

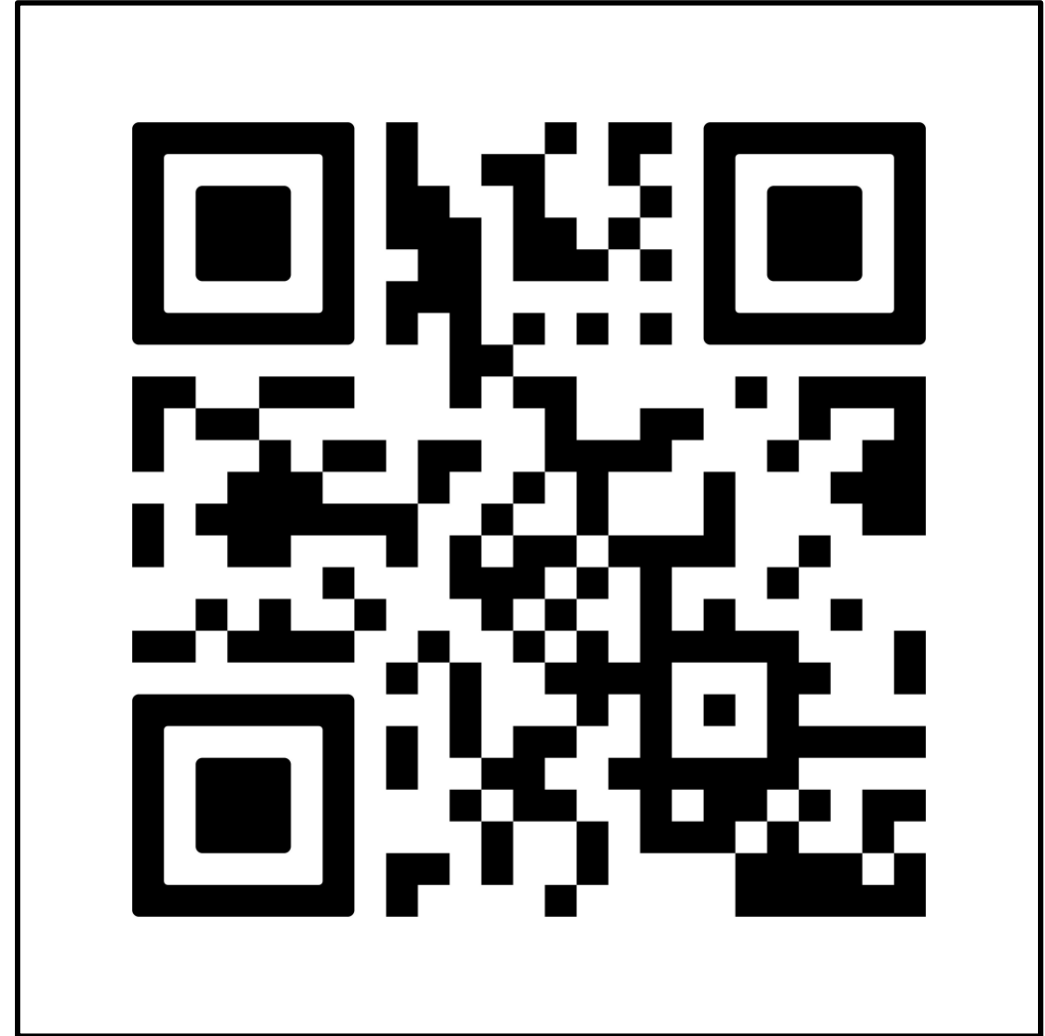


# CTE and STEM:

## *It's Time for a Take Over!*

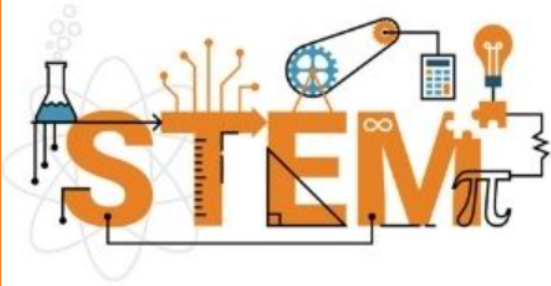
How CTE and STEM are connected and how to connect educational pathways to be able to incorporate STEM Concepts into pathways.

- We can help you start or refresh your own program!
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*Scan me*

# WHAT IS STEM?



STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH) learning focuses on the interconnected content areas of science, technology, engineering, and math and recognizes the importance of inquiry, investigation, and innovation to power our economy and advance our society. We need our future leaders—today’s learners—to have the hands-on, real-world experiences that will help them develop the skills required to drive and thrive in a strong, information-age economy.

*“High-quality CTE entails project- and problem-based learning that illustrates the power of STEM to address real-world challenges.”*

# WHAT DOES STEM LOOK LIKE IN CTE?

# 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



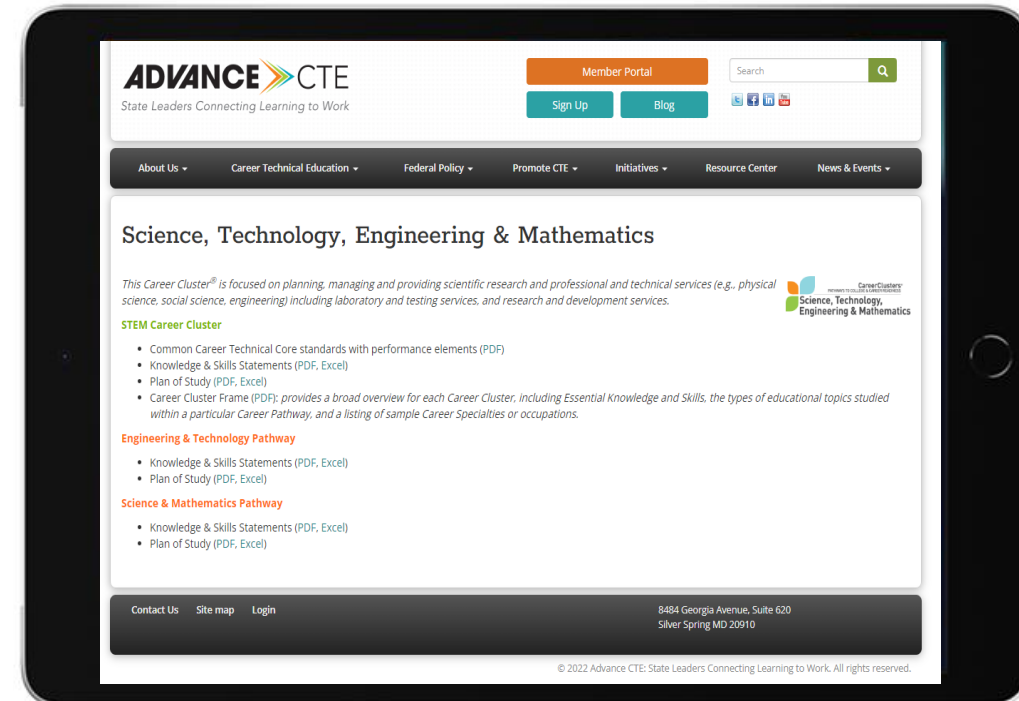
**M**

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



## The Career Clusters and Sample Related STEM CAREERS

|                                                                           |                                                                                                                                                                                                                                                                                                                                                            |                                                           |                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Career Cluster</b><br><b>Agriculture, Food &amp; Natural Resources</b> | <b>Samples of Stem Careers<sup>25</sup></b> <ul style="list-style-type: none"> <li>• Agriculture Technicians</li> <li>• Agriculture Engineers</li> <li>• Forest and Conservation Workers</li> <li>• Foresters</li> <li>• Food Science Technicians</li> <li>• Veterinarians</li> <li>• Marine Biologists</li> <li>• Water Resource Specialists v</li> </ul> | <b>Career Cluster</b><br><b>Hospitality &amp; Tourism</b> | <b>Samples of Stem Careers<sup>25</sup></b> <ul style="list-style-type: none"> <li>• Museums/Zoos/Aquariums Personnel</li> <li>• Parks and Gardens Rangers</li> <li>• Brewers</li> <li>• Pastry and Specialty Chefs</li> </ul>                                                                                         |
| <b>Architecture &amp; Construction</b>                                    | <ul style="list-style-type: none"> <li>• Architects</li> <li>• Civil Engineers</li> <li>• Civil Engineering Technicians</li> <li>• Surveyors</li> <li>• Drafters</li> <li>• Cost Estimators</li> </ul>                                                                                                                                                     | <b>Human Services</b>                                     | <ul style="list-style-type: none"> <li>• Developmental Psychologists</li> <li>• Personal Trainers</li> <li>• Mental Health Counselors</li> <li>• Massage Therapists</li> </ul>                                                                                                                                         |
| <b>Arts, A/V Technology &amp; Communications</b>                          | <ul style="list-style-type: none"> <li>• Graphic Designers</li> <li>• Telecommunications Engineering Specialists</li> <li>• Multimedia Artists &amp; Animators</li> <li>• Audio Technicians</li> </ul>                                                                                                                                                     | <b>Information Technology</b>                             | <ul style="list-style-type: none"> <li>• Programmers</li> <li>• Hardware, Software Engineers</li> <li>• Computer Support Specialists</li> <li>• Information Security Analysts</li> <li>• Database Administrators</li> <li>• Webmasters</li> <li>• Video Game Designers</li> </ul>                                      |
| <b>Business Management &amp; Administration</b>                           | <ul style="list-style-type: none"> <li>• Accountants</li> <li>• Auditors</li> <li>• Operations Research Analysts</li> </ul>                                                                                                                                                                                                                                | <b>Law, Public Safety, Corrections &amp; Security</b>     | <ul style="list-style-type: none"> <li>• Emergency Medical Technicians</li> <li>• Firefighter/Inspectors</li> <li>• Fire-Prevention and Protection Engineers</li> <li>• Brownfield Redevelopment Specialists and Site Managers</li> </ul>                                                                              |
| <b>Education &amp; Training Finance</b>                                   | <ul style="list-style-type: none"> <li>• STEM K-12 or postsecondary Teachers</li> <li>• Speech-Language Pathologists</li> <li>• Actuaries</li> <li>• Financial Analysts</li> <li>• Financial Planners</li> <li>• Loan Officers</li> <li>• Investment Bankers</li> </ul>                                                                                    | <b>Manufacturing</b>                                      | <ul style="list-style-type: none"> <li>• Aircraft Mechanics and Service/Avionics Technicians</li> <li>• Automotive Mechanics</li> <li>• Mechanical Engineers</li> <li>• Electronics Engineers</li> <li>• Electronics Engineering Technicians</li> <li>• Wind Turbine Service Technicians</li> <li>• Welders</li> </ul> |
| <b>Government &amp; Public Administration</b>                             | <ul style="list-style-type: none"> <li>• Patent Officer</li> <li>• Cryptographers</li> <li>• Policy Analysts</li> <li>• Climate Change Analysts</li> <li>• Intelligence Analysts</li> </ul>                                                                                                                                                                | <b>Marketing</b>                                          | <ul style="list-style-type: none"> <li>• Interactive Media Specialists</li> <li>• Market Researchers</li> <li>• Forecasting Managers</li> <li>• Inventory Manager/Analysts</li> </ul>                                                                                                                                  |
| <b>Health Science</b>                                                     | <ul style="list-style-type: none"> <li>• Physicians</li> <li>• Nurses</li> <li>• Geneticists / Biotechnology Researchers</li> <li>• Biologists</li> <li>• Dietitians and Nutritionists</li> <li>• Dental Hygienists</li> </ul>                                                                                                                             | <b>STEM</b>                                               | <ul style="list-style-type: none"> <li>• Any/all of careers listed</li> </ul>                                                                                                                                                                                                                                          |
|                                                                           |                                                                                                                                                                                                                                                                                                                                                            | <b>Transportation, Distribution &amp; Logistics</b>       | <ul style="list-style-type: none"> <li>• Transportation Planners</li> <li>• Transportation Engineers</li> <li>• Occupational Health and Safety Technicians</li> <li>• Transportation Vehicle, Equipment and Systems Inspectors</li> </ul>                                                                              |

## *Problem Statement:*

STEM & CTE Education need a roadmap of how they are connected and what should be used for *teaching* and *learning* to help students grasp STEM concepts.



# Next Generation STEM Standards

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigation
4. Analyzing and Interpreting Data
5. Using Mathematics and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information

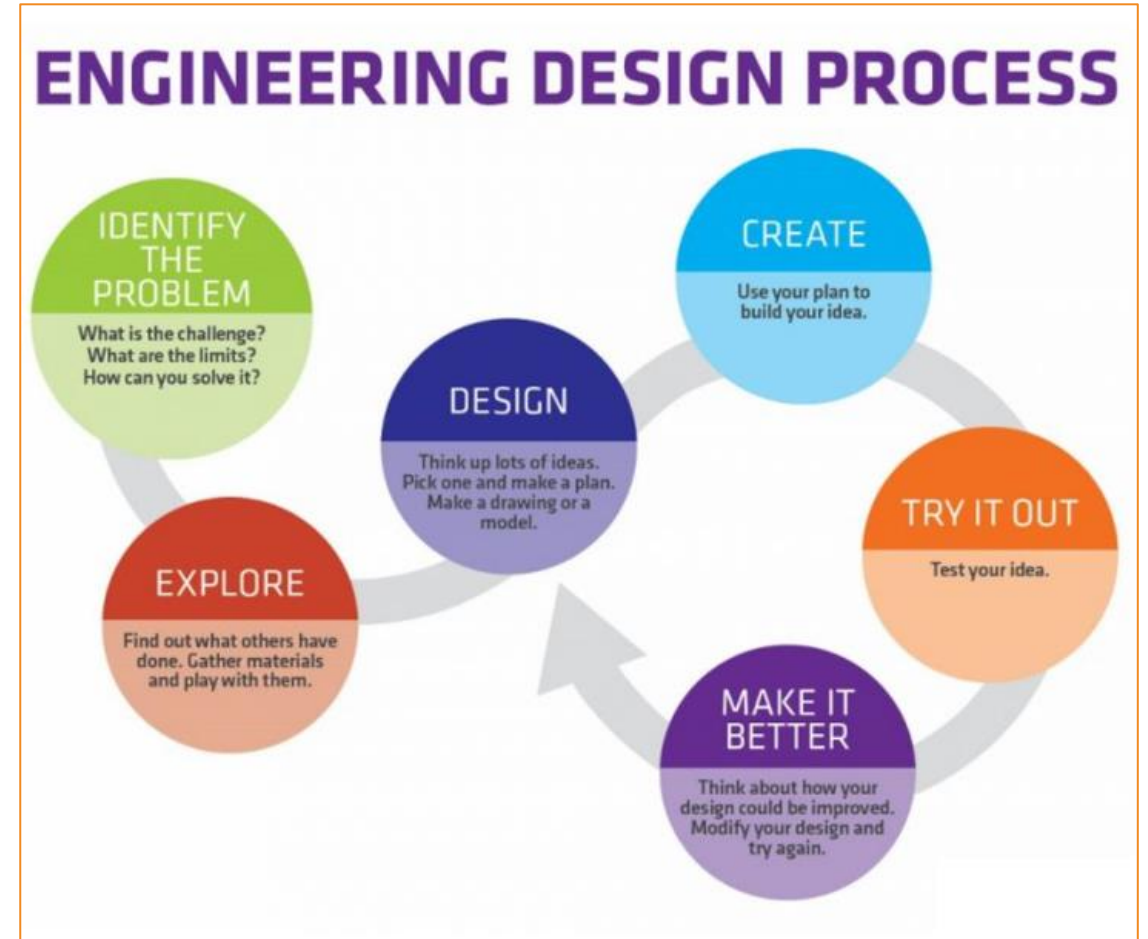
## DEFINITIONS OF TECHNOLOGY, ENGINEERING, AND APPLICATIONS OF SCIENCE

**Technology** is any modification of the natural world made to fulfill human needs or desires [2].

**Engineering** is a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants [2].

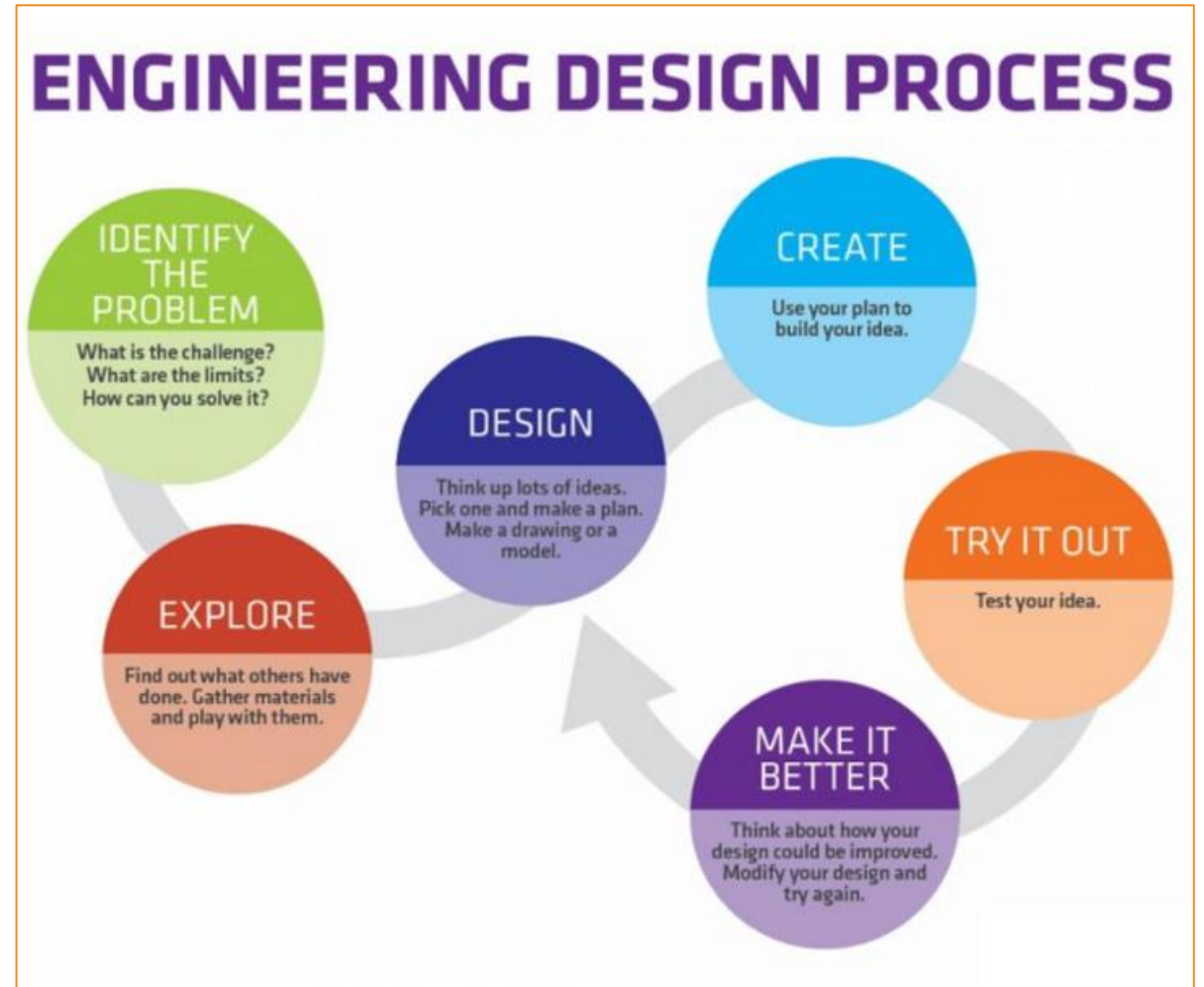
**An application of science** is any use of scientific knowledge for a specific purpose, whether to do more science; to design a product, process, or medical treatment; to develop a new technology; or to predict the impacts of human actions.

# Method to the Measurement



# How do we use this design for our classrooms?

- Focus on Learning Structures:
  - *Individual Learning*
  - *Team Learning*
  - *Learning in Action*



# STEM SURVEY FOR CTE EDUCATORS

*What is STEM to you?*

# Job Titles & Type of class do you teach?

Individual Learning

Team Learning

Learning in Action

## CTE Job Titles

| ANSWER CHOICES                                     | RESPONSES |
|----------------------------------------------------|-----------|
| ▼ Middle School Science Instructor                 | 4.44%     |
| ▼ High School Science Instructor                   | 17.78%    |
| ▼ Middle School STEM Instructor                    | 22.22%    |
| ▼ High School STEM Instructor                      | 20.00%    |
| ▼ Middle School CTE Instructor                     | 0.00%     |
| ▼ High School CTE Instructor                       | 20.00%    |
| ▼ 2-Year Post-Secondary Instructor                 | 0.00%     |
| ▼ 4-Year Post-Secondary Instructor                 | 0.00%     |
| ▼ Other (please specify) <a href="#">Responses</a> | 15.56%    |
| TOTAL                                              |           |

| ANSWER CHOICES                                     | RESPONSES |
|----------------------------------------------------|-----------|
| ▼ STEM/STEAM                                       | 55.56%    |
| ▼ Maker's Space/Exploratory Class                  | 20.00%    |
| ▼ General Science                                  | 11.11%    |
| ▼ Animal Science/Plant Science/Vet Science         | 13.33%    |
| ▼ Physical Science/Life Science/ Earth Science     | 28.89%    |
| ▼ CTE Generalist Class                             | 15.56%    |
| ▼ Other (please specify) <a href="#">Responses</a> | 22.22%    |

- Others included:
  - Engineering, Biotechnology, Additive and Subtractive manufacturing, Electricity, Horticulture, Greenhouse Management

# Number of students in class?

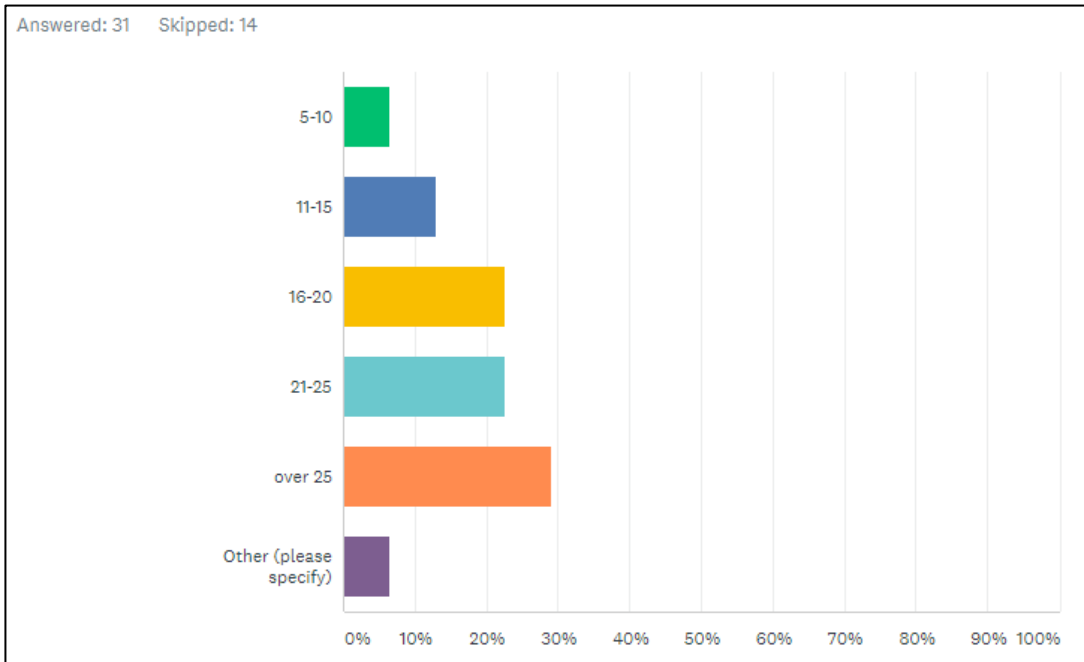
## Number of students for group work?

Individual Learning

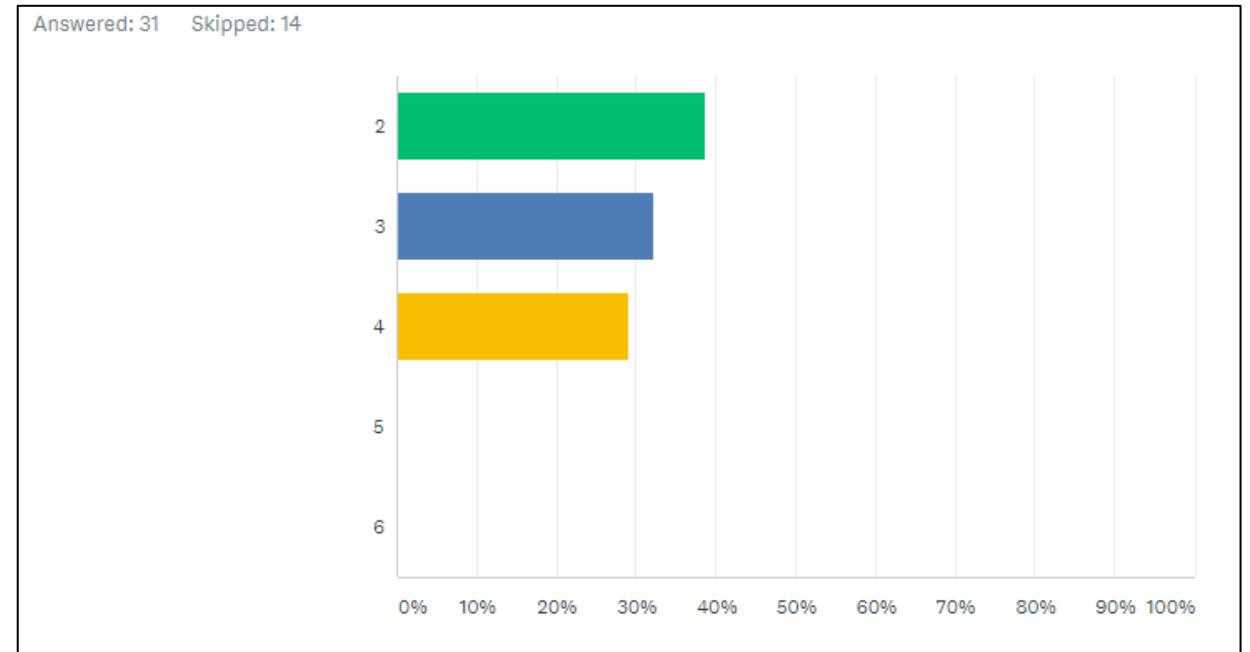
Team Learning

Learning in Action

### Students in STEM classes



### Students for STEM group work

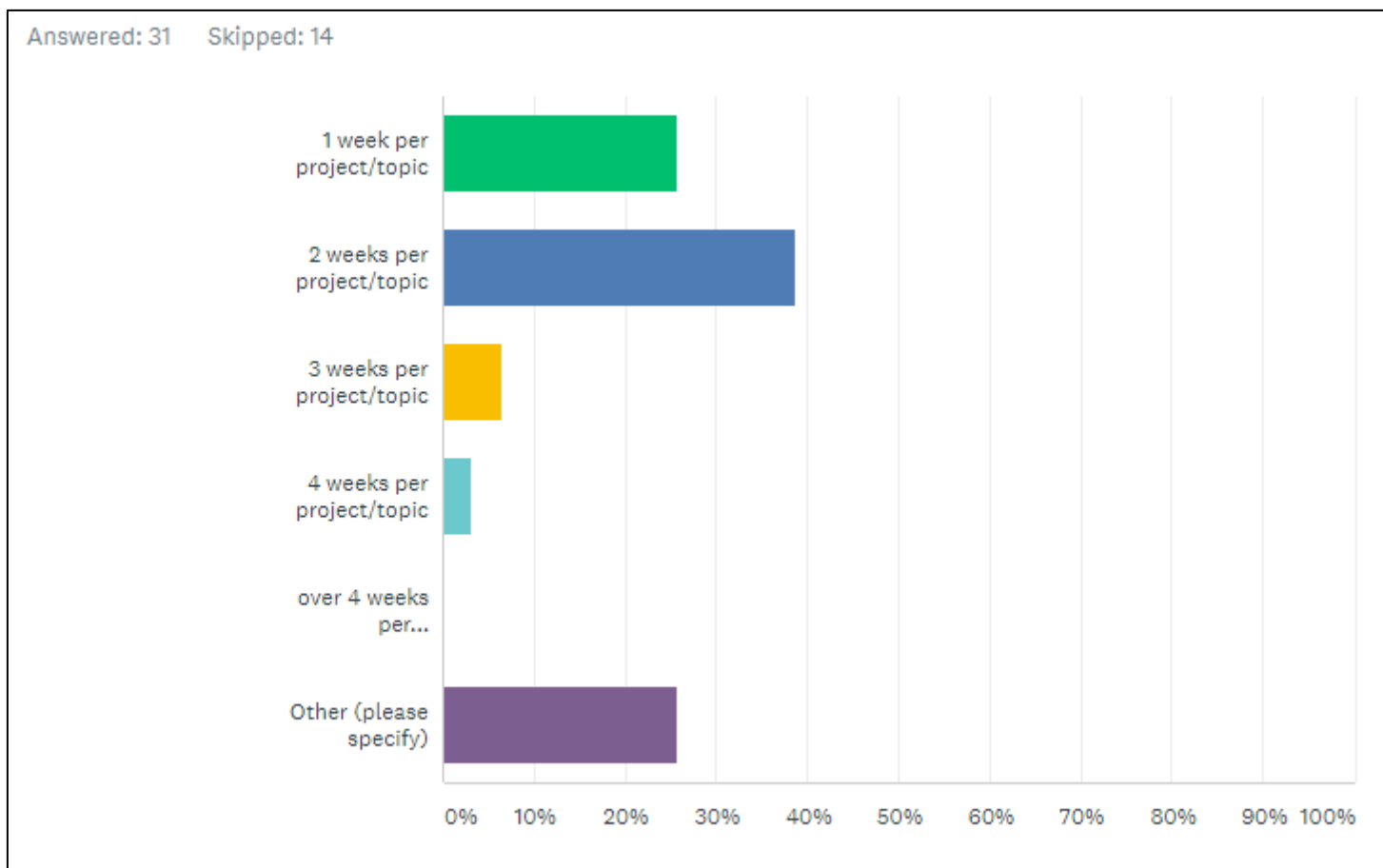


# Average “Time on Task” for STEM Projects

Individual Learning

Team Learning

Learning in Action

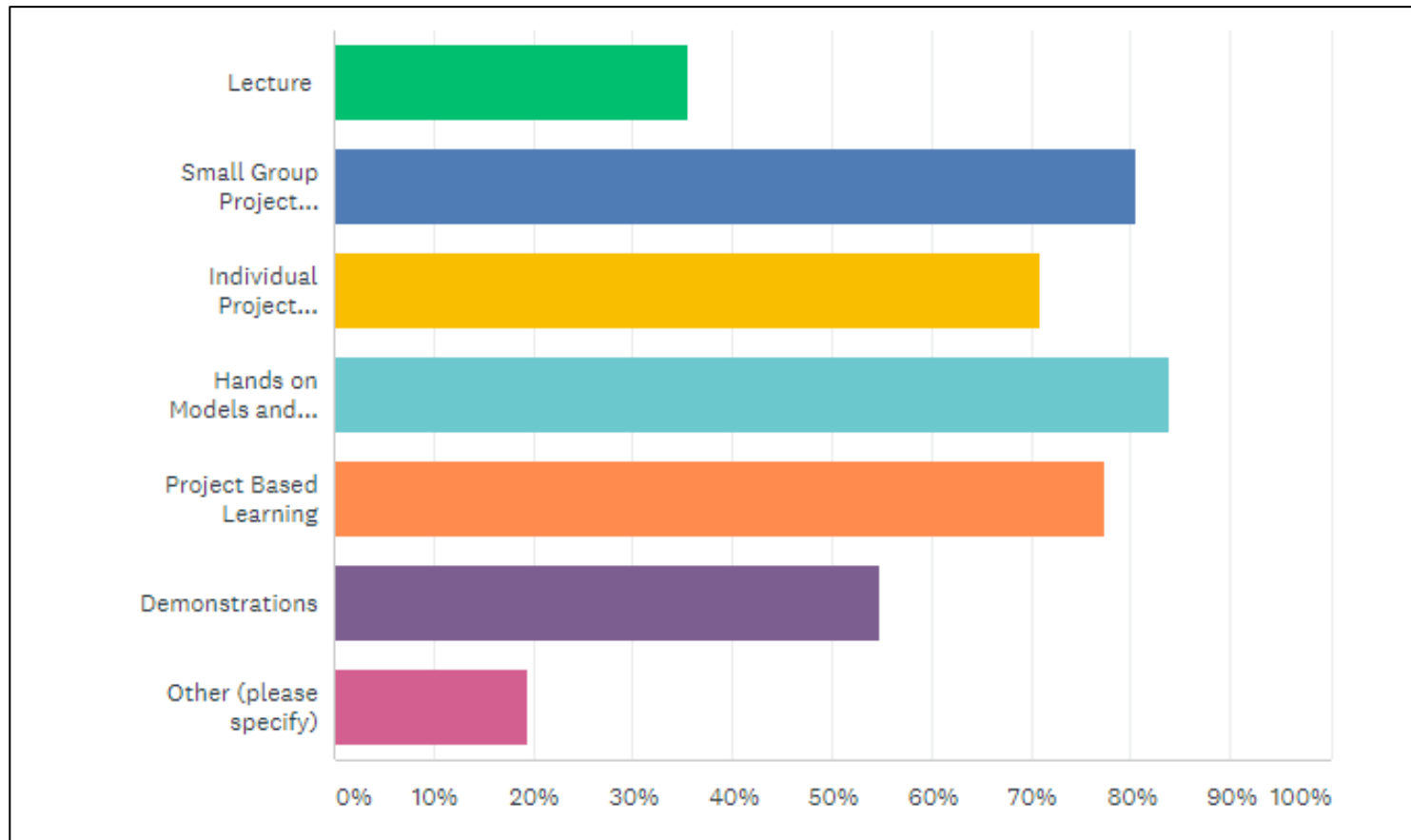


# Types of teaching models work best in STEM

Individual Learning

Team Learning

Learning in Action



# STEM Methodology based off of Engineering Design

## Individual Learning

- Identify the Problem
  - Problem Statements
  - What do you know about the challenge
  - What don't you know about the challenge
- Explore
  - Research the challenge
  - What is known about the challenge already?
  - What resources could help you or are needed

## Team Learning

- Design
  - Collaborate on lots of ideas to help the challenge
  - Filter down ideas to best options
  - Plan a course forward
- Create
  - Prototype your ideas
  - Modify plan as building blocks are put into place
  - Problem solve your ideas

## Learning in Action

- Try it Out
  - Test your ideas
  - Create competitions for best results
  - Identify successes and failures
- Make it Better
  - Think about improvements
  - Analyze outcomes
- Design Again
  - Redesign or revise problems
  - Develop and create new outcomes

# STEM SOLUTIONS For CTE

*Bringing STEM products  
into your classroom for  
engagement*

# RC Tractor Pull Challenge



[www.realityworks.com](http://www.realityworks.com)



# 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

Price: \$2,999



# Product Promo



<https://www.realityworks.com/wp-content/uploads/2023/12/RC-Tractor-Product-Feature-Short-Video.mp4>

# Rules of Engagement

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

## RC Tractor Pull Challenge Curriculum

- 5 lessons on Tractor Pull

### 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

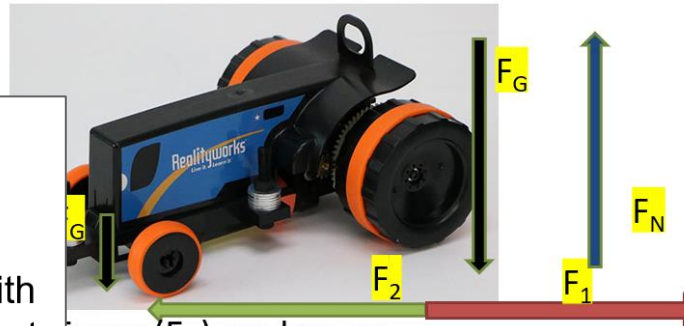
# RC Tractor

## Newton's 3<sup>rd</sup> 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

5

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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*).

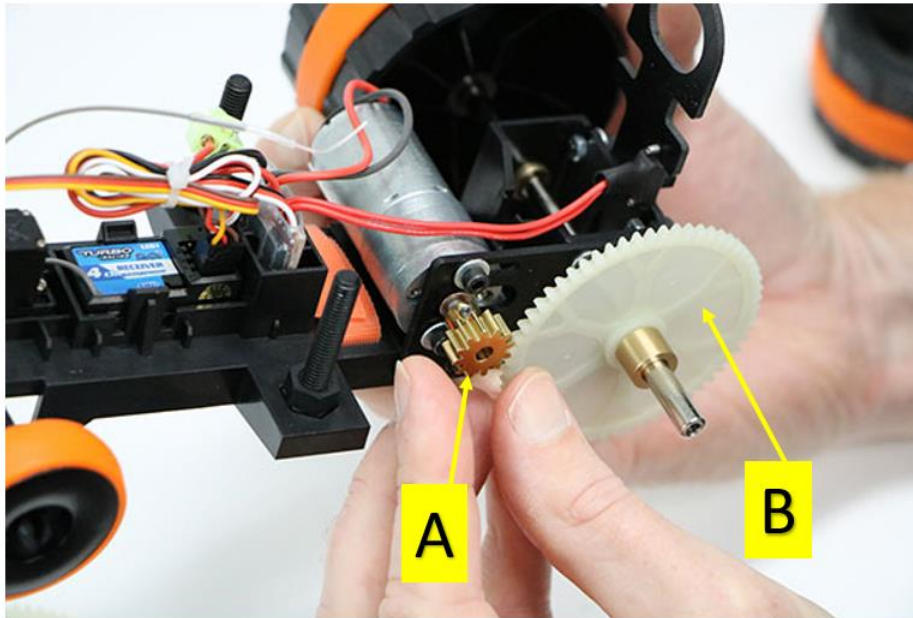
Is your data consistent with this explanation? Answer questions 1-2 on the worksheet

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## 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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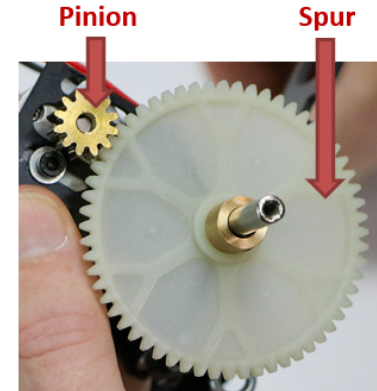
## Mechanical Advantage

- 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.

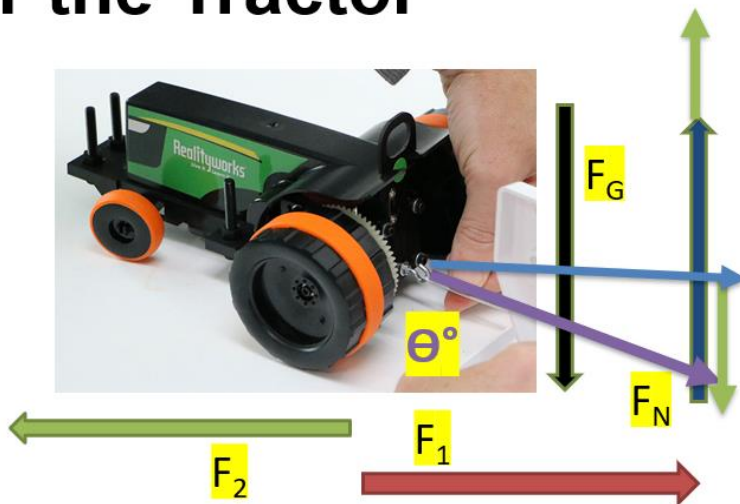
- $MA = \frac{\text{Teeth on spur gear}}{\text{Teeth on pinion gear}}$
- Example: A spur gear has 36 teeth. Which has a bigger MA (mechanical advantage), a 9-tooth or 12-tooth pinion gear?
- $MA = \frac{36}{9} = 4$
- $MA = \frac{36}{12} = 3$
- The 10-tooth pinion gear has the larger MA, meaning it will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



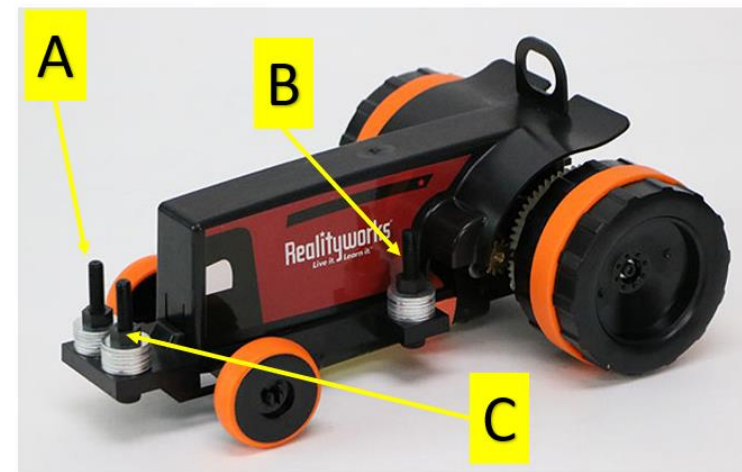
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## Posts for Weights

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> <sup>1</sup> | Small                     | Small                      | Low                        | Even                           |                       |
| Large                     | <u>Large</u> <sup>2</sup> | Small                      | Low                        | Even                           |                       |
| Large                     | Small                     | <u>Medium</u> <sup>3</sup> | Low                        | Even                           |                       |
| Large                     | Small                     | <u>Large</u> <sup>3</sup>  | Low                        | Even                           |                       |
| Large                     | Small                     | Small                      | <u>Medium</u> <sup>4</sup> | Even                           |                       |
| Large                     | Small                     | Small                      | <u>High</u> <sup>4</sup>   | Even                           |                       |
| Large                     | Small                     | Small                      | Low                        | <u>Front max</u> <sup>5</sup>  |                       |
| Large                     | Small                     | Small                      | Low                        | <u>Middle max</u> <sup>5</sup> |                       |
| Large                     | Small                     | Small                      | Low                        | <u>None</u> <sup>5</sup>       |                       |
| <u>Small</u> <sup>1</sup> | Small                     | Small                      | High                       | Even                           |                       |
| Large                     | <u>Large</u> <sup>2</sup> | Small                      | High                       | Even                           |                       |
| Large                     | Small                     | <u>Medium</u> <sup>3</sup> | High                       | Even                           |                       |
| Large                     | Small                     | <u>Large</u> <sup>3</sup>  | 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<br>$\text{Force}_{\text{out}} = \text{MA} \times \text{Force}_{\text{in}}$ | RPM<br>$\text{Speed}_{\text{out}} = \text{Speed}_{\text{in}} / \text{MA}$ |
|-------------|-----------|------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 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.

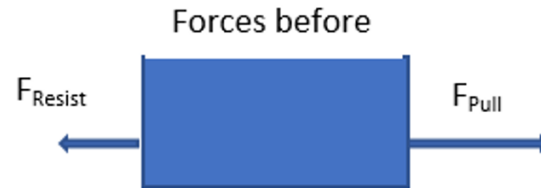
| Tire Diameter | Spur Gear Diameter | MA<br>$\text{MA} = D_{\text{in}} / D_{\text{out}}$ |
|---------------|--------------------|----------------------------------------------------|
| Small         | Small              |                                                    |
| Small         | Medium             |                                                    |
| 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<br>$\text{MA}_T = \text{MA}_1 \times \text{MA}_2$ | (b) Force out<br>$F_o = F_{\text{in}} \times \text{MA}_T$ | (c) Speed out<br>$S_o = S_{\text{in}} / \text{MA}_T$ |
|-------------|-----------|-------|----------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------|
| 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).

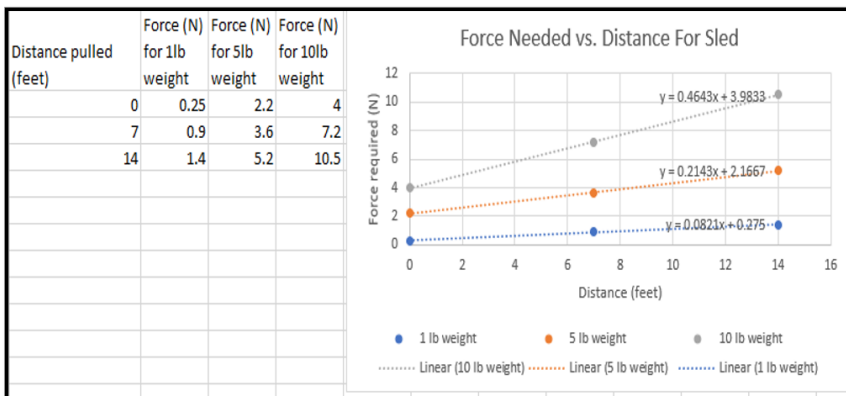
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Physics of the Tractor Pull

15

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## Force Required To Pull the Sled at Various Distances



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Physics of the Tractor Pull

10

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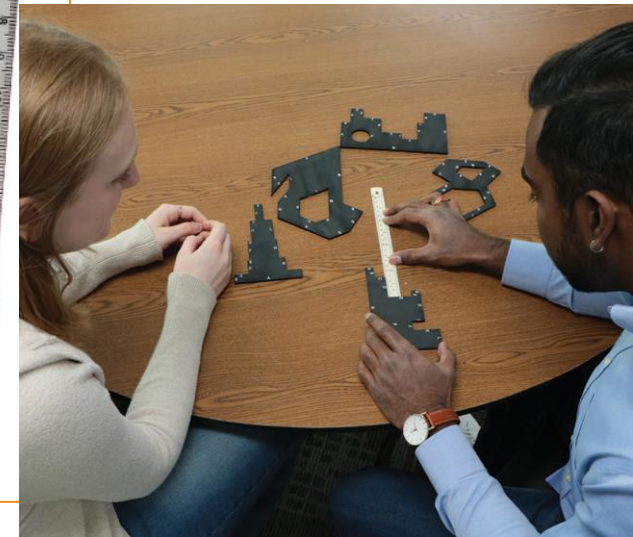
Physics of the Tractor Pull

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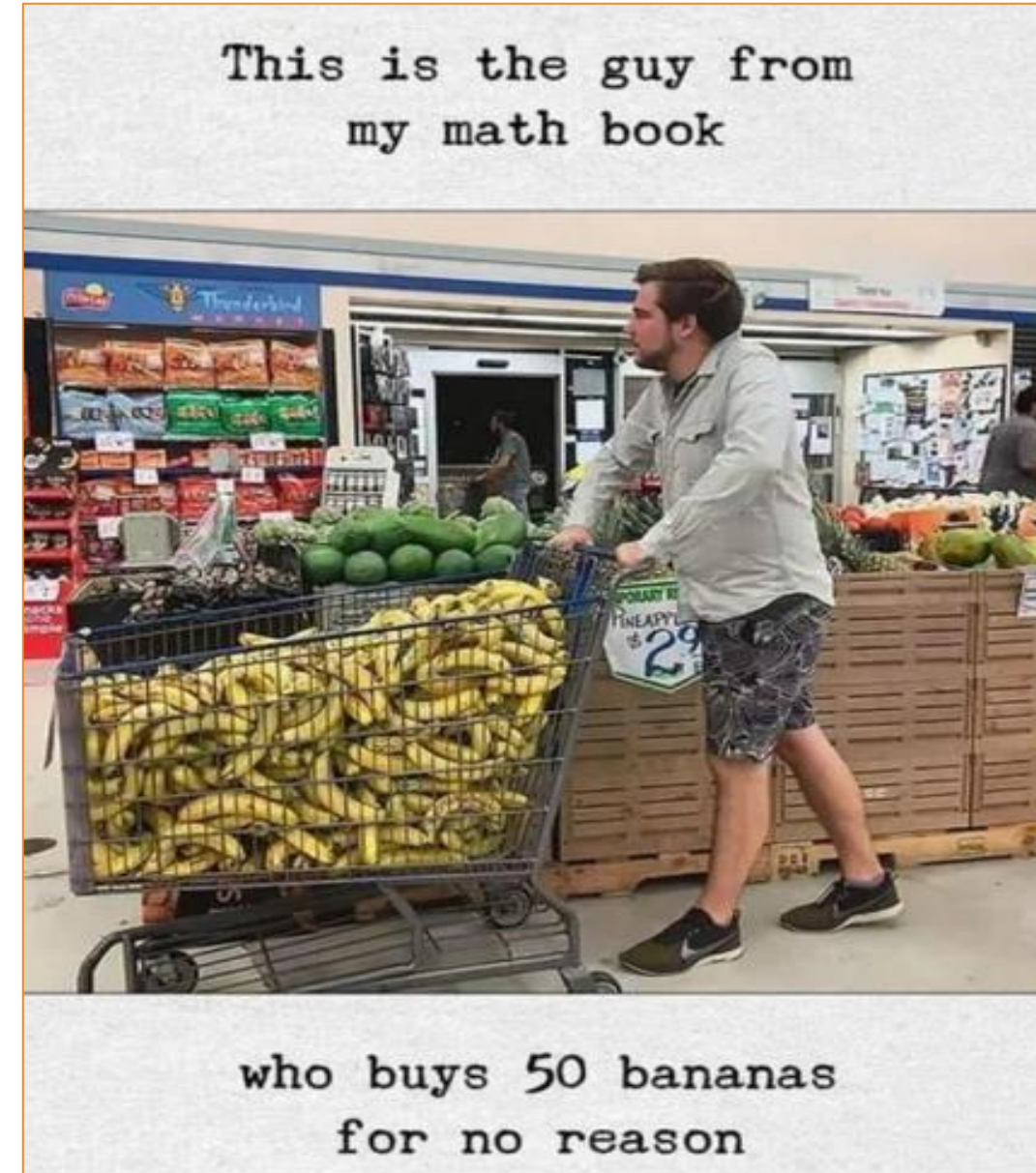
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# Measurement Math Kit



# What Do They Need to Know?

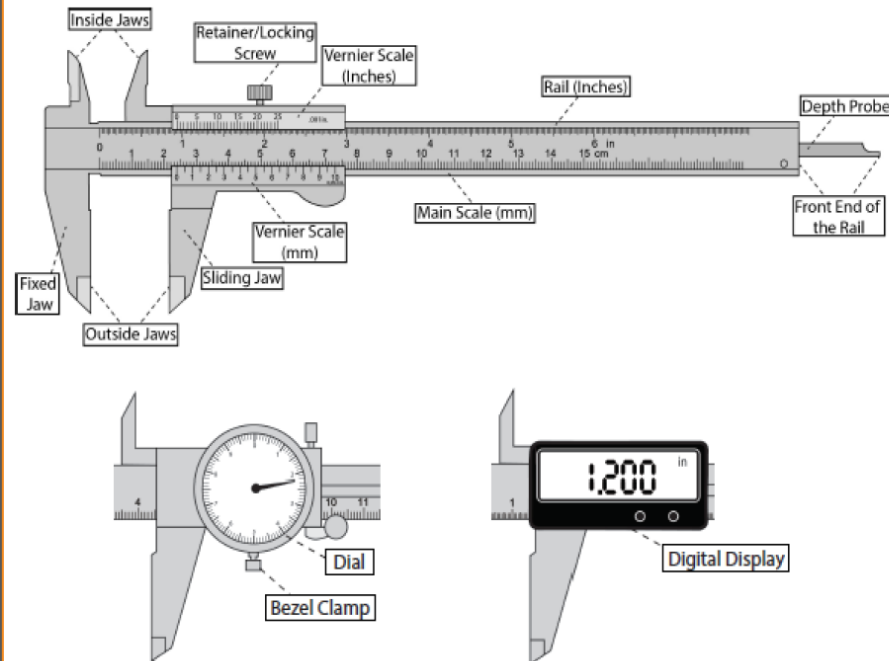
- Basics
  - Decimals
  - Fractions
  - Ratios
  - Conversions
  - Measurements



# Bite Sized Chunks

## Using a Caliper

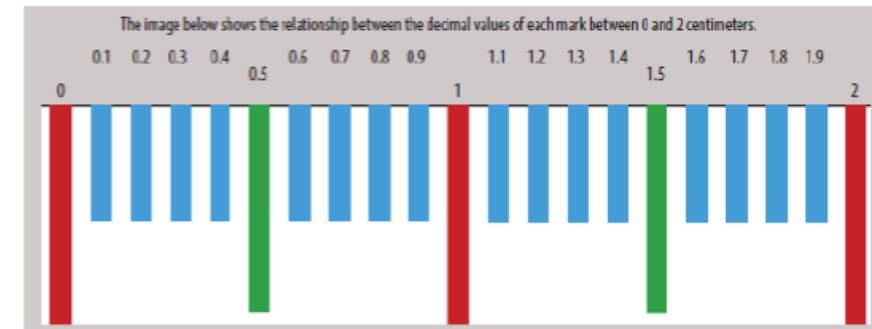
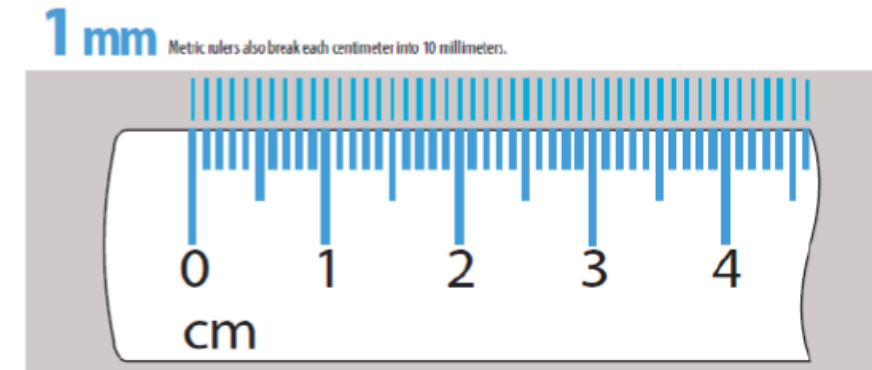
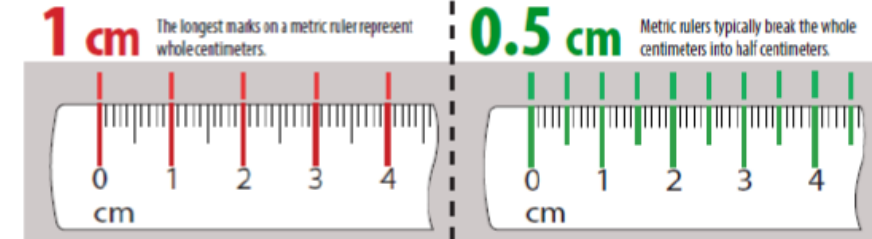
### Caliper Parts



## Using a Ruler

### Measurement Units on a Ruler (Metric)

Metric rulers typically measure distances in centimeters and millimeters. Each centimeter is broken down into ten sections called millimeters.



# Integration

## Conversion

- Standard
- Metric



## Fractions

- Ruler
- Tape Measure
- Caliper



## Decimals

- Add/Subtracting
- Multiplying/Dividing



Decimals to  
Fractions



Fractions to  
Decimals



Combining  
Measurements

Measurement  
Practice



Real World  
Practice



Assessment  
Opportunity



Measurement  
Practice

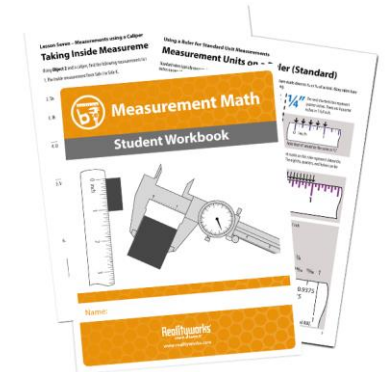
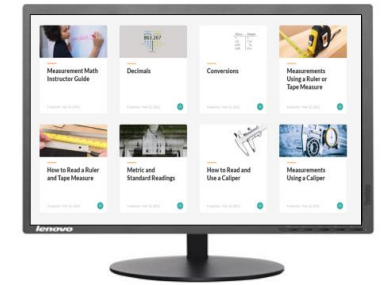
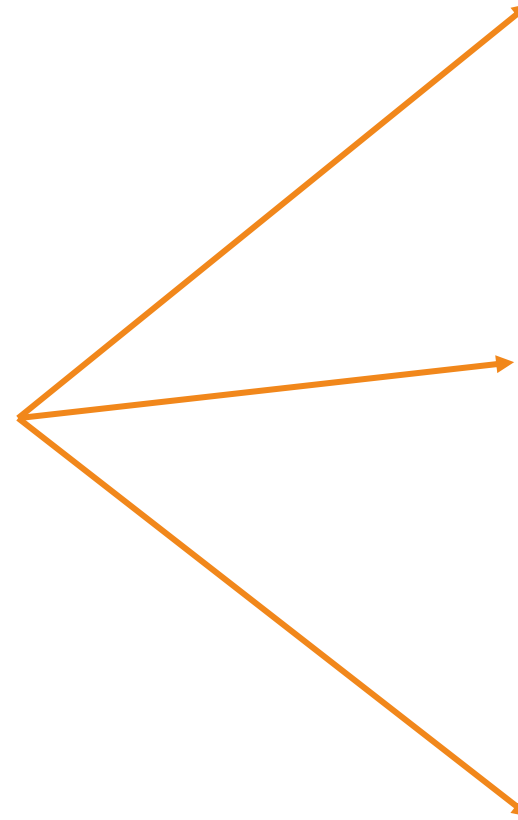


Real World  
Practice



Assessment  
Opportunity

# Multiple Modalities



# Measurement Math Lessons

- Lesson 1: Metric and Standard Readings
- Lesson 2: How to Read a Ruler/Tape Measure
- Lesson 3: How to Read/Use a Caliper
- Lesson 4: Decimals
- Lesson 5: Conversions
- Lesson 6: Measurements Using a Ruler or Tape Measure
- Lesson 7: Measurement Using a Caliper

# Student Workbooks

**Using a Ruler for Standard Unit Measurements**  
**Measurement Units on a Ruler (Standard)**

Standard rulers typically measure distances down to  $\frac{1}{16}$  of an inch, although some versions have marks down to  $\frac{1}{8}$  or  $\frac{1}{4}$  of an inch. Many rulers have inches on one side and centimeters on the other. Rulers are generally  $\frac{1}{2}$ ,  $\frac{3}{4}$ , or 1 inch long.

**$\frac{1}{16}$ "** The largest marks on a ruler represent whole inches. The next smallest lines represent  $\frac{1}{16}$  of an inch. There are 2 half inches in 1 inch.

**$\frac{1}{8}$ "** The next smallest lines represent  $\frac{1}{8}$  of an inch. The  $\frac{1}{16}$  and  $\frac{1}{8}$  are shown, as these eighth fractions can be reduced.

**$\frac{1}{4}$ "** The next smallest lines represent  $\frac{1}{4}$  of an inch. There are 4 quarter inches in 1 inch.

**$\frac{1}{2}$ "** The next smallest lines represent  $\frac{1}{2}$  of an inch. There are 2 half inches in 1 inch.

The image below shows the relationship between the fractional and decimal values of each mark between 0 and 1 inch.

| Fraction        | Decimal |
|-----------------|---------|
| $\frac{1}{16}$  | 0.0625  |
| $\frac{1}{8}$   | 0.125   |
| $\frac{3}{16}$  | 0.1875  |
| $\frac{1}{4}$   | 0.25    |
| $\frac{5}{16}$  | 0.3125  |
| $\frac{3}{8}$   | 0.375   |
| $\frac{7}{16}$  | 0.4375  |
| $\frac{1}{2}$   | 0.5     |
| $\frac{9}{16}$  | 0.5625  |
| $\frac{5}{8}$   | 0.625   |
| $\frac{11}{16}$ | 0.6875  |
| $\frac{3}{4}$   | 0.75    |
| $\frac{13}{16}$ | 0.8125  |
| $\frac{7}{8}$   | 0.875   |
| $\frac{15}{16}$ | 0.9375  |
| 1               | 1       |

The fractional measurements should always be communicated in their reduced form (for example,  $\frac{1}{2}$  instead of  $\frac{2}{4}$ ).

**Using a Ruler**  
**Measuring an Object with a Ruler**

- Line up the 0 mark with the first edge of the object.
- Identify where the second edge of the object lands on the ruler. The corresponding point on the ruler will give us our measurement.
- Reading: If the object does not line up exactly with a mark, choose the mark that is closest to the edge of the object.
- Find the fractional inch component by counting how many whole inches fall within the object's boundary. In this example, the object is longer than 2 inches, but less than 3 inches. (Leave whole inch component at 2.)
- Find the fractional inch component by determining what fraction of an inch the object edge ends. This fraction needs to be added to the whole inch. In this example, the object is closest to the  $\frac{3}{4}$  inch line.

Add the findings together. The answer for this example is  $2 + \frac{3}{4} = 2 \frac{3}{4}$  inches.

**Using a Ruler**  
**Measurement Units on a Ruler (Metric)**

Metric rulers typically measure distances in centimeters and millimeters. Each centimeter is broken down into ten sections called millimeters.

**1 cm** The largest marks on a metric ruler represent whole centimeters.

**$\frac{1}{2}$  cm** Metric rulers typically break the whole centimeters into half-centimeters.

**1 mm** Metric rulers also break each centimeter into 10 millimeters.

The image below shows the relationship between the decimal values of each mark between 0 and 2 centimeters.

| Centimeters | Millimeters |
|-------------|-------------|
| 0           | 0           |
| 0.1         | 1           |
| 0.2         | 2           |
| 0.3         | 3           |
| 0.4         | 4           |
| 0.5         | 5           |
| 0.6         | 6           |
| 0.7         | 7           |
| 0.8         | 8           |
| 0.9         | 9           |
| 1           | 10          |
| 1.1         | 11          |
| 1.2         | 12          |
| 1.3         | 13          |
| 1.4         | 14          |
| 1.5         | 15          |
| 1.6         | 16          |
| 1.7         | 17          |
| 1.8         | 18          |
| 1.9         | 19          |
| 2           | 20          |

**Using a Caliper**  
**Caliper Basics**

Calipers are measuring tools commonly used for the following:

- Measuring thickness
- Measuring internal/external diameters
- Measuring the inside/outside, or depth of an object

**Standard Units on a Caliper**

- The scale on a caliper should be labeled with a unit, typically centimeters or inches.
- Most calipers are divided up into ten parts instead of the typical 100 parts on a ruler.

**Using a Caliper**  
**Caliper Parts**

**Using a Caliper**  
**Reading a Caliper**  
**Reading Vernier Calipers**

- Read the main scale measurement.
- Read the secondary scale measurement.
- Find the sum of the two measurements.

**Reading Dial Calipers**

- Zero out the dial.
- Adjust the jaws to measure the object.
- Look at the sliding jaw and note the last main scale that it passed.
- Look at the dial and determine which number the hand is pointing to.
- The sum of the two readings is the final measurement.

**Reading Digital Calipers**

Digital calipers are the easiest to read, however, they are often more expensive than a dial or vernier caliper.

- Select the preferred measurement scale (inches or centimeters) and read the number displayed.
- Most digital calipers will read up to a thousandth of an inch or millimeter.

**Using a Caliper**  
**Measuring with a Caliper**  
**Steps to Measuring Inside Dimensions**

The upper set of jaws on the caliper are used to measure the inside diameter of a hole.

- Loosen the top screw.
- Adjust the upper jaws so that they are slightly smaller than the hole being measured.
- Slide the jaws into the hole.
- Adjust the upper jaws until they hit the walls of the hole.
- Turn the lock screw to set the jaws in place.
- Take the measurement.

**Steps to Measuring Outside Dimensions**

The lower set of jaws are used to measure the outside diameter of a cylinder or the length/width of an object.

- Slide the top screw and adjust the jaws to fit around the object being measured.
- Slide the jaws until they are clamped tightly around the object.
- Turn the lock screw so that the lower jaws are set.
- Take the measurement.

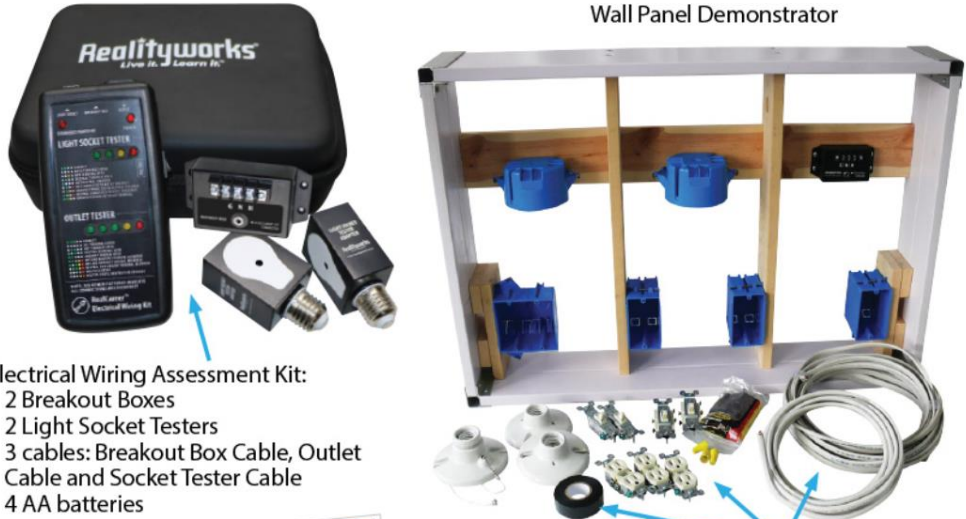
Measurement Math Student Workbook | Realityworks, Inc.

**Measurement Math**  
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# Electrical Wiring Kit



**Wall Panel Demonstrator**

**Electrical Wiring Assessment Kit:**

- 2 Breakout Boxes
- 2 Light Socket Testers
- 3 cables: Breakout Box Cable, Outlet Cable and Socket Tester Cable
- 4 AA batteries

**Electrical wiring components:**

- 2 single Pole Switches
- (2) 3-way switches
- (3) 15A duplex receptacles
- 2 ceramic lamp holders
- 1 ceramic lamp holder, with pull chain
- 20 feet of 14-2 NM-B with ground wire
- 13 feet of 14-3 NM-B with ground wire
- 25 standard wire connectors
- 1 roll of black electrical tape

**RealCareer™ Electrical Wiring Kit**

**Student Exercises**

**Additional features and functions:**

- Portable, battery-operated kit
- Uses low-voltage DC power to assess AC wiring
- Instant assessment and corrective feedback

**Student Exercise Workbook**  
(16 student-led exercises)



# Components



## Electrical Wiring Assessment Kit:

- 2 Breakout Boxes
- 2 Light Socket Testers
- 3 cables: Breakout Box Cable, Outlet Cable and Socket Tester Cable
- 4 AA batteries

## Wall Panel Demonstrator



## Electrical wiring components:

- 2 single Pole Switches
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- 1 roll of black electrical tape



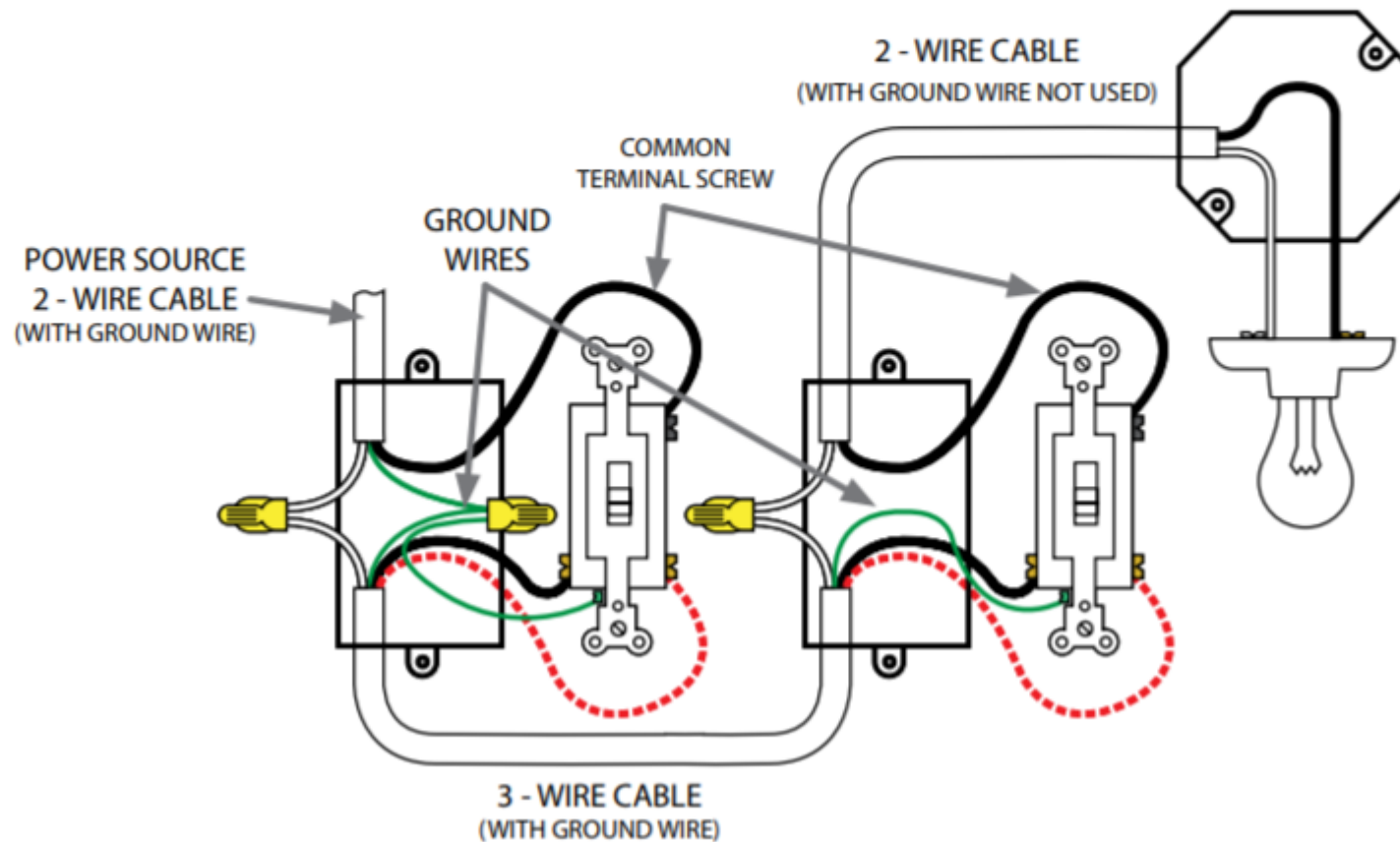
## RealCareer™ Electrical Wiring Kit

### Additional features and functions:

- Portable, battery-operated kit
- Uses low-voltage DC power to assess AC wiring
- Instant assessment and corrective feedback

Student Exercise Workbook  
(16 student-led exercises)

## Exercise Eleven – 3-Way Switches with a Light, Power Entry through both Switches First



# How Does Electricity Get to

## How Does Electricity Get to The Home?

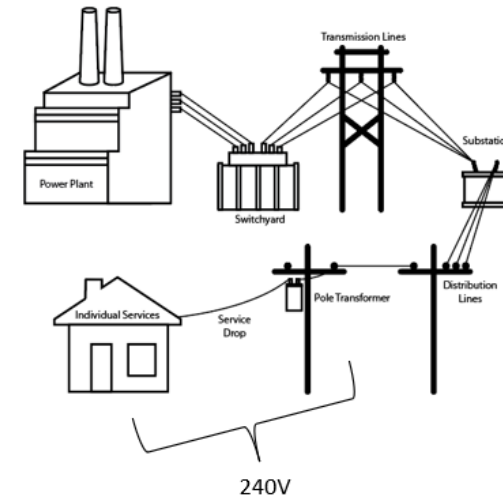
1. Power Source
2. Grid
3. Homes and where it is sent

- Electricity is produced by such as a hydroelectric plant, wind turbine, solar plant.
- The voltage is stepped up and transmitted. This lowers the loss by resistance in the wires which can add up over long distances.

- Once electricity nears the home, the voltage is stepped down to a manageable voltage.
- Distribution lines take electricity to neighborhoods and then to individual homes.

## How Does Electricity Get to The Home?

- The final step-down occurs at a pole transformer outside your home, where the voltage is dropped down to 240V.
- 240V enters your home (service drop or entrance).

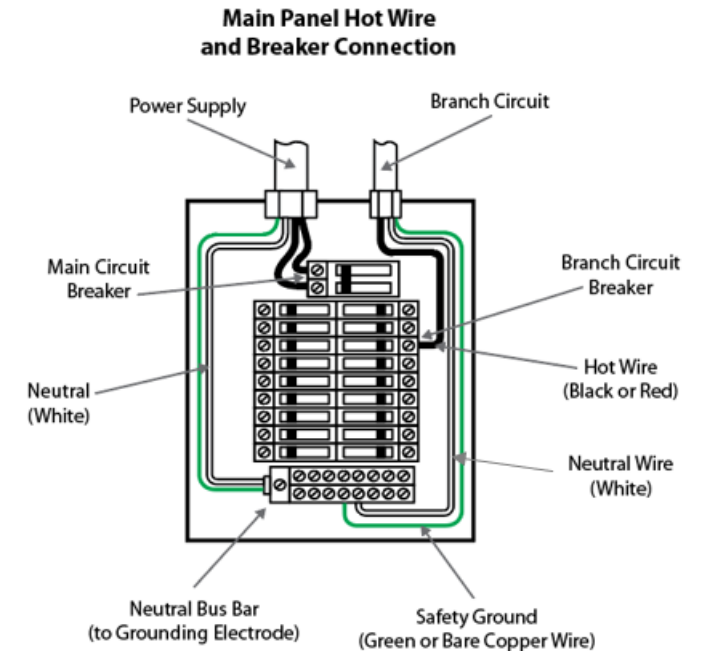


# How Is Electricity Distributed Within a Home?

- Electricity enters your home as 240V service lines.
- It goes through a meter, so the utility company can get paid for electricity you use.
- It enters your main panel as two 120V service lines.
- Household circuits can be split between these service lines.
- 240V loads can be placed across the two service lines to get the higher voltage.

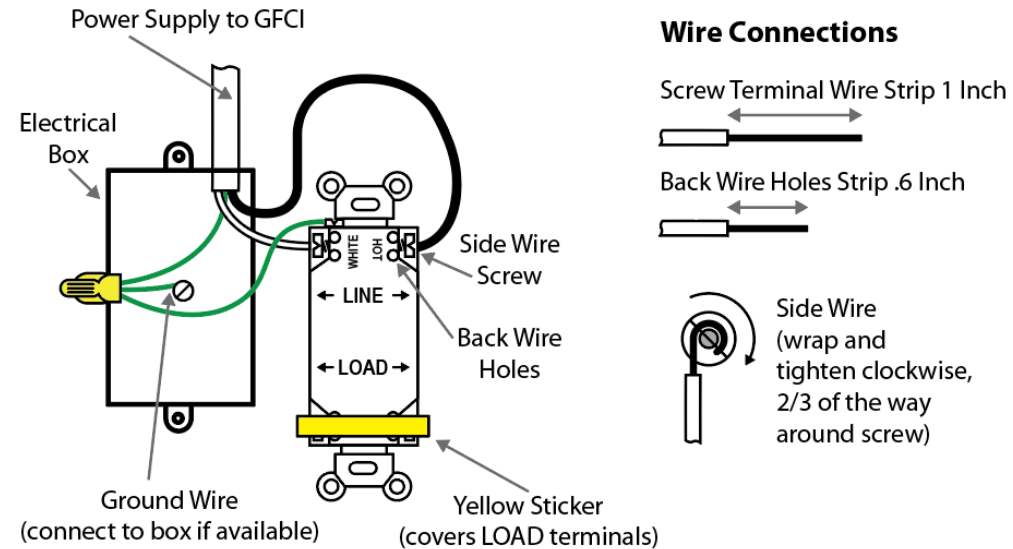
## The Main Panel

- Splits incoming 120V/240V supply into individually protected branch circuits.
- A Main Circuit Breaker will disconnect power to the entire panel.
- Each branch circuit has a 15A or 20A breaker that will disconnect power to that branch when the current level is exceeded.



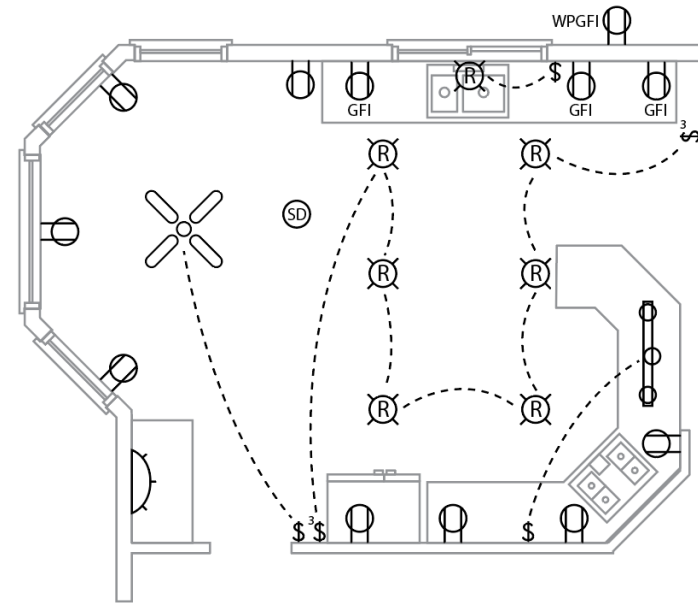
# Wiring Diagrams

- For simple wiring projects, replacements, or add-ons, many fixtures will come with instructions that specify critical mounting dimensions, safety procedures, wire connections, and setup instructions

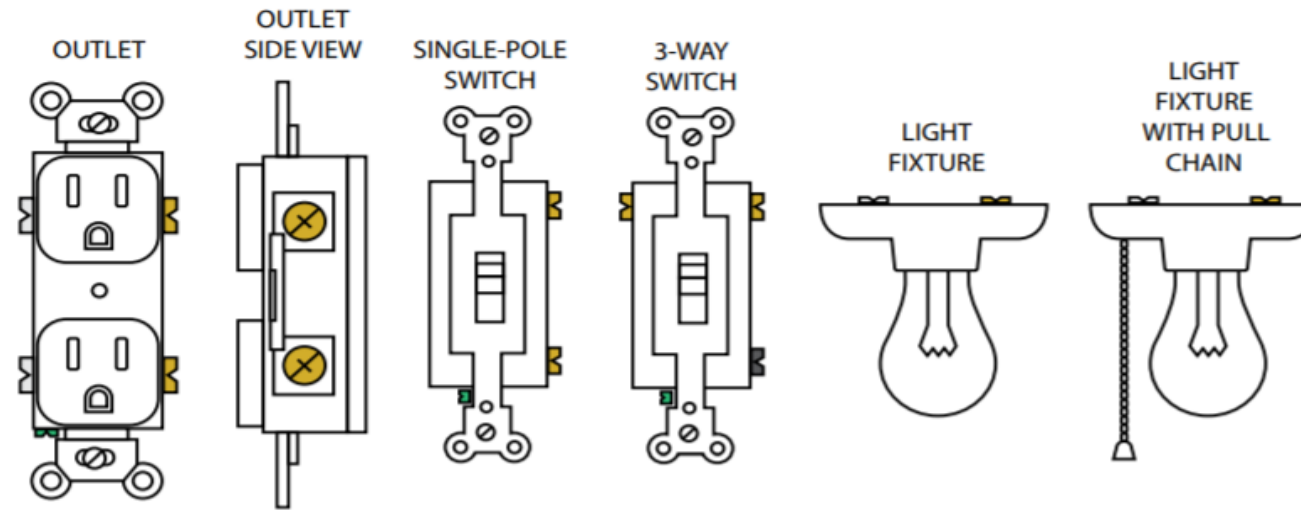


# Wiring Diagrams

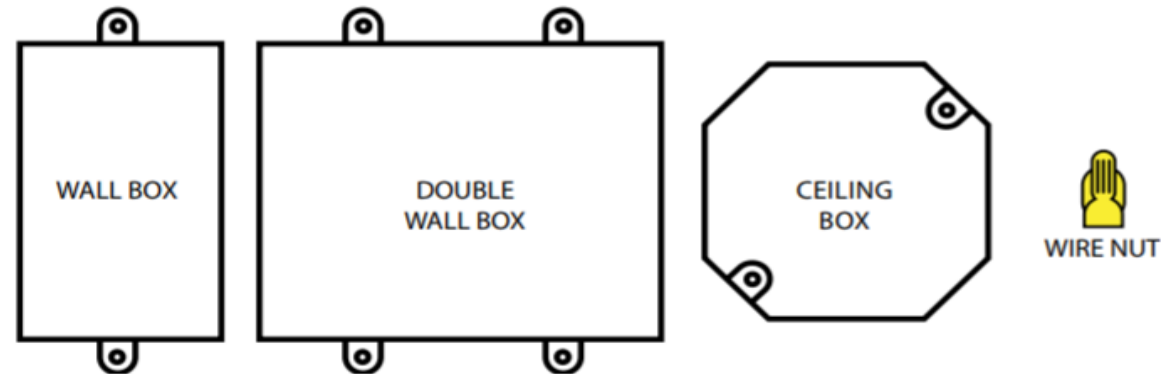
- For new construction or large wiring projects, you may have some form of wiring diagram or blueprint.
- Diagrams often show location of outlets, switches, fans, etc., but don't always detail connections, branch circuits, etc.
- They usually have a legend or key to understand symbols used (see Slide #24).
- They may have a bill of materials or materials list as well.



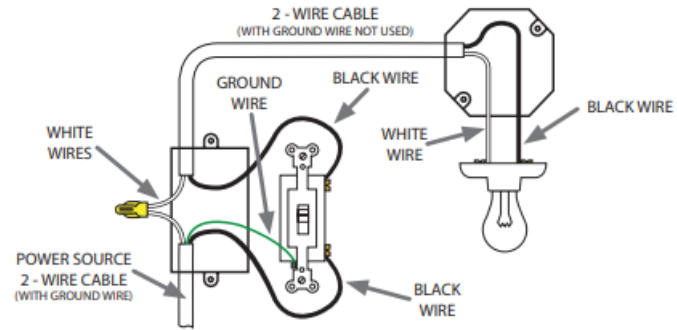
# Electrical Components



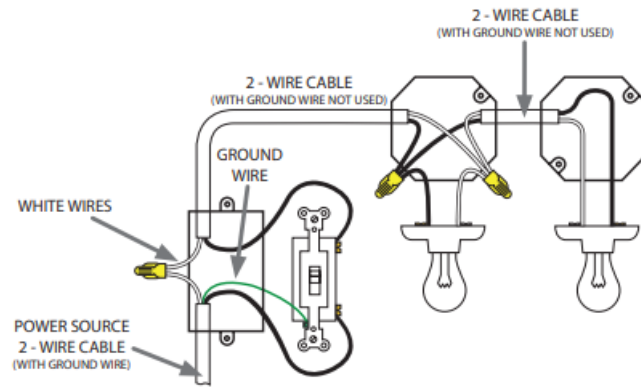
## Diagram Legend



### Exercise 3: Single-Pole Switch Controlling 1 Light



### Exercise 4: Single-Pole Switch Controlling 2 Lights

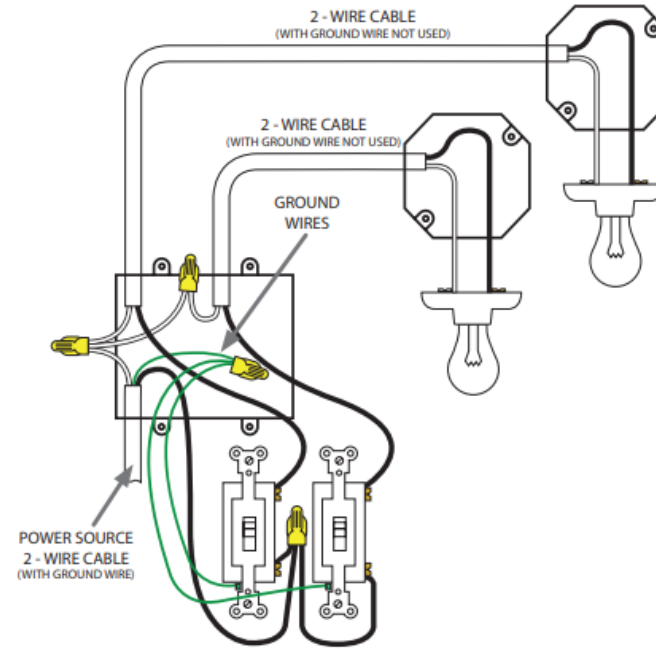


| WIRE AND SCREW COLOR DIAGRAM KEY |                      |                      |                       |
|----------------------------------|----------------------|----------------------|-----------------------|
| BLACK WIRE (HOT)                 | BLACK TERMINAL SCREW | WHITE WIRE (NEUTRAL) | SILVER TERMINAL SCREW |
| RED WIRE (HOT)                   | BRASS TERMINAL SCREW | GREEN WIRE (GROUND)  | GREEN GROUNDING SCREW |

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### Exercise 5: 2 Single-Pole Switches Controlling 2 Lights

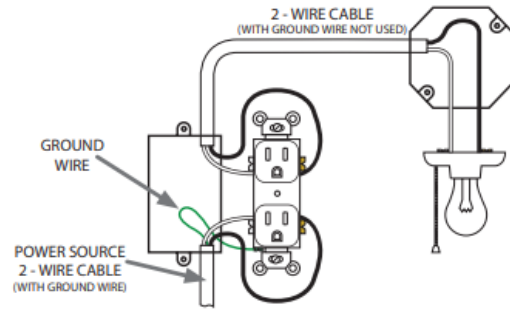


| WIRE AND SCREW COLOR DIAGRAM KEY |                      |                      |                       |
|----------------------------------|----------------------|----------------------|-----------------------|
| BLACK WIRE (HOT)                 | BLACK TERMINAL SCREW | WHITE WIRE (NEUTRAL) | SILVER TERMINAL SCREW |
| RED WIRE (HOT)                   | BRASS TERMINAL SCREW | GREEN WIRE (GROUND)  | GREEN GROUNDING SCREW |

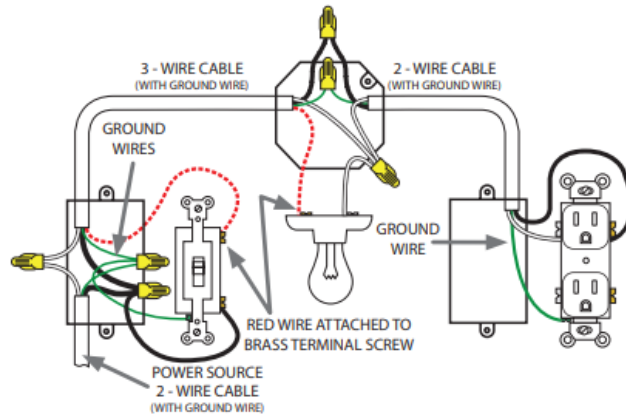
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### Exercise 6: Outlet, Light w/Pull Chain – Power Through Outlet



### Exercise 7: Single-Pole Switch, Light, and Outlet Using 14-3

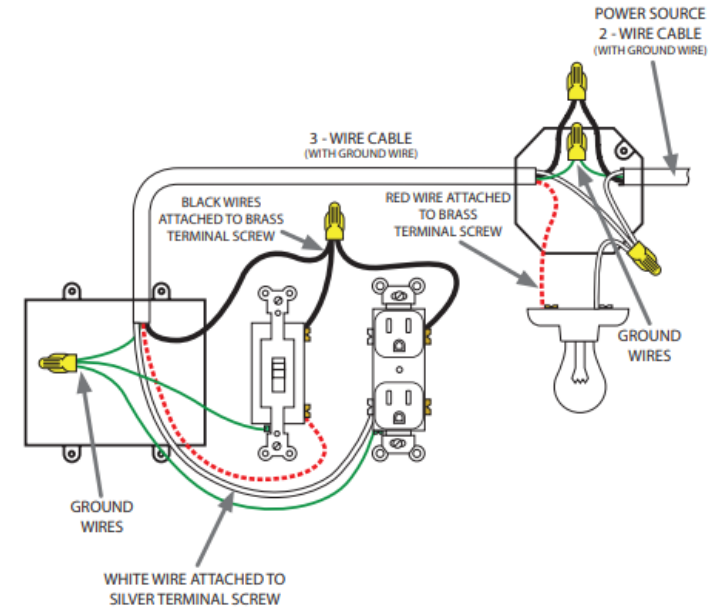


| WIRE AND SCREW COLOR DIAGRAM KEY |                        |                        |                         |
|----------------------------------|------------------------|------------------------|-------------------------|
| — BLACK WIRE (HOT)               | ■ BLACK TERMINAL SCREW | — WHITE WIRE (NEUTRAL) | ■ SILVER TERMINAL SCREW |
| ... RED WIRE (HOT)               | ■ BRASS TERMINAL SCREW | — GREEN WIRE (GROUND)  | ■ GREEN GROUNDING SCREW |

6

RealCareer™ Electrical Wiring Kit – Exercises

### Exercise 8: Switch in a Double Gang Box w/Light in Another Box, Power From Light



| WIRE AND SCREW COLOR DIAGRAM KEY |                        |                        |                         |
|----------------------------------|------------------------|------------------------|-------------------------|
| — BLACK WIRE (HOT)               | ■ BLACK TERMINAL SCREW | — WHITE WIRE (NEUTRAL) | ■ SILVER TERMINAL SCREW |
| ... RED WIRE (HOT)               | ■ BRASS TERMINAL SCREW | — GREEN WIRE (GROUND)  | ■ GREEN GROUNDING SCREW |

RealCareer™ Electrical Wiring Kit – Exercises

7

# WHAT IS STEM?

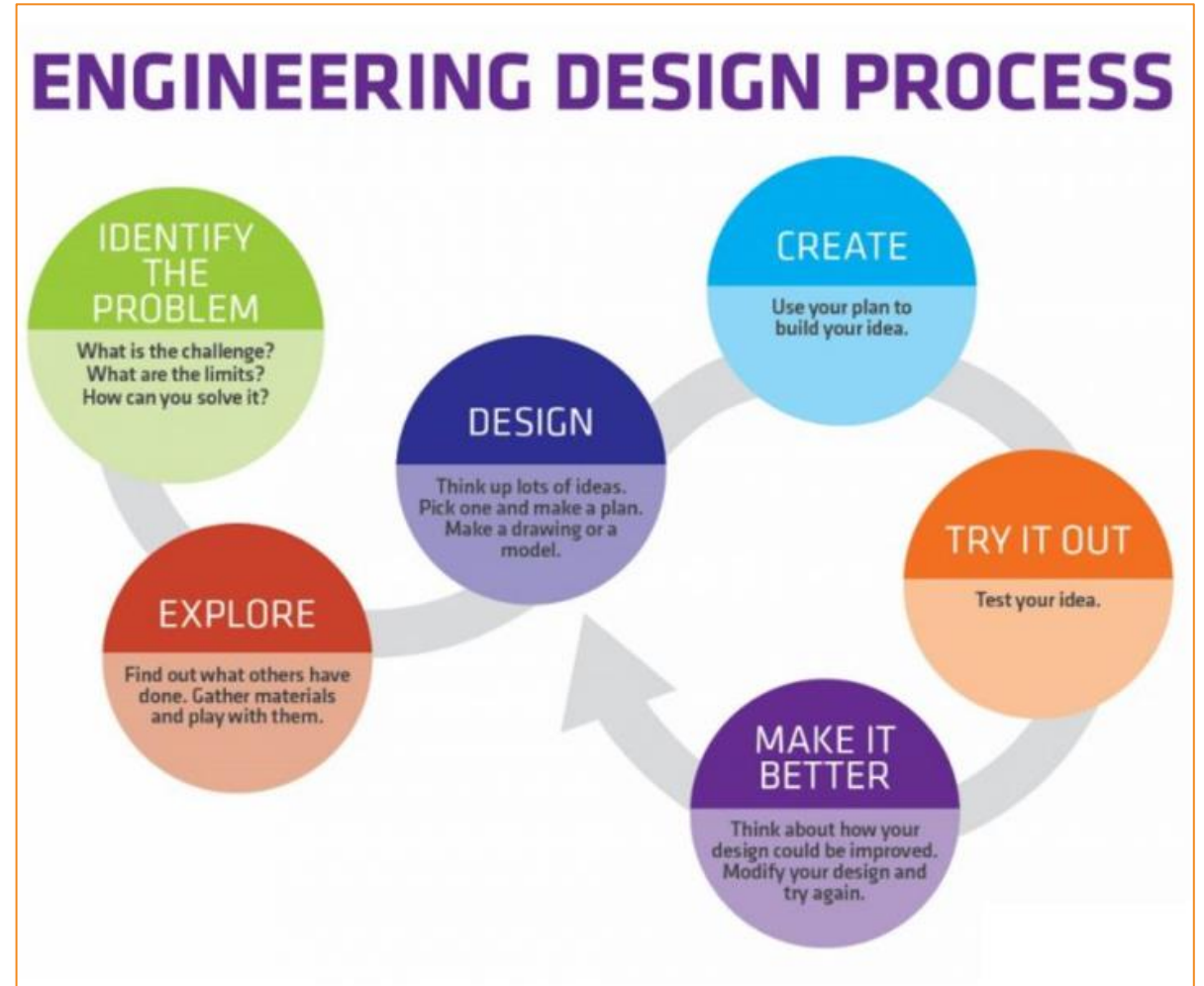
***Statement:***

**CTE Education is STEM & STEM is CTE Education, we are teaching and using STEM to create next generation learners.**

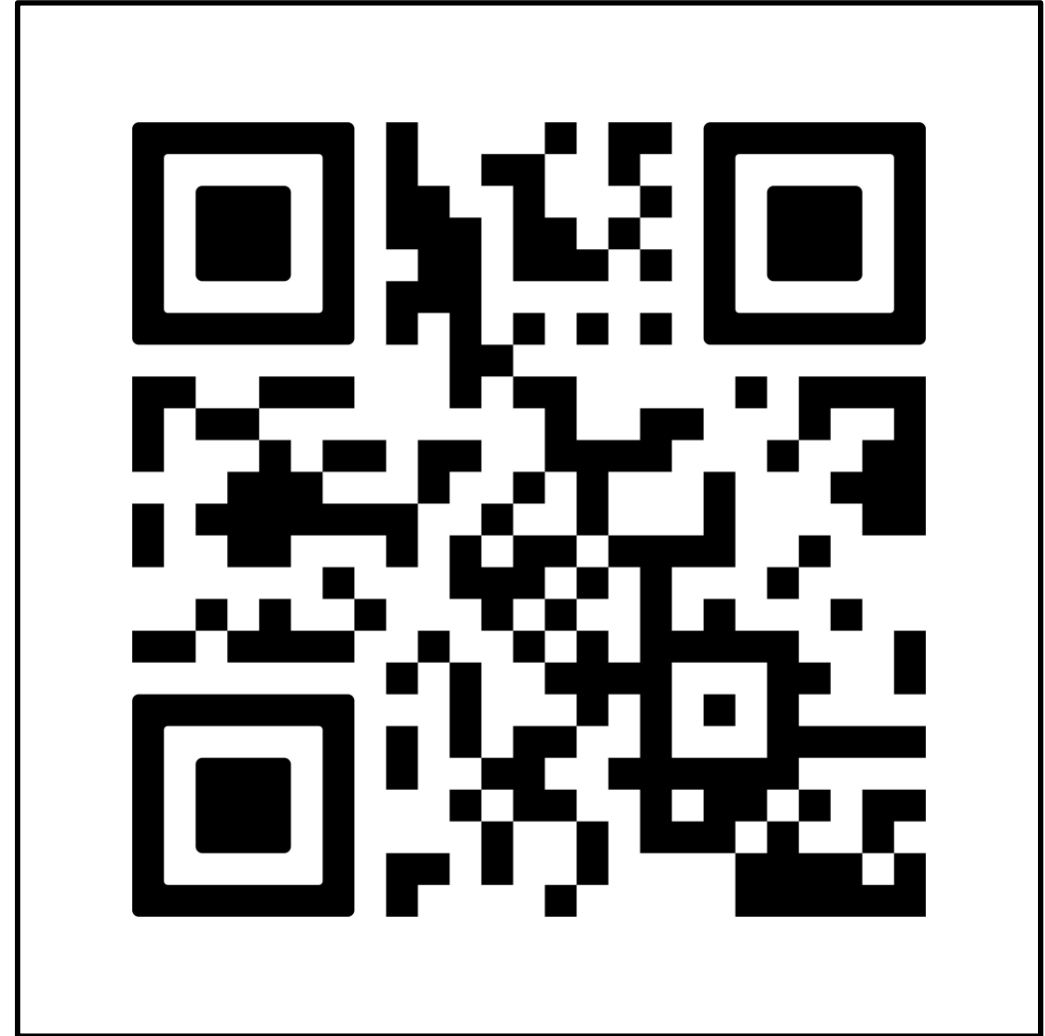


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  - *Learning in Action*



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