**What does Fire Truck Horsepower have to do with math? **

**Video:** [**https://youtu.be/BrnajTX2MvU**](https://youtu.be/BrnajTX2MvU)

**Lesson Plan**

**Teacher Note:** Please preview the entire video and pre-work the solutions in order to anticipate students’ needs, misconceptions and materials unique to your classroom.

You will also need to determine the background knowledge of your students regarding the following topics, and decide the best method for providing that background in order to support the conceptual understanding of the mathematics shown in the video.

* Formulas
* Variables
* Percentages
* Scale Factor

**Common Core Mathematical Content Standards**

* 6.EE.2 Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real world problems.

**Common Core Mathematical Practice Standards**

1. Make sense of problems and persevere in solving them.

2. Reason abstractly and quantitatively.

3. Construct viable arguments and critique the reasoning of others.

**Company Information**

At Pierce Manufacturing, we build trucks that live up to your demands. It’s not some nine-to-five-go-home-and-forget-about-it kind of thing. Too much rides on what you do. To our team, there is no room for anything less than the absolute best.

What [began in 1913](https://www.piercemfg.com/Pierce/History?hsLang=en-us), building truck bodies on Model T Ford chassis in an old converted church, has evolved to creating highly customized, carefully designed and engineered [pumpers](https://www.piercemfg.com/products/products-overview/pumpers?hsLang=en-us), [aerials](https://www.piercemfg.com/products/products-overview/aerials?hsLang=en-us), [tankers](https://www.piercemfg.com/products/products-overview/tankers?hsLang=en-us) and [rescue units](https://www.piercemfg.com/products/products-overview/rescues?hsLang=en-us) that have no equal.

Behind every Pierce truck is a team of professionals whose mission is to build your truck, exactly how you ordered it. To us, every step of the process is personal; from innovation and expertise, to the customization and service. When the best people you know are the very people you serve, there is only room for exceptional.

**Summary**

The fire truck is a piece of machinery that is called on to help with life-saving work. It is critical that it performs flawlessly. To do this, engineers need to make sure that the size of the engine can provide enough power for all the important truck systems. This video will ask students to determine if a requested fire truck engine size will work for a customer’s request.

**Pre-Activity Discussion:**

* Vocabulary
  + Water Pressure in pounds per square inch
  + Flow rate in gallons per minute
  + Horsepower
  + Efficiency

**Differentiation:**

* The questions on the student handout are scaffolded to meet the needs of students who may need extra support.
* Eliminating some of the added questions, and just posing the questions from the video would be a possible differentiation strategy for students who do not need the extra support.
* Students may also benefit by working with others as part of a partner/group investigation.

**Part 1: (0:00 – 1:26)**

BREAK 1

* Problem posed: *Does our 450 horsepower fire truck engine have enough power to handle a 2000 gal/min water pump?*
* Have students use part one of student handout to document the formula and measurements given in Part 1 of the video.
* Information given
  1. Horsepower (HP) = PQ/(1714 • E)
  2. 1714 represents the *numeric scale factor* needed so we can obtain the pump power in HP if we have the pressure in psi units and the flow rate in gallons per minute. This is an approximate number used in engineering calculations.
  3. Desired horsepower = 450
  4. P = desired pressure = 150 pounds per square inch (psi) (required by NFPA)
  5. Q = desired flow rate = 2000 gallons per minute
  6. E = efficiency = 60%
* Students are asked to calculate the horsepower needed, and make a decision on the student handout.
* Before showing Part 2 have students share their answers and problems solving methods.

**Part 2: (1:29 – 1:59)**

BREAK 2

* Discuss the solution from Part 1 and any calculation errors or misconceptions
* Problem posed: *Does our 450 horsepower fire truck engine have enough power to handle a 2000 gal/min water pump as well as the other important truck systems?*
* Information given
  + Horsepower is needed to run other important parts of the firetruck (air compressor, cooling system, alternator)
  + 20% of the engine’s 450 total horsepower should be allotted to run the other fire truck systems.
* Students are asked to answer the question on the student handout.
* Before showing Part 3 have students share their answers and problems solving methods.

**Part 3: (2:30 –** **3:23)**

* Discuss the solution from Part 2 and any calculation errors or misconceptions.

**Extension:**

* Investigate the history of horsepower, and some other applications of it.
* Investigate the origin of the scale factor 1714 in the field of engineering (hint – NASA used it!)
* Investigate water pressure, flow rate and the force exerted on the object being doused. If pressure is increased, how much water could be conserved? If pressure is increased does the water cause too much damage to the object?
* Find the flow rate common water sources, such as kitchen sink, water fountain. Collect for 10 seconds, measure the water collected and then convert to gal/min How do you think Pierce confirms their 2000gpm flow rate?
* Investigate the connection between temperature and horsepower. Do our cold Wisconsin winters affect the horsepower available to power the fire truck? What about very warm temperatures?

**Student Handout - *What does fire truck horsepower have to do with math?***  Name(s):

**Pre-Video Discussion:**  *Notes on important background information.*

**Problem:** *Does our fire truck engine have enough horsepower to handle a 2000 gal/min water pump?*

**Break 1:**

1. What measurements are given to you in the video?

2. What is the formula you will be using and what do each of the variables represent?

3. Use the formula to determine if the 450 horsepower engine will be enough to pump 2000 gallons per minute. Justify your reasoning.

**Break 2:**

4. Calculate the amount of horsepower available for the water pump given that there are other important systems that need power too?

5. Using your previous answers, will the 450 horsepower engine have enough power to pump the water and run all the other truck systems? Why?

**ANSWER KEY – What does fire truck horsepower have to do with math?**

**Problem:** *Does our fire truck engine have enough horsepower to handle a 2000 gal/min water pump?*

**Break 1:**

1. What measurements are given to you in the video?

**1714 represents the *numeric scale factor* needed so we can obtain the pump power in HP if we have the pressure in psi units and the flow rate in gallons per minute. This is an approximate number used in engineering calculations.**

**Desired horsepower = 450**

**P = desired pressure = 150 pounds per square inch (psi)**

**Q = desired flow rate = 2000 gallons per minute**

**E = efficiency = 0.6**

1. What is the formula you will be using and what do each of the variables represent?

**Horsepower (HP) = PQ/(1714 • E) See above**

1. Use the formula to determine if the 450 horsepower engine will be enough to pump 2000 gallons per minute. Justify your reasoning.

**HP = ((150)(2000)) / ((1714)(0.6))**

**HP = 292**

**Break 2:**

1. Calculate the amount of horsepower available for the water pump given that there or other important systems that need power too?

**(450)(0.8) = 360**

1. Using your previous answers, will the 450 horsepower engine have enough power to pump the water and run all the other truck systems? Why?

**Yes, 360 HP > 292 HP**