**What do Fire Truck Axle Weights have to do with math?**

**Video:** [**https://youtu.be/nCeL58SPjoY**](https://youtu.be/nCeL58SPjoY)

**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.

* Order of Operations
* Formulas

**Common Core Mathematical Content Standards**

* 6.NS.2 Fluently divide multi digit numbers using the standard algorithm.
* 6.NS.3 Fluently add subtract, multiply and divide multi digit decimals using the standard algorithm for each operation.
* 7.NS Apply and extend previous understandings of operations with fractions to add, subtract, multiply and divide rational numbers.

**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**

When a customer orders a fire truck from Pierce, they ask for specific equipment they want the truck to be able to carry. When engineers design the truck to the customer’s specifications, they need to be careful that the weight for all that equipment is not too heavy for the axles of the truck.

Axle weights are important for the following reasons. First of all, the suppliers of axles rate the carrying capacity of their axles so they don’t fail and that the brakes attached to the axle are sufficient.  The second reason is that the Federal Government requires an OEM – Original Equipment Manufacturer like Pierce to specify the rated axle capacities and they cannot be exceeded.

**Pre-Activity Discussion:**

* Vocabulary
* Axle - central pin, bar or shaft for a rotating wheel or gear.
* Center of Gravity – the point where the weight is balanced for that object
* Wheelbase – the distance between the center of the front axle wheel and the center of the rear axle wheel.
* Rated Axle Capacity – the maximum amount of weight allowed at the ground for a particular axle

**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 – 1:18)**

BREAK 1

* Information given – See summary above.
* Questions posed to students on the handout – *What do you think could happen if the weight on the axles is higher than the limit?*
* Discuss student ideas, and any misconceptions or questions.

**Part 2: (1:19 – 2:50)**

BREAK 2

* Problem posed: *Will the equipment that the customer ordered be too heavy for the front and/or rear axles of the standard fire truck?*
* Information given:
  + Maximum front axle rating is 12.000 pounds
  + Maximum rear axle rating is 20,000 pounds
  + Wheel base = 180 inches
  + Weight on rear axle = (weight of item x CG distance from front axle) / wheel base
  + Weight on front axle = weight of item – it’s weight on rear axle
* Students are given the information in the table in the video on the student handout and then asked to answer the problem posed.
* Before showing Part 3, have students share their answers and problem solving methods.

**Part 3: (2:53 –** **4:00)**

BREAK 3

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

**Extension:**

* Investigate the axle capacity for pickup trucks and/or semi-trucks.
  + Which models can carry higher weights?
  + Does this ability to carry more weight impact the price?
* Periodically, along interstate highways, there are facilities called “Weigh Stations”. Investigate their purpose.
* Do states have different rules about axle weights? Do axle weight limits vary by country?

**Student Handout - *What do Fire Truck Axle Weights have to do with math?***  Name(s):

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

**Break 1:**

1. What do you think could happen if the weight on the axles is higher than the limit? Explain.

**Break 2: Problem:** *Will the equipment that the customer ordered be too heavy for the front and/or rear axles of the standard fire truck?*

2. List the information and formulas given in the video.

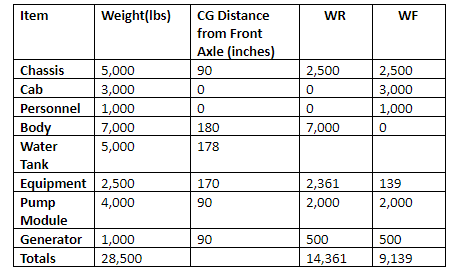
3. Use the information from #1 above and the table below to help you calculate the front and rear axle weights*. (Hint: calculate the weights on the rear axles first because your answers will be needed to find the weights on the front axle.)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Weight**  **(lbs.)** | **CG Distance**  **from front axle (inches)** | **Weight on Rear Axle**  **(lbs.)** | **Weight on Front Axle**  **(lbs.)** |
| **Chassis** | **5,000** | **90** |  |  |
| **Cab** | **3,000** | **0** |  |  |
| **Personnel** | **1,000** | **0** |  |  |
| **Body** | **7,000** | **180** |  |  |
| **Water Tank** | **5,000** | **178** |  |  |
| **Equipment** | **2,500** | **170** |  |  |
| **Pump Module** | **4,000** | **90** |  |  |
| **Generator** | **1,000** | **90** |  |  |
| **Total** |  |  |  |  |

4. Will the equipment that the customer ordered be too heavy for the front and/or rear axles of the standard fire truck? Why or Why not?

**Answer Key *What do Fire Truck Axle Weights have to do with math?***

\*\* NOTE: Students should calculate the rear axle weight first because that number is needed in order to calculate the weight on the front axle.



**Both the front and rear totals are less than the maximum weight rating, so yes the customer’s order will work with the standard truck.**