NUMB3RS Activity: Energy
Episode: "Burn Rate"

Topic: Solving Equations **Grade Level:** 9 - 10
Objective: Solve for an unknown value in an equation.
Time: 15 minutes
Materials: TI-83 Plus/TI-84 Plus graphing calculator

Introduction

In "Burn Rate," Charlie helps the FBI investigate a series of mail bombings with seemingly unrelated targets. Charlie explains "explosions are all about physics and math: burn rates, brisance and pressure waves." He compares the bomb to a hand hitting a table set for a meal. "By the way objects are displaced, I can tell you the size of the hand, how tight the grip, or how much energy was imparted on impact; just like I can analyze what kind of bomb we're looking at here." In this activity, students will use radical equations to solve problems about energy.

A thorough background solving radical equations is not necessary, but student will need to understand the meaning of the square root of a number and determine how to isolate a variable within a square root. Examples are given below. The equation given in the activity is hypothetical, but was developed from the laws of physics. Brief explorations of unit analysis and the development of the formula are included in the extension section.

Discuss with students

A comfort level with square roots will help students solving the equations in this activity. In this activity, we will only be concentrating on positive square roots. The examples below can serve as a warm up investigation.

1. Solve $x = 2 + \sqrt{9}$
2. Solve $5 = \sqrt{x}$
3. Solve $20 = 12 + 2\sqrt{2x}$

Discuss with students Answers:
1. *x = 5* **2.** *x = 25* **3.** *x = 8*

Student Page Answers:
1a. *.05 kg* **1b.** *4000 joules* **2a.** *average person swinging baseball bat* **2b.** *bullet traveling at 900 m/s* **2c.** *1 gram of TNT* **2d.** *kinetic energy of a car at highway speed* **2e.** *1 kg of TNT* **2f.** *lightning bolt* **2g.** *annual power use of one clothes dryer* **2h.** *energy consumed by average automobile in US* **2i.** *eruption of Krakatoa* **3a.** *shorter* **3b.** *4 m* **4a.** $d = 16/(625m^2)$ **4b.** *40 m; 3 m* **4c.** *when the mass doubles, the distance is cut by a factor of 4*

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Name ____ Date _______________

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In “Burn Rate,” Charlie helps the FBI investigate a series of mail bombings with seemingly unrelated targets. Charlie explains “explosions are all about physics and math: burn rates, brisance and pressure waves.” He compares the bomb to a hand hitting a table set for a meal. “By the way objects are displaced, I can tell you the size of the hand, how tight the grip, or how much energy was imparted on impact; just like I can analyze what kind of bomb we're looking at here.” In this activity, students will use radical equations to solve problems about energy.

The equation below gives a relationship between the energy E of a certain bomb, the mass m of a particle in the bomb, and the distance d the particle travels. Energy is measured in joules (kg m^2/s^2), mass is measured in kilograms and distance is measured in meters. The constant of 25,000 arises from physics formulae. The physics principles and a unit analysis are presented in more detail in the extensions section.

$$E = 25{,}000m\sqrt{d}$$

1. A piece of shrapnel weighing 50 grams is found 10 meters from the site of the bomb.

a. Determine the value of m, remembering mass is measured in kilograms.

b. Calculate E, the energy of that portion of the bomb.

2. To get a sense of the size of a joule, match each item below with its energy level.

Energy level, in joules	**Item**
a. 80	lightning bolt
b. 1,400	kinetic energy of a car at highway speed
c. 4,000	energy consumed by average automobile in US in one year
d. 350,000	annual power use of one clothes dryer
e. $4(10^6)$	average person swinging baseball bat
f. $1.5(10^9)$	1 gram of TNT
g. $3.2(10^9)$	1 kg of TNT
h. $7.2(10^{10})$	eruption of Krakatoa
i. $1.5(10^{17})$	bullet traveling at 900 m/s

3. Using the energy level you determined in Question 1b, the equation for the situation presented earlier is $4{,}000 = 25{,}000m\sqrt{d}$. Recall that a 50 gram piece of shrapnel traveled 10 meters.

a. Should an 80 gram piece of shrapnel travel a longer or a shorter distance than the 50 gram piece?

b. Calculate the expected distance from the bomb of the 80 gram piece.

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4. **a.** Solve the equation $E = 25{,}000m\sqrt{d}$ for *d*. Check your rewritten equation by verifying that when *m* = 0.05 kg, d =10 m.

b. Calculate the distance a 25 gram piece will travel and the distance a 100 gram piece will travel.

c. Use the results of Question 4b to determine a rule about the distance a piece will travel when its mass is doubled.

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The goal of this activity is to give your students a short and simple snapshot into a very extensive math topic. TI and NCTM encourage you and your students to learn more about this topic using the extensions provided below and through your own independent research.

Extensions

- The original equation for energy is given below. Using the estimated values given, verify the equation $E = 25000m\sqrt{d}$ used in the activity, where a = 10°, g = 9.8 m/s^2, l = 0.1 m, and t = 0.0000107 s.

$$E = \frac{ml\sqrt{\dfrac{dg}{2t^2 \cos a \sin a}}}{2}$$

- The units of a joule are (kg)(m^2)/s^2. Verify that the equation below results in the correct units for energy, measured in joules, where E is energy, C is a constant, m is mass in kg, l is length in m, d is distance in m, g is acceleration of gravity in m/s^2, and t is time in s. This equation is an expansion of the one used in the activity.

$$E = Cml\sqrt{\frac{dg}{t^2}}$$

Additional Resources

- An online unit conversion tool can be found at **http://www.onlineunitconversion.com**.

- An introduction to solving radical equations is available at **http://www.purplemath.com/modules/solverad.htm**.

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