ACTIVITY: Calculate Horsepower

Grade Level: Prealgebra or algebra

Introduction

In this mathematics activity, students will investigate how the unit of horsepower came to be and how it is used today. They will investigate the horsepower of an engine in a modern vehicle of their choice and solve equations using this unit of power.

Objectives

Students will:

- solve the formula for power for different variables
- use the relationship that one horsepower equals 550 foot pounds per second to convert from horsepower to power
- perform calculations using the formula and the converted units

Time Frame

- 45 minutes for the activity
- Pre-activity homework assignment for gathering horsepower information

Materials

- Solving Horsepower worksheet, duplicated for each student

Procedure

Prior Knowledge

1. Students should be familiar with the scientific units of force, work, and power.
2. Ask students to describe where they have heard the term horsepower used. (When describing engines such as those in a vehicle, lawnmower, chainsaw, or vacuum cleaner.)
3. Ask students to relate what they think horsepower is. (A unit of power: the rate at which work can be done.)
4. Share with students the story of how the unit of horsepower came to be: In the 1770's, Scottish engineer James Watt developed a new kind of steam engine. He figured that the best way to sell it was to compare it to the power of the most familiar "engine" at the time—the horse. To quantify the rate at which a horse could do work, he set one up with a rope and pulley to lift a load. He calculated that a horse was strong enough to lift a weight of 550 pounds the height of 1 foot in 1 second. Watt defined that quantity—550 "foot-pounds" per second—as one horsepower:

   1 horsepower = 550 foot-pounds/second

Parts of this activity were adapted from "Calculating Human Horsepower" by Pam Cox and Linda Bridges in Mathematics Teacher, March 1999

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Exploration

5. Have students choose a make and model of a vehicle and research its engine's horsepower. They can investigate the specifications of their family's vehicle, or use advertisements or the internet to find details on a vehicle of their choice.

6. Have students complete the calculations on the worksheet Solving Horsepower.

Wrap-Up

7. If students realize their correct answers to questions 5, 6, and 7 sound a bit unrealistic in terms of the force, the distance, and the time it would take a car to pull a load, remind students that horsepower is a measure of the power of the engine, not the car wholesale. Consider that the car chassis has weight and the tires create friction: there are a number of factors that reduce the actual performance of force, distance, and time if that engine is powering a car pulling a load.

8. Have students consider their results and discuss how and why engines revolutionized the work that horses did during James Watt's day. (A single engine could do many times the work of a single horse, etc.)

Extension

9. Students may inquire about the unit watts, which was named after James Watt. Explain that a watt, like horsepower, is a unit of power. One horsepower is equivalent to 746 watts. That means if a 1-horsepower horse walked a treadmill, it could operate a generator to produce a continuous 746 watts (That is, until it tired—it would be difficult for a horse to exert that much power for a whole working day). Ask: How many 40-watt light bulbs could that horse's power light up? (18.65)

Answer Key

1. $F = \frac{pt}{d}$ 2. $d = \frac{pt}{F}$ 3. $t = \frac{dF}{p}$

4. Say their vehicle's horsepower is 160 hp. Answer is:

$$\frac{(160 \text{ hp}) \times (500 \text{ ft-lbs/sec})}{1 \text{ hp}} = 88{,}000 \text{ ft-lbs/sec}$$

(This hypothetical quantity is used to solve questions 4, 5, and 6 to show procedure. Actual student answers will vary based on their vehicle's horsepower.)

5. $F = \frac{pt}{d} = \frac{(88{,}000 \text{ ft-lbs/sec}) \times (60 \text{ sec})}{300 \text{ ft}} = 17{,}600 \text{ lbs}$ (based on 160 hp engine)

6. $d = \frac{pt}{F} = = \frac{(88{,}000 \text{ ft-lbs/sec}) \times (240 \text{ sec})}{275 \text{ ft}} = 76{,}800 \text{ lbs}$ (based on 160 hp engine)

7. $t = \frac{dF}{p} = = \frac{(625 \text{ lbs}) \times (200 \text{ ft})}{88{,}000 \text{ ft-lbs/sec}} = 1.42 \text{ sec}$ (based on 160 hp engine)

Solving Horsepower Worksheet

Name: _____ Date: _____

d = distance (ft) F = force (lbs) t = time (sec) p = power (ft-lbs/sec)

Formula for power: $p = \frac{dF}{t}$

1 horsepower (hp) = 550 ft-lbs/sec

Directions

Step 1: Solve the formula for different variables

1. Solve the formula for power for force.

2. Solve the formula for distance.

3. Solve the formula for time.

Step 2: Apply the formulas above using your car's horsepower:

Make and model of vehicle: _____ My vehicle has _____ horsepower.

4. Use your car's horsepower to calculate how much power it has.

5. How many pounds of force could your vehicle's engine apply through a distance of 300 feet in 1 minute?

6. Say your vehicle's engine applies 275 pounds of force in 4 minutes. Through what distance would it be applied?

7. How much time would it take for your vehicle's engine to apply a force of 625 pounds through a distance of 200 feet?