



Bring STEM Concepts to Life with this New Remote-Control Challenge

Objectives of the Webinar

- Learn how STEM and CTE work together through hands on learning opportunities
- Learn the parts and pieces of the Realityworks RC Tractor Pull Challenge
- Review methods for implementing this training tool to address key STEM concepts
- Acquire free resources for your classroom



Driving toward STEM Education through CTE

What is **STEM**?

S

SCIENCE

Observing,
experimenting,
making
predictions,
asking
questions



T

TECHNOLOGY

Being inventive,
using tools,
making things
work, identifying
issues, using
computers



E

ENGINEERING

Solving
problems,
using materials,
designing
and creating,
building



M

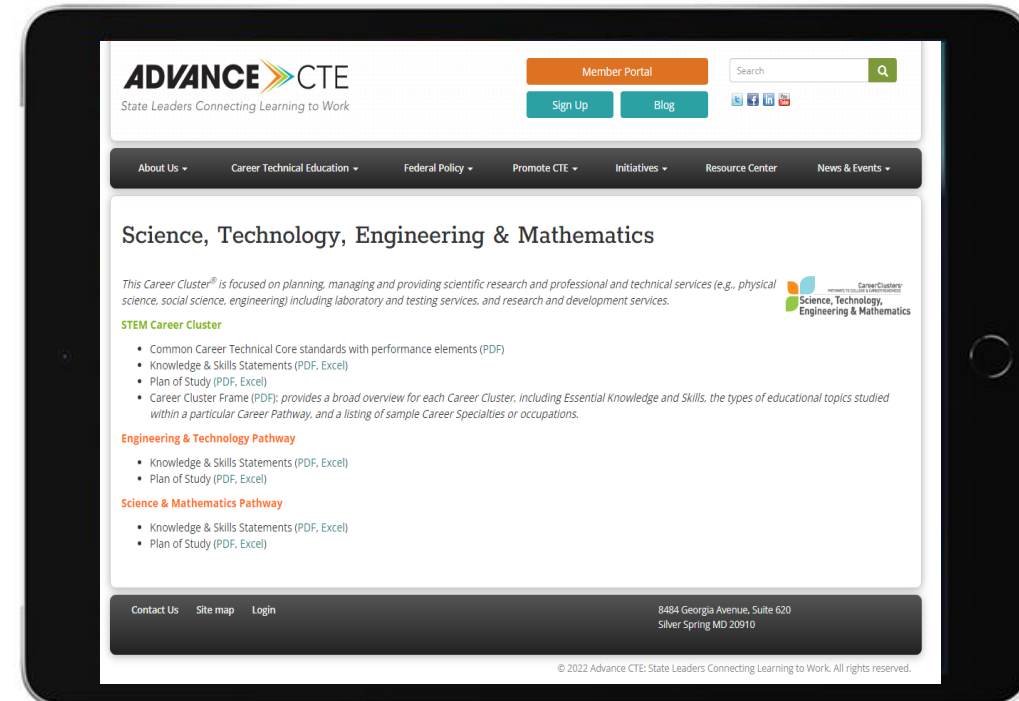
MATH

Patterning,
sequencing,
exploring shapes,
numbers,
volume and
size



- Helping to create critical thinking and problem solving to your classroom
- Bringing competition into your learning helps grow skill and understanding
- Engages learning in a new format and arena

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Courses that this product enhances?

- Agriculture
- STEM
- Trades
- Science

AGRICULTURE

- Exploratory / Introductory Agriculture Classes
- Agriculture Mechanics
- Agricultural & Field Management
- Agriculture Structures and Electronics

STEM:

- General STEM/ Introductory STEM
- Engineering Prep Classes
- Design and Engineering Principles

TRADES:

- General Trade Skills Course/ Introductory Course
- Simple Machines & Basic Mechanics
- FabLab Experience

SCIENCE:

- General Science
- Physical Science
- Physics
- Applied Science

RC Tractor Pull Challenge *with Pulling Sled*

Classroom Set of Tractors

- 5 Tractors
 - 5 RC Remotes (1 per tractor)
 - 5 batteries (1 per tractor)
 - Tractor weights (60 per tractor)
 - Pinion gears (2 per tractor)
 - Spur gears (3 per tractor)
 - Tractor Covers (1 per tractor)
- 1 pulling sled
 - 12 sled weights per tractor

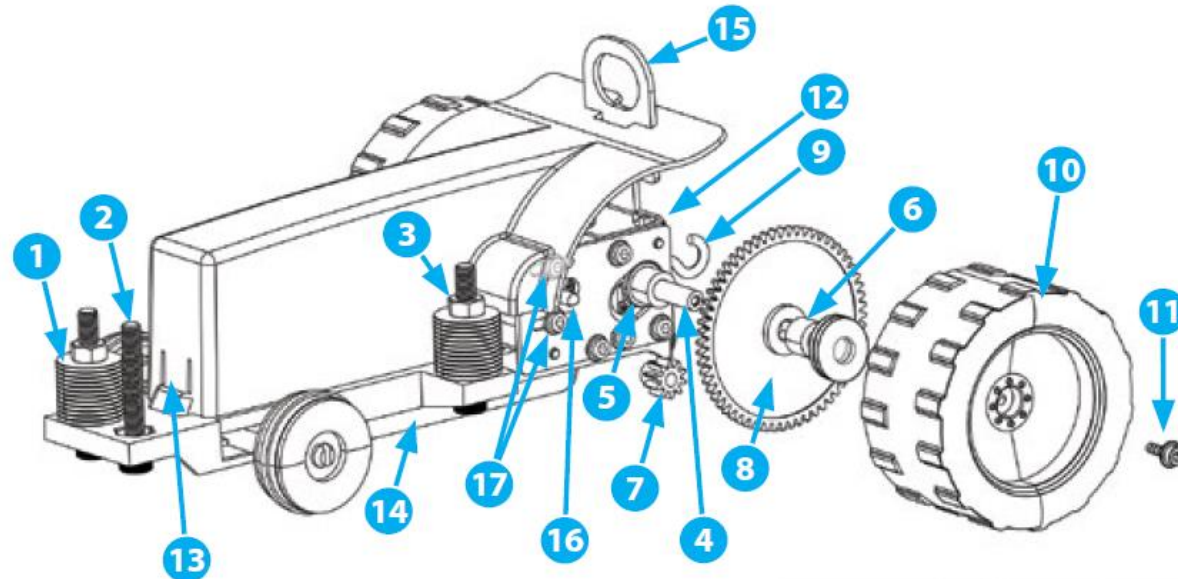


Each Tractor Includes Multiple Variables

Parts identification:

Tractor

- | | | |
|-------------------------|-------------------------------|----------------------------------|
| 1. Washer weights | 7. Pinion gear | 12. Tractor on/off switch |
| 2. Weight post | 8. Spur gear | 13. Tractor cover removal button |
| 3. Weight post nut | 9. Tow hitch | 14. Battery location |
| 4. Adjustable rear axle | 10. Rear tire | 15. Handle |
| 5. Axle bushing | 11. Rear tire bolt and washer | 16. Motor rod |
| 6. Axle locking collar | | 17. Motor mount adjustment screw |



Curriculum & Competition

Curriculum

Rules of Engagement

Curriculum Overview

- **Lesson 1: *Building & Inspecting the Tractor***
 - Getting set up, identifying the parts of the tractor
 - Weight distribution on the tractor (washer weight movement – 3 weight positions)
 - Drive gears, wheel gears and hitch height
 - Variable testing
- **Lesson 2: *Tractor Pull Testing***
 - First Pulls & Pulling Hypothesis
 - Weight distribution & data collection
 - Weight pulling – different amounts and distance
- **Lesson 3: *Testing the Data***
 - What data patterns come forward?
 - What variables matter?
 - Science behind drive gears, wheel gears, and tire diameter
- **Lesson 4: *Force and Friction***
 - Force – where is it coming from?
 - Resistance changes and pulling due to angles
 - Friction and the effect it has on a pull
- **Lesson 5: *Tractor Pull Challenge***
 - Use the data to create the best pulling tractor
 - Compete against all 5 tractors
 - Competition Trials

- Learn STEM concepts like:
 - *Scientific Process*
 - *Torque & Power*
 - *Friction*
 - *Force*
 - *Balance & Equilibrium*
 - *Center of Gravity*
 - *Gear Ratios*
 - *Data Collection*

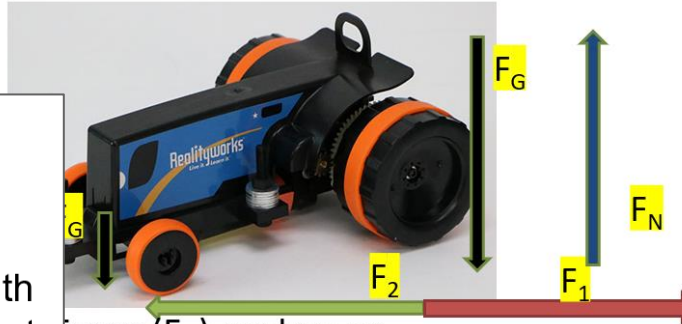
RC Tractor

Newton's 3rd Law

- When the tractor pushes against the ground (F_1), the ground pushes against the tractor (F_2). F_1 (push) = F_2 (friction)
- It's technically the friction pushing back on the tire that moves the tractor. Without enough friction, more force is useless.

Gravity and Normal Force

The total weight of the tractor is about 5 N split unevenly between the lighter front and heavier rear.



Force (F_N) pushes up
(F_G) pulls down.

Tractor Pull

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How Much Difference Do the Weights Make?



The weight in the middle (*blue*) also works like a lever, with the fulcrum at the front tire. This downward force applies a small downward force (*orange*) on the rear tires, slightly increasing the normal force (*purple*).

Is your data consistent with this explanation? Answer questions 1-2 on the worksheet

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Tractor Pull

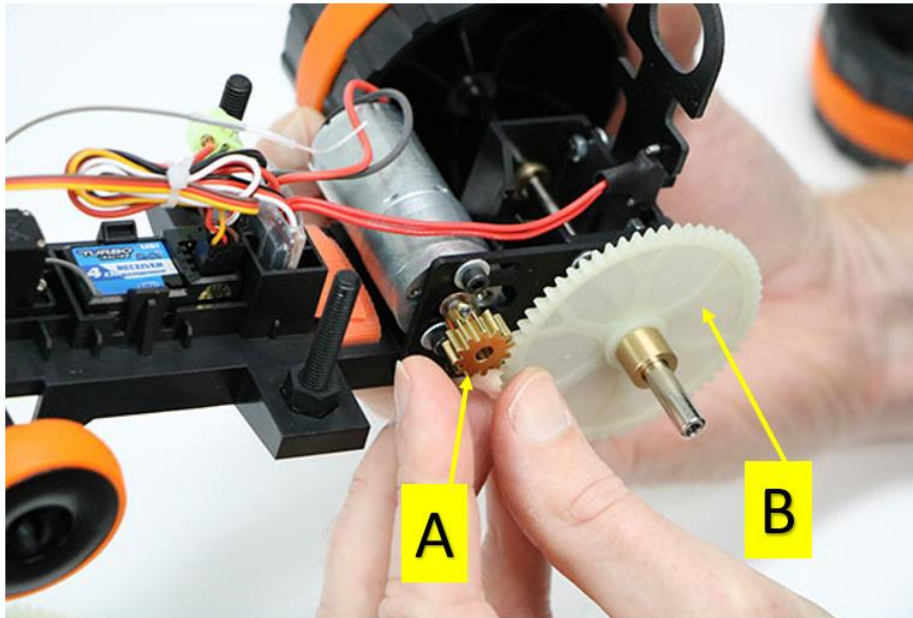
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Gears

A: 2 pinion gears adjusted with the small hex key
B: 3 spur gears (small and large) adjusted with the small hex key
C: **Gently** slide the gears on the motor rod and axle



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Tires

- Tires come in two sizes, small and large
- Adjust with the largest hex key



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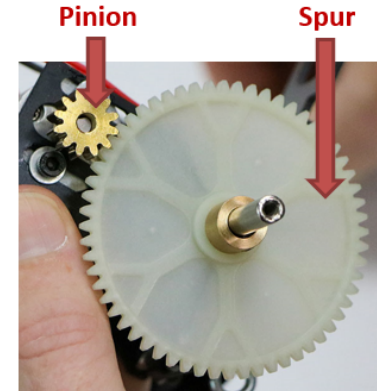
Mechanical Advantage

- The wheel/axle mechanical advantage
- $MA = \frac{r_1}{r_2}$ (r = resistance)
- These will all be < 1 , so not technically an advantage
- Calculate MA for each combo on worksheet



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Gears



Complete question 1 on the *Gears and Wheels* worksheet.

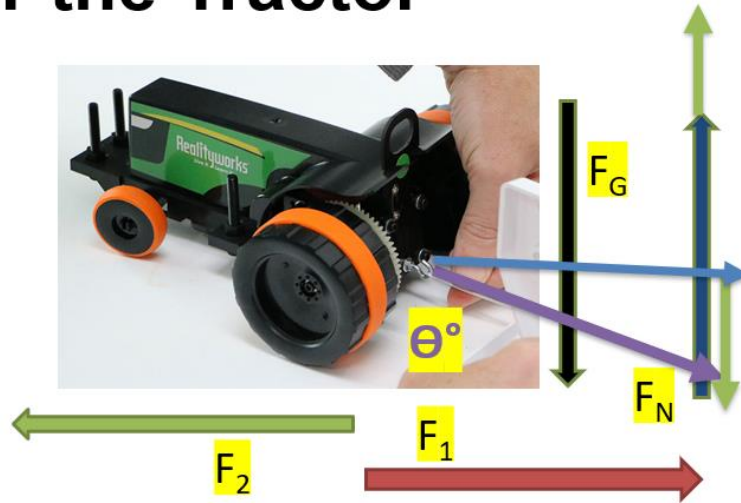
- $MA = \frac{\text{Teeth on spur gear}}{\text{Teeth on pinion gear}}$
- Example: A spur gear has 36 teeth. Which has a bigger MA (mechanical advantage), a 9-tooth or 12-tooth pinion gear?
- $MA = \frac{36}{9} = 4$
- $MA = \frac{36}{12} = 3$
- The 10-tooth pinion gear has the larger MA, meaning it will multiply the force more.

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For the Tractor

Now, the purple line is broken into green (down), which adds to the F_g and requires F_N

to increase by the same amount. This increases F_1 (Friction) and the F_2 (the push forward).



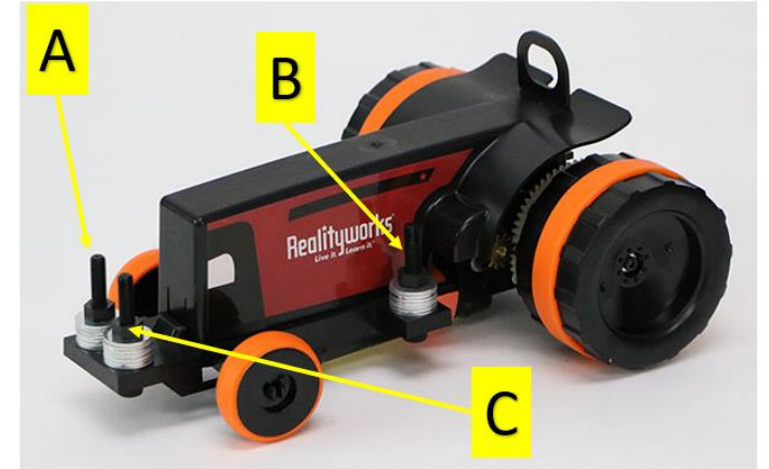
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Posts for Weights

A: 2 posts for weights in the front
B: 2 posts for weights in the middle

- 60 weights total
- Keep the tractor balanced (left to right)

C: Use the nuts to secure the weights



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Data Collection & Data Analysis

Physics of the Tractor Pull Curriculum

Name: _____ Class: _____

Divide and Conquer – Data Table

Directions: Place your data from all experiments in the table below.

Tires	Pinion Gear	Spur Gear	Hitch	Weights	Pull (m) and comments
Large	Small	Small	Low	Even	
<u>Small</u> ¹	Small	Small	Low	Even	
Large	<u>Large</u> ²	Small	Low	Even	
Large	Small	<u>Medium</u> ³	Low	Even	
Large	Small	<u>Large</u> ³	Low	Even	
Large	Small	Small	<u>Medium</u> ⁴	Even	
Large	Small	Small	<u>High</u> ⁴	Even	
Large	Small	Small	Low	<u>Front max</u> ⁵	
Large	Small	Small	Low	<u>Middle max</u> ⁵	
Large	Small	Small	Low	<u>None</u> ⁵	
<u>Small</u> ¹	Small	Small	High	Even	
Large	<u>Large</u> ²	Small	High	Even	
Large	Small	<u>Medium</u> ³	High	Even	
Large	Small	<u>Large</u> ³	High	Even	

Physics of the Tractor Pull Curriculum

Name: _____ Class: _____

Gears and Tires

Directions: Solve each problem as directed in the presentation.

- After slide 5, calculate the mechanical advantage for each of the possible gear combinations from lesson two using the data you collected in lesson one. Show your work.

Pinion Gear	Spur Gear	Mechanical Advantage
Small	Small	
Small	Medium	
Small	Large	
Large	Small	
Large	Medium	
Large	Large	

- After slide 7, if your electric motor spun at 180 rpm and 10 N of force, how fast (rpm) and forceful (N) would it turn the spur gear for each combination below? Show your work.

Pinion Gear	Spur Gear	MA from Q1	Force $\text{Force}_{\text{out}} = \text{MA} \times \text{Force}_{\text{in}}$	RPM $\text{Speed}_{\text{out}} = \text{Speed}_{\text{in}} / \text{MA}$
Small	Small			
Small	Large			
Large	Small			

Physics of the Tractor Pull Curriculum

- After slide 10, calculate the MA for each of our tire and axle combinations, using the data from lesson one.

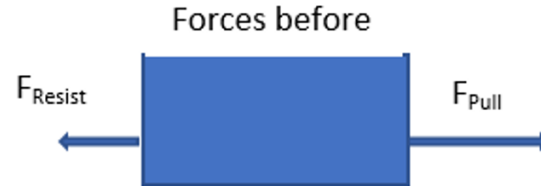
Tire Diameter	Spur Gear Diameter	MA $\text{MA} = D_{\text{in}} / D_{\text{out}}$
Small	Small	
Small	Medium	
Small	Large	
Large	Small	
Large	Medium	
Large	Large	

- After slide 12, if your small spur gear was turning with an edge speed of 0.25 meters per second and 4.0 N of force, (a) how fast and (b) with how much force would the small tire turn?
 -
 -
- After slide 15, (a) what is the MA for each of the combinations below? If the force applied from the pinion gear was 8 N and it spun at 3.0 m/s, (b) how much force and (c) how fast would the edge of the tire spin?

Pinion Gear	Spur Gear	Tire	(a) MA total $\text{MA}_T = \text{MA}_1 \times \text{MA}_2$	(b) Force out $F_o = F_{\text{in}} \times \text{MA}_T$	(c) Speed out $S_o = S_{\text{in}} / \text{MA}_T$
Large	Medium	Large			
Small	Large	Small			

STEM Concepts

Force Diagram of Sled: Start



The sled starts moving initially because the $\Sigma \text{Forces} = F_{\text{Pull}} - F_{\text{Resist}} > 0$. Or more simply,

$$F_{\text{Pull}} > F_{\text{Resist}}$$

What Is Friction?

- $F_{\text{Friction}} = F_{\text{Normal}} \times \mu$
- Technically, this is 2 different equations, 1 for static friction and 1 for kinetic friction.

$$F_{\text{Static Friction}} = F_{\text{Normal}} \times \mu_s$$

$$F_{\text{Kinetic Friction}} = F_{\text{Normal}} \times \mu_k$$
- For the tractor, we want to maximize friction (a.k.a. traction).
- For the sled, friction is our enemy (it slows the tractor down).

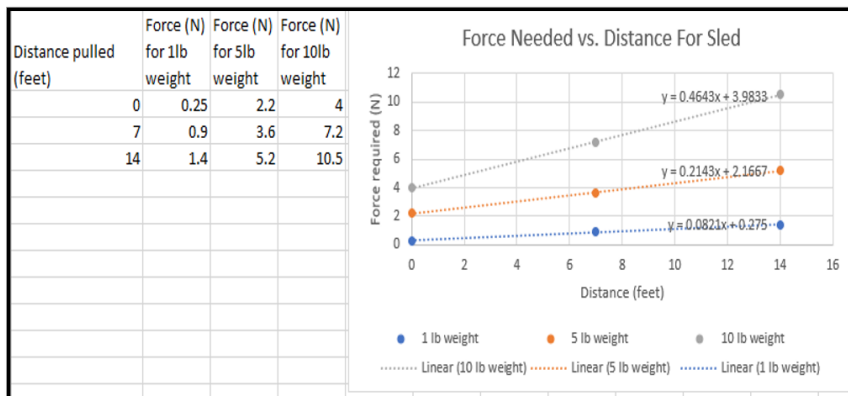
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Force Required To Pull the Sled at Various Distances



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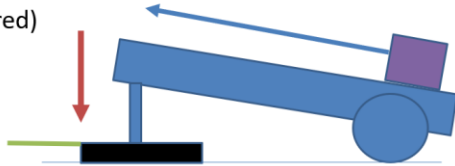
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Pulling Sled

How Does the Sled Change Its Resistance?

As the weight box (purple) moves up the rails, it increases the amount of downward force (red) on the skid plate (black)

The sled touches the ground at 2 points: The skid plate (black) and the wheel (blue)



Physics of the Tractor Pull

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How Does the Sled Change Its Resistance?

The skid plate (black) has friction and as the weight box (purple) moves over the skid plate, friction increases.

The wheels have very little friction, making the sled easy to pull with the weight box (purple) when over the wheels (blue).

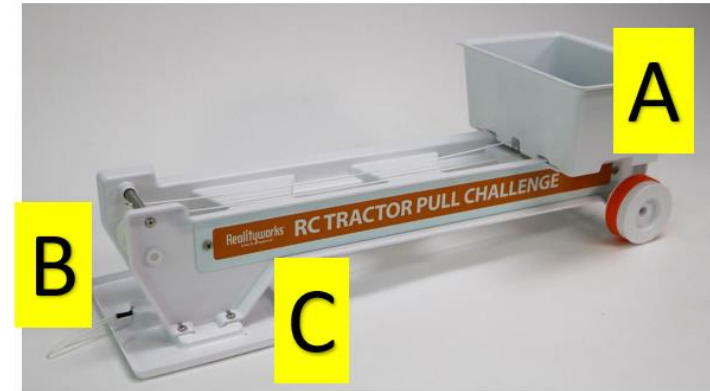


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Parts of the Model: Sled



A: Weight box (it moves towards B as the tractor pulls the sled)

B: Rope

C: Skid plate

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- Create competition by understanding the data and applying it to real world situations
- Help students learn through problem solving and goal setting activities

Competition

Competition Based Learning

C.E.R. Framework

- Claim: What statement or conclusion can you make?
- Evidence: What data and/or observations from the experiment can you use to support the claim?
- Reasoning: A direct link between the claim and evidence, often using a science idea

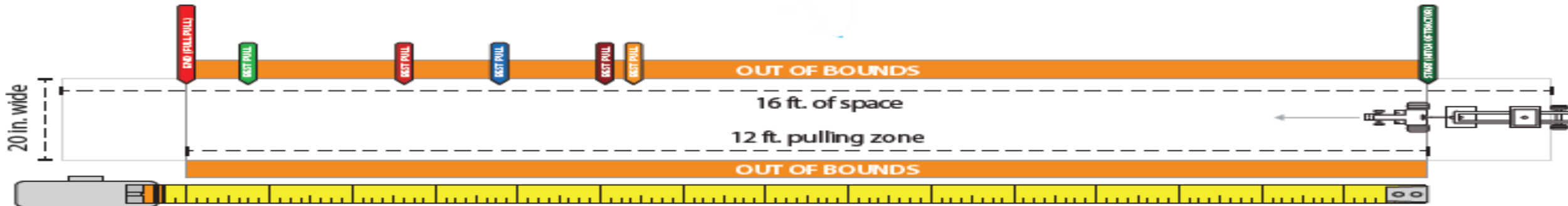
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- Create Learning Objectives for the Competition
- Set rules for the competition
- Allow for discussion and adjustments between competitions
- Reflect on what and why success and failures happened



Creating Analysis helps Competition

- STEM means research and analysis, including competition allows for different research and testing to be applied
- Collecting Data is good, analysis and using data is better!
- Help your students see results in their learning – the *AH HA* moments!

C.E.R. Group 1

Tires	Pinion Gear	Spur Gear	Hitch	Weights	Pull (m) and comments
<u>Large</u>	Small	Small	Low	Even	
<u>Small</u>	Small	Small	Low	Even	
<u>Small</u>	Small	Small	High	Even	
<u>Large</u>	Small	Small	High	Even	
C: E: R:					

Physics of the Tractor Pull

C.E.R. Group 2

Tires	Pinion Gear	Spur Gear	Hitch	Weights	Pull (m) and comments
Large	<u>Small</u>	Small	Low	Even	
Large	<u>Large</u>	Small	Low	Even	
Large	<u>Large</u>	Small	High	Even	
Large	<u>Small</u>	Small	High	Even	
C: E: R:					

Physics of the Tractor Pull

C.E.R. Group 3

Tires	Pinion Gear	Spur Gear	Hitch	Weights	Pull (m) and comments
Large	Small	<u>Small</u>	Low	Even	
Large	Small	<u>Medium</u>	Low	Even	
Large	Small	<u>Large</u>	Low	Even	
Large	Small	<u>Small</u>	High	Even	
Large	Small	<u>Medium</u>	High	Even	
Large	Small	<u>Large</u>	High	Even	
C: E: R:					

Physics of the Tractor Pull

C.E.R. Group 4

Tires	Pinion Gear	Spur Gear	Hitch	Weights	Pull (m) and comments
Large	Small	Small	<u>Low</u>	Even	
Large	Small	Small	<u>Medium</u>	Even	
Large	Small	Small	<u>High</u>	Even	
C: E: R:					

Physics of the Tractor Pull

C.E.R. Group 5

Tires	Pinion Gear	Spur Gear	Hitch	Weights	Pull (m) and comments
Large	Small	Small	Low	<u>Even</u>	
Large	Small	Small	Low	<u>Front max</u>	
Large	Small	Small	Low	<u>Middle max</u>	
Large	Small	Small	Low	<u>None</u>	
C: E: R:					

Physics of the Tractor Pull

Compete for Learning

Rules

- Each team will have 10 minutes to prepare their tractor at the start, then 2 minutes each time to attach the sled and complete their run
- Any tractor failing to complete a full pull has its distance recorded (see next slide) and is out of the competition
- Any tractor completing a full pull has FP (Full Pull) recorded and moves to the next round
- A full pull is defined by the weight box reaching the top of the sled, not by a distance

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Rules

- A run is finished when the tractor comes to a stop, when whole tractor or sled leaves the boundaries of the competition area, or if someone touches the tractor/sled
- In the case of a malfunction, the instructor may allow a redo
- Once every group still in the competition has attempted a given weight, the weight is increased, and the remaining groups pull again until there are no full pulls

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*EDUCATION IS NOT THE
LEARNING OF FACTS BUT
THE TRAINING OF THE
MIND TO THINK.*

- Albert Einstein

Scoring Sheet

Team	DISTANCE				Place
	Trial 1	Trial 2	Trial 3	Trial 4	
Team 1					
Team 2					
Team 3					
Team 4					
Team 5					

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Physics of the Tractor Pull

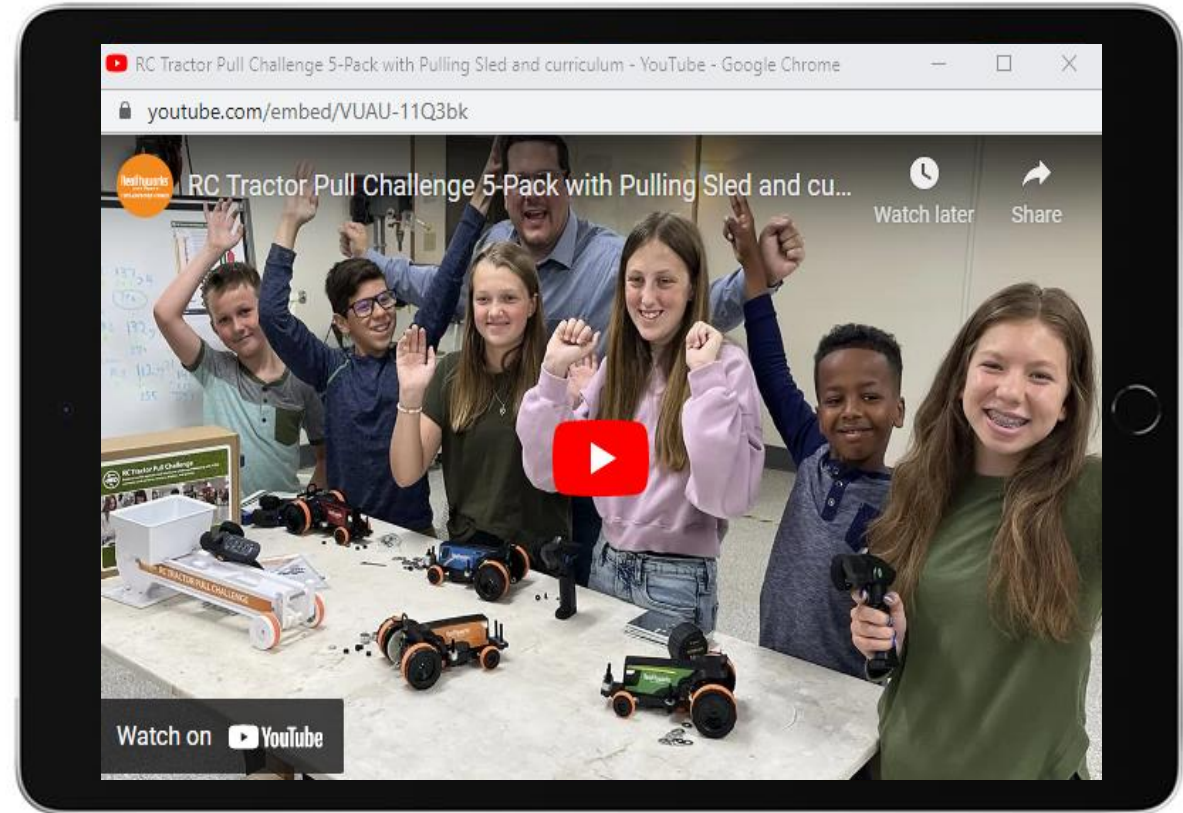
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Reminders:

- Check out our product at:
www.realityworks.com
- View our promotional video
<https://www.youtube.com/embed/VUAU-11Q3bk>
- Free lesson on Tractor Pull at:
<https://www.realityworks.com/product/rc-tractor-pull-challenge-5-pack-with-pulling-sled/>



<https://www.youtube.com/embed/VUAU-11Q3bk>



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