Measuring Horsepower: How Many Horses are You Worth?
Teacher Resource

Skills:

- This project leads students through the process of calculating how much horsepower they generate while giving historical context from the early Industrial Revolution—the late 18th and early 19ths centuries.

Method:

- In order to complete this project, students need access to a flight of stairs and the ability to climb those stairs.
- This project involves multiplying and dividing with decimals, and units of measurement students may not be familiar with.

Materials:

- Student worksheets
- Flight of stairs
- Meter stick or ruler with centimeters
- Scale
- Stopwatch

Background:

- ***Horsepower*** – a unit of measurement for power created by Scottish inventor James Watt to help people compare engines to horses
- ***Industrial Revolution*** – a time period of major change in the late 1700s and the 1800s
- ***Joule*** – a unit of measurement for work or energy named after James Joule, an English physicist
- ***Watt*** – a unit of measurement for power named after James Watt

    - Have you heard of horsepower?
    - If so, where have you heard that term?
    - What do you think it means?
    - Where do you think it comes from?

Horsepower is a unit that measures power. You may have heard it used to describe the power of cars or other vehicles, and that is because the power of an engine is almost always measured in horsepower.

When engines were still very new, the engineers who designed them needed to find a way to sell them to the people who might want to use them. One of those engineers was a man named James Watt, whose engines were much better than the engines that had come before because they used less fuel. This was very impressive to the people who had those engines, but most of his potential customers weren't using engines at all yet, so talking about fuel use didn't mean much to them. In the late 1700s and early 1800s, most of these people were using the same power source—workhorses.

So, James Watt came up with a way to measure how much power a workhorse from his time could generate. He measured the amount of weight that a workhorse of his time could easily lift (Force), he measured how far it was lifted (Distance), and he measured how long it took for the weight to be lifted the distance (Time). From these measurements he created a unit that he called "horsepower," which he claimed was the amount of power regularly generated by a workhorse.

Today, the students will be measuring how much power they can generate measured in horsepower.

1. **Hypothesis**

If 1 Horsepower is about the strength of one workhorse working normally, how much horsepower do you think you will be able to generate? Walking? Running? Students should record their answers on the provided work sheet.

In order to measure power, we first have to measure how much work you are doing, so we have to know how much weight is being lifted, how far it is being lifted, and how fast it is being lifted.

Work = Force x Distance

Power = Work ÷ Time

2. **Force (Weight)**

First, how much weight is being lifted. Students must take turns weighing themselves and recording the results in pounds (lbs.)

Pounds is a great measurement for everyday use, but for the math in this experiment, we need that weight to be in newtons (N). One pound is about 4.45 newtons, so the total number of pounds multiplied by 4.45 will give the student's weight in newtons.

___ lbs. x 4.45 = ____ N

3. **Distance (Height)**

Now, how high is that weight going to be lifted? For the purposes of this experiment, horizontal distance doesn't matter, only vertical. Use the meter stick or ruler to measure the height of one stair in centimeters (cm). This will need to be in meters (m) for the rest of our math, so now we need to convert centimeters to meters. There are 100 centimeters in one meter, so all we need to do is divide the number of centimeters by 100. The easiest way to do this is just move a decimal to places to the left.

__ cm ÷ 100 = ____ m

That measurement in meters multiplied by the number of stairs will give you the total distance in meters that the weight will be lifted.

____ m x ____ stairs = ____ m

4. **Work**

Now we have to numbers we need to calculate the work equation above. The student's weight in newtons (N) multiplied by the total distance lifted in meters (m) will give the amount of work required in joules (J)

____ N x ____ m = ______ J

5. **Time**

Time to go up the stairs! Stopwatches will allow each student's classmates to measure their time from the bottom to the top in seconds (secs). The worksheet has spaces for four trials per student—feel free to do more if time allows. Try moving up the stairs at different speeds. We recommend trying both running, which should give the highest horsepower, and walking, which would give a more accurate sustained horsepower.

6. **Power**

Horsepower is a unit of power, and we are going to use it, but to use the simple equation written above, we're first going to be using a different unit, the watt (W). Work in joules (J) divided by time in seconds (secs) will give the power in watts. Do this for each time trial conducted.

____ J ÷ ____ secs = ______ W

From watts, we only need to do one more bit of math to reach horsepower. One horsepower (HP) is equal to 746 watts (W), so the number of watts divided by 746 will provide the horsepower for each of the watt totals above.

____ W ÷ 746 = ______ HP

How do you measure up?

- While it would make sense for a horse to be able to produce 1 HP, modern day scientists and mathematicians have found that a horse actually produces around 0.86 HP. Historians think that James Watt's math might have been a little wrong on purpose—if he overestimated what a workhorse was capable of, his engines would always seem to be more powerful, even if the number of actual horses was the same number as the engine's measured horsepower.
- A squirrel's horsepower is somewhere around .0007.
- When working normally, the average adult workman produces a steady .09 HP.
- At his very fastest, Olympic Gold Medalist and fastest man alive Usain Bolt is capable of producing 3.5 HP
- Hoover dam produces 2,682,044 HP when running at capacity.
- When the NASA Space Shuttles were in use, their three engines could produce 37 million horsepower (37,000,000 HP) for the takeoff sequence.

Next Generation Sunshine State Standards

MAFS.5.MD.1.1: Convert among different sized standard measurement units within a given measurement system and use these conversions in solving multi-step, real world problems.

- **MAFS.5.MD.1.AP.1b**: Convert standard measurements of length to solve real-world problems.

MAFS.5.NBT.1.3: Read, write, and compare decimals to thousandths

- **MAFS.5.NBT.1.AP.3**a: Read, write, or select a decimal to the hundredths place.

MAFS.5.NBT.2.7: Add, subtract, multiply, and divide decimals to hundredths.

MAFS.6.NS.2.3: Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.

- **MAFS.6.NS.2.AP.3a**: Solve one-step addition, subtraction, multiplication, or division problems involving decimals whose place value ranges from the thousand to the thousandths places.