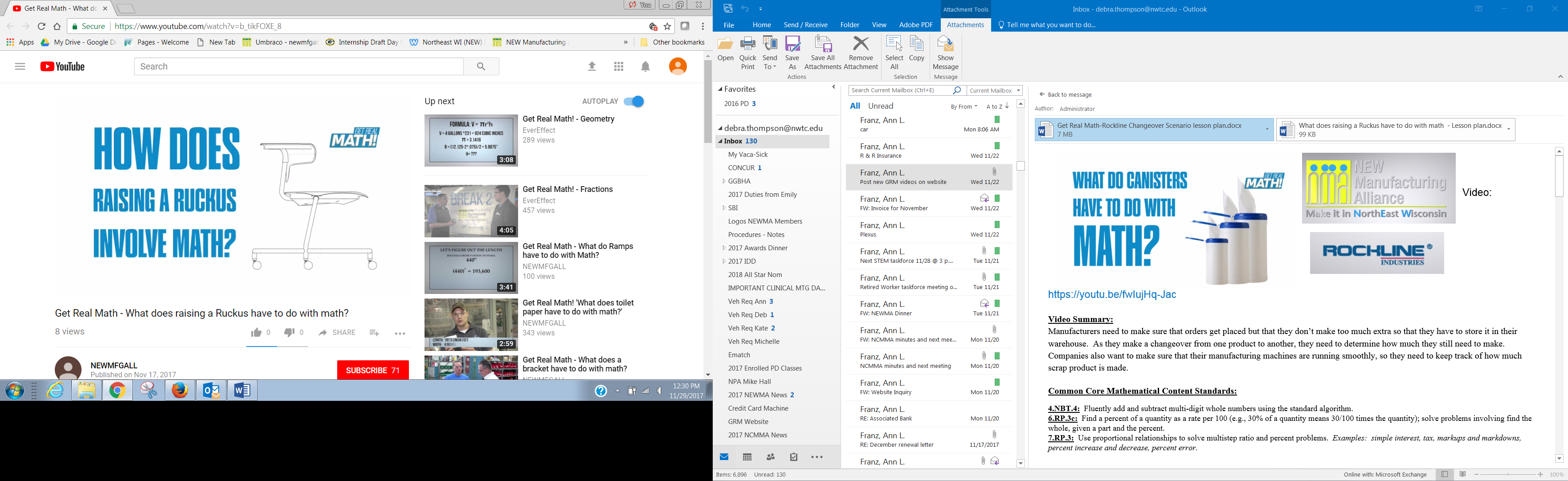
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**What does raising a Ruckus have to do with math?**

**VIDEO:** <https://youtu.be/gfJasQmq1B4>

**Lesson Plan**

**Teacher Note:** Please preview the entire video and pre-work the questions 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.

* + Solving two step equations
  + Integers
  + Forces
  + Equilibrium

**Common Core Mathematical Content Standards**

* 7.EE Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
* A-CED Create equations that describe numbers or relationships.
* N-VM Represent and model with vector quantities.
* High School Mathematical 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.

4. Model with mathematics

6. Attend to precision

**Company Information**

In 1941, when Krueger Metal Products, Inc. was founded, the war made resources scarce. Daily, founder Al Krueger would call on steel companies to purchase materials to make folding chairs. The scrap available determined what he could produce…a novel way of manufacturing.  Today, KI is still known for innovative manufacturing. What’s different is that innovation also includes the approach it takes with its workforce.

That approach helped the company expand its portfolio well beyond the folding chair. The Green Bay plant manufactures various seating products, Manitowoc focuses on architectural wall and panel systems, while Bonduel produces fixed seating and tables.

KI purposely cultivates a work environment that encourages employees to share ideas and try new things. During a shift, you won’t just see repetitive work at a single machine. Rather, employees also engage in all facets of the business – from cross-training in other cells to planning sessions and discussions with customers.

KI prides itself on mentoring the next generation of skilled workers. KI has partnered with local schools, supports both youth and adult apprenticeships, and supports continuing education for all employees. KI has entered into a unique partnership that pairs high school students with the company’s engineers to solve real-world manufacturing problems. During its busy summers, the company hires more than 400 students across its three plants.

That’s why KI’s tagline “Furnishing Knowledge” is so fitting…it offers far more than furniture.

Learn More About KI Manufacturing <QR CODE to manufacturing video: <https://www.youtube.com/watch?v=huFCL-7S42s&t=26s>>

**Summary**

Customer safety is a high priority for manufacturers. When designing a product, many prototypes are created and research is conducted to determine if the product is safe for customers. In the case of furniture, stability is a critical area to test. This video shows how mathematics and physics help to create a stable chair, and ultimately, keep customers safe.

**Pre-Activity Discussion:**

* In the first sentence of the video, a KI employee states, “The research for our new Ruckus chair has been going really well.” Discuss what kinds of things would have to be “researched” in order to design a chair.
* Discuss and identify forces/torques that may act on the chair and cause it to be unstable.
* **Vocabulary**
  + **Stability** - the ability of a body to restore to its original static equilibrium, after it has been slightly displaced.
  + **Equilibrium** - a state of rest or balance due to the equal action of opposing forces. When a condition of equilibrium exists, *all combined forces and/or torques are equal to zero.*
  + **Force** – something that causes a change in motion of an object.
  + **Moment of Force OR Torque** – a force that tends to cause rotation around a reference point like a fulcrum. *It is calculated by multiplying the force by the perpendicular distance from the force to the reference point (M = fd*). Increasing the distance to the fulcrum allows the same force to create a larger torque…like using your hand versus a wrench to loosen a bolt.
  + **Fulcrum** -the point on which a lever is supported and on which it pivots.
  + **CAD** – computer-aided design, the use of computer systems to aid in the creation, modification or analysis of a technical drawing or design.
  + **Free Body Diagram** – a diagram used to show the relative size and direction of all forces acting upon an object in a given situation.

**Differentiation:**

* The questions on the student handout are scaffolded to meet the needs of middle school students who may need extra support.
* Eliminating some of the added questions and/or just posing the question(s) from the video would be a possible differentiation strategy for students who do not need the extra support.
* A blank free body diagram of the Ruckus chair is given below.
* Students may also benefit by working with others as part of a partner/group investigation of this problem.

**Summary of Information needed to solve the problem posed in the video:**

* Moment of Force or Torque (M) = (force) x (distance to fulcrum)
* There are three forces acting on the chair
  + Vertical force the students is exerting
  + Horizontal force the student is exerting
  + Force at the center of gravity of the chair
* The rear caster is our fulcrum (labeled A)
* A person perched on the backrest of the chair is applying 135 pounds of vertical force and a horizontal force of 20 pounds in order to tip the chair.
* The weight of the chair is 25 pounds.
* The back of the chair has a height of 29.5 inches from the floor.
* The center of gravity of the chair is 11.4 inches forward of the backrest.
* The equation for this problem, based on the definition of torque is:

Sum of the Moments (torques) using “A” as the fulcrum

**=**

**(horizontal force)(vertical distance to A) + (vertical force)(horizontal distance to A) + (vertical force)(horizontal distance to A)**

Seat of the chair

Back of the chair

Back of the chair

* Because we want the chair to be stable or in a state of equilibrium, we want sum of the moments of the forces (torques) to equal zero.

**Part 1: (0:00 – 1:00)**

During BREAK 1

* Discuss the problem that we are being asked to solve. *(How far back from the backrest should the caster be placed to increase the stability of the chair under the given conditions?)*
* Revisit vocabulary and the formula for torque.
* Introduce the unlabeled Free Body Diagram of the Ruckus chair.
* Have students begin labeling the diagram with the information given in the video

**Part 2: (1:03 – 1:37)**

During BREAK 2

* Have students make corrections to any errors in the labeling of their Ruckus diagram and add the new dimensions that were given the video.
* Ask students to use the formula for torque and the diagram measurements to write and solve an equation with one unknown *(x= the horizontal distance from the back of the backrest that the caster should be placed)*
* Before showing Part 3, have students share their equations and solutions,

**Part 3: (1:41 – 2:45)**

* Solutions
* After showing the solutions, have students reflect on any errors in their thinking and calculations.

**Extension:**

* Use unit analysis to “prove” that the final answer should be in inches.
* A distance of 1.90625 inches from the back of the backrest was the distance we calculated. If the caster was placed at a distance of 2.3 inches from the backrest, what would be the vertical force a student could exert on the backrest of the chair? Do you think your answer will be greater or less than 135lbs? Find the solution and explain your result.
* Adjust the height of the backrest and/or the distance from the seat’s center of gravity to the backrest to create a chair that can handle150 pounds of vertical force on the backrest.

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

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

**Problem:** *How far from the back of the backrest does the caster need to be placed in order to stabilize the chair?*

**Break 1:**



**A**

**X**

**Break 2:**

Sum of the Moments (torques) using “A” as the fulcrum

**=**

**(horizontal force)(vertical distance to A) + (vertical force)(horizontal distance to A) + (vertical force)(horizontal distance to A)**

Back of the chair

Back of the chair

Seat of the chair



**A**

**X**

**Blank Diagram**



**ANSWER KEY – What does raising a Ruckus have to do with math?**



**(11.4 in + x)**

**X**

**29.5 in**

**20 lbs**

**13.5 lbs**

**25 lbs**