw manufacturers who claim that the environmental effects caused by plastic straws are often exaggerated.

Alternatives to Plastic Straws

There are few environmental friendly and biodegradable alternatives to plastic drinking straws that are available. These alternatives include paper straws, bamboo straws, pasta straws and straws made out of straw. However, such straws are usually expensive as their production cost is high (relative to that of plastic straws) and hard to obtain. Other alternatives such as glass straws and metal straws are dangerous, and also leave a bad impact on the environment when they are finally disposed.

<https://greenthatlif.com/why-plastic-straws-are-a-problem/>

<https://www.worldatlas.com/articles/are-plastic-drinking-straws-harmful-to-the-environment.html>