**What does Blowing Snow have to do with math?**

**Video:** [**https://youtu.be/0zAfJHwCGak**](https://youtu.be/0zAfJHwCGak)

**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.

* Percentages
* Order of Operations
* Sine ratio (calculate the sine value of an angle using a calculator)

**Common Core Mathematical Content Standards**

* 7.RP.3 - Solve multistep ratio and percent problems.
* G-MG - Apply geometric concepts in modeling situations.
* High School Modeling Standard

**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**

Ariens Company is a Brillion, Wisconsin-based equipment company which manufactures snow blowers, lawn mowers, and other “chore products” for commercial and high-end consumer markets. This four-generation company has a long history and touts itself as being the “mower of the White House lawn” and “official snow blower of Lambeau Field”.

**Summary**

As all Wisconsinites know snow blowers are an important tool to help us dig out from one of our many winter snow storms. It is also important that that snow blower throw the snow far enough away so that we are not wasting time by moving it more than once. Less time out in the cold, means more time inside drinking hot cocoa and watching Packer football. Thanks to Ariens company for understanding our Wisconsin winter needs!

**Pre-Activity Discussion:**

* Vocabulary
	+ Projectile Motion
	+ Velocity
* Depending on the high school course in which this video is being used, there are two projectile motion diagrams available to use as you open the lesson with students. The simpler one is used in the video.

**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 – 0:37)**

BREAK 1

* Have students brainstorm what information they might need about the snow thrower in order to determine if it is capable of throwing snow a distance of at least 40
* Have students use Part 1 of student handout to document their discussion.
* Share ideas whole group

**Part 2: (0:40 – 2:15)**

 BREAK 2

* Discuss any errors or misconceptions in student thinking and calculations from Part 1.
* Information given in the video
	+ Projectile motion diagram (see teacher answer key)
	+ Formula for the horizontal distance the projectile travels, Range (R) = $\frac{u^{2}sin2θ}{g}$
		- *u* = exit velocity of the snow in feet per second (68ft/sec)
		- Θ = theta, the exit angle of the snow in degrees (51 degrees)
		- *g* = gravitational constant (-32 feet per second2 …but for this calculation use the absolute value of -32. So, 32)
* Students will calculate the horizontal distance the snow will travel on the student handout.
* Before showing Part 3 have students share their answers and problem solving methods.
* Students are asked if their answer seems reasonable. It should not.
* Ask students: “What could be we be forgetting about? What are other factors that could determine how far the machine can throw the snow?”

**Part 3: (2:17–** **3:41)**

BREAK 3

* Discuss any errors or misconceptions in student thinking and calculations from Part 2.
* Information given in the video
	+ Three things that reduce the horizontal distance the snow can travel.
		- The two that reduce the fan’s ability to push the snow at the maximum velocity, therefore changing the value of *u (exit velocity)* in the range formula
			* Engine working to move the fan given the weight of the snow – 30%
			* Engine working to move the machine’s wheels forward – 10%
		- The last one changes the overall distance or range the snow travels and will be calculated in Part 4
			* Air resistance acting on the snow exiting – 15%
* Students will calculate the revised R, horizontal distance the snow will travel without air resistance, on the student handout.
* Before showing Part 4 have students share their answers and problem solving methods.

**Part 4: (3:43 – 4:17)**

BREAK 4

* Discuss any errors or misconceptions in student thinking and calculations from Part 3
* Students will calculate the final value of R, horizontal distance the snow will travel *with* air resistance, on the student handout.
* Before showing Part 5 have students share their answers and problem solving methods.

 **Part 5: (4:19 – 4:41)**

* Discuss any errors or misconceptions in student thinking and calculations from part 3

**Extension:**

* Experiment with the chute angle, how does increasing it or decreasing it effect the horizontal range of the snow blower?
* Explore the origins of the projectile motion formula that was given on the problem. Where did it come from? Why does it work?
* Write a mock blog post that compares and contrasts the 9 Ariens snow blowers that are shown on their company website. PDF’s of the various owner’s manuals are available online to help with the technical information about each one.

**Student Handout - *What does injection molding have to do with math?***  Name(s):

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

**Problem:** *Can the snow blower throw snow a distance of at least 40 feet?*

 **Break 1:**

1. What information will you need to have about the snow thrower in order to determine if it is capable of throwing snow a distance of at least 40 feet?

**Break 2:**

* Formula for the horizontal distance the projectile travels, Range (R) = $\frac{u^{2}sin2θ}{g}$

2. Calculate the horizontal distance the snow will travel as it comes out of the chute. Show your work.

3. Does your answer seem reasonable? Why or why not?

**Break 3:**

4. Consider the three factors that were stated video. Which part of the range formula is affected by each of the factors?

5. Recalculate the range the snow can be thrown using the new exit velocity.

**Break 4:**

6. Calculate the final distance the snow can be thrown. Does the snow blower meet the 40 foot expectation?

**Answer Key – What does blowing snow have to do with math?**

**Problem:** *Can the snow blower throw snow a distance of at least 40 feet?*

 **Break 1:**

1. What information will you need to have about the snow thrower in order to determine if it is capable of throwing snow a distance of at least 40 feet?

Answers vary

**Break 2:**

* Formula for the horizontal distance the projectile travels, Range (R) = $\frac{u^{2}sin2θ}{g}$

2. Calculate the horizontal distance the snow will travel as it comes out of the chute. Show your work.

 682(sin (2•51)) / 32

 4624(.978) / 32

4522.272 / 32

141.321 feet

3. Does your answer seem reasonable? Why or why not?

 No, seems too far for a walk behind snow blower, over 47 yards

**Break 3:**

4. Consider the three factors that were stated video. Which part of the range formula is affected by each of the factors?

 The two that affect the exit velocity (*u*) are the weight of the snow and the forward motion of the wheels. The air resistance will affect the total range, R, or distance.

5. Recalculate the range the snow can be thrown using the new exit velocity.

 30% + 10% = 40 % reduction in velocity

 100% fan capacity - 40% reduction = 60% fan capacity

 68 feet/sec • 0.60 = 40.8 feet/sec exit velocity (after reduction for weight of snow & wheel propulsion)

 New horizontal distance R = 40.82 (sin(2•51)) / 32 = 50.9 feet

**Break 4:**

6. Calculate the final distance the snow can be thrown. Does the snow blower meet the 40 foot expectation?

100% of distance - 15% reduction = 85% of distance due to air resistance

 50.9 feet • 0.85 = 43.3 feet

 yes