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**What does a Flushing Toilet have to do with Math?**

**VIDEO:** [**https://youtu.be/gYJS8sSo820**](https://youtu.be/gYJS8sSo820)

**Lesson Plan**

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

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

**Common Core Mathematical Content Standards**

* 6.RP.3d – Use ratio reasoning to convert measurement units, manipulate and transform units appropriately when multiplying and dividing quantities.
* 7.NS.3 – Solve real world and mathematical problems involving the four operations with rational numbers
* 7.EE – Use properties of operations to generate equivalent expressions and solve real life problems using numerical and algebraic expressions and equations.

**Common Core Mathematical Practice Standards**

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

2. Reason abstractly and quantitatively.

6. Attend to precision.

**Company Information**

Since 1873, Kohler Co. has been improving the level of gracious living by providing exceptional products and services for our customers’ homes and their lifestyles.  We believe better business and a better world go hand-in-hand. [Watch Our World video](https://www.youtube.com/watch?v=wU7sb6UZmS4&rel=0). Whether that is beautiful [kitchen and bath products](https://www.us.kohler.com/us/), [innovative engines and generators](https://power.kohler.com/en/engines), [memorable hospitality offerings](https://www.americanclubresort.com/) or developing clean water, sanitation, and community development solutions around the world. To put it simply, we strive to enhance the quality of life for current and future generations through design, craftsmanship and innovation and fueled by the passion of more than 36,000 associates worldwide.

**Summary**

What is one things that you use every day that does not require electricity?...A toilet! How are formulas, rates and ratios used to determine toilet tank water levels with each flush? You will explore the math and science behind the flushing action of a toilet, a simple machine that we depend on so much!

**Pre-Activity Discussion:**

* How does a toilet work?
	+ The first part of the video discusses this process, but activating a student’s prior knowledge will be helpful.

**Summary of information presented in video**

* Tank length (L) = 36.73 cm
* Tank width (W) = 17.73 cm
* Upper water line height (UWL) = 20.62cm
* Actual water in tank (water used in a flush – ATW) = 1.28 gal per flush
* 1 gal of water = 3,785 cubic centimeters
* Formula for lower water level of tank: LWL  = UWL – $\frac{V}{L x W}$ (V = volume of the FLUSH)

**Differentiation:**

* The formula above is included on the student handout. Eliminating the formula and having students construct it on their own would be one possible differentiation method.
* Using unit analysis during the solution process can provide support and confirm solution methods.
* Students may also benefit by working with others as part of a partner/group investigation.

**Part 1: (0:00 – 1:20)**

BREAK 1

* Discuss the process of flushing a toilet. – Here is a transcript of what was presented in the video.
	+ *When you press down on the toilet handle, it lifts up a flush valve in the tank. As the valve opens, the water inside the tank rushes out into the bowl. A float that rides on the surface of the water inside the tank then lowers as the tank is flushed. When the float drops as low as it can go, it opens up a gate inside the fill valve which lets clean water enter into the tank until the float reaches a set level and shuts off the fill valve so the tank does not overflow.*
* Ask - What was surprising to you? What was different than you expected? Misconceptions?
* Brainstorm the math and science that may be involved in the mechanics of “the flush”

**Part 2: (1:23 – 2:29)**

 BREAK 2

* Problem posed: *What is the lower water level (LWL) in the toilet tank?*
* Discuss the problem that we are being asked to solve.
* What are the things we need to figure out? Do we have all the information we need? If not, what else do we need?
* Information given in the video
	+ Tank length (L) = 36.73 cm
	+ Tank width (W) = 17.73 cm
	+ Upper water line height (UWL) = 20.62cm
	+ Actual water in tank (water used in a flush – ATW) = 1.28 gal per flush
	+ 1 gal of water = 3,785 cubic centimeters
* Have students use Part 2 of student handout to document their discussion and solution.
* Before showing Part 3 have students share their answers and methods.
* Discuss any errors or misconceptions in student thinking and calculations

**Part 3: (2:34 –** **3:15)**

* The answer is presented.
* Students are challenged to find out more about the math and science behind “the flush”
* Bonus question: How much does the water level go down in the tank when the toilet is flushed? (7.44cm)

**Extension questions:**

* How does gravity play a pivotal role in toilet operations?
* Do all toilets work the same way?
* What is potential energy?
* What is kinetic energy?
* How could engineers increase the potential and/or kinetic energy of water?
* Pull apart and analyze the formula that was given. Why does it work for this situation?

**Student Handout - *What does a Flushing Toilet have to do with math?***

Name(s):

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

**Break 1:**

List some of the math and science that you think may be involved in the mechanics of “the flush”

**Break 2:**  Problem: *What is the lower water level (LWL) in the toilet tank?*

Formula: LWL  = UWL – $\frac{V}{L x W}$ (V = volume of the FLUSH)

**Bonus question:** *How much does the water level go down in the tank when the toilet is flushed?*

**ANSWER KEY – What does a Flushing Toilet have to do with Math?**

**Break 1:**

Answers Vary

**Break 2:** Problem: *What is the lower water level (LWL) in the toilet tank?*

Formula: LWL  = UWL – $\frac{V}{L x W}$ (V = volume of the FLUSH)

Volume of water per flush (V)

Our toilet uses 1.28 gal per flush

1 gallon = 3785.41 cubic centimeters so 1,28 gallons = 4848.32 cubic cm per flush

Length x Width = 651.22 sq cm

Upper water level is 20.62 cm

Lower water level = 20.62 cm – (4848.32 cu cm / 651.22 sq cm)

 = 20.62 cm – 7.44 cm

 = 13.18 cm