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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.

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- We can help you start or refresh your own program!
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WHAT IS STEM?

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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."

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WHAT DOES STEM LOOK LIKE IN CTE?

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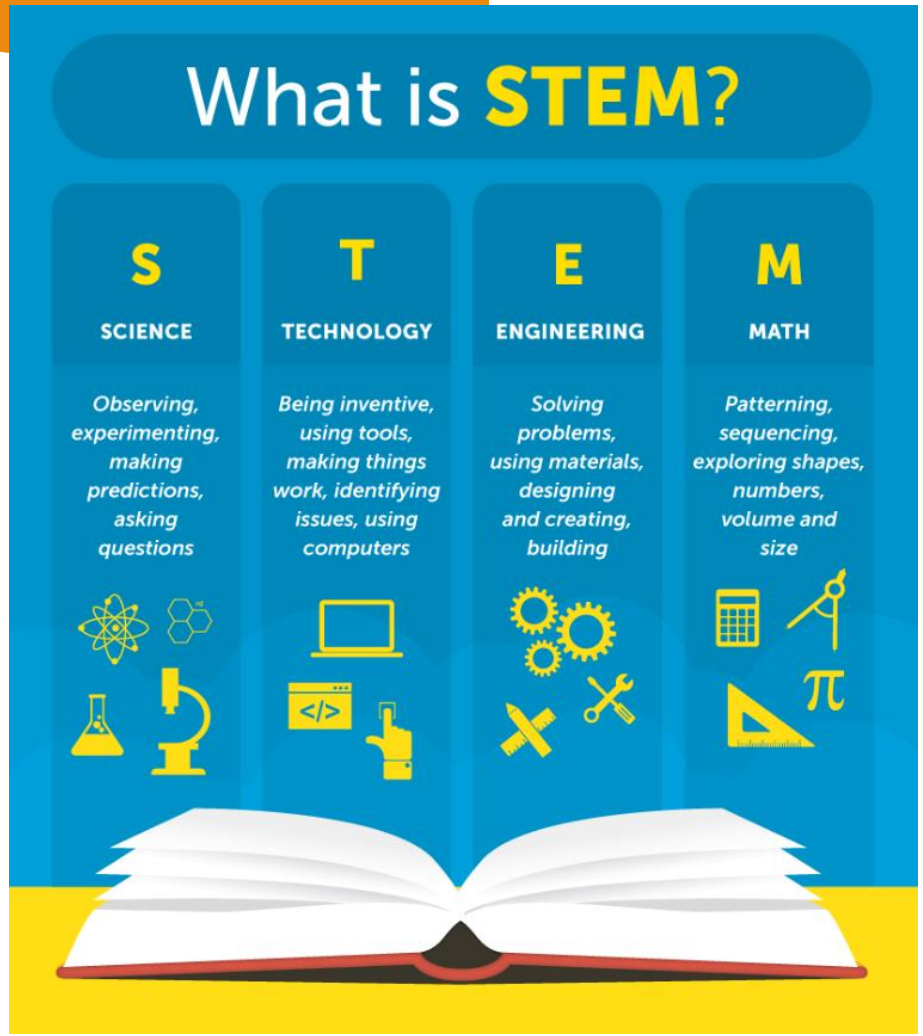
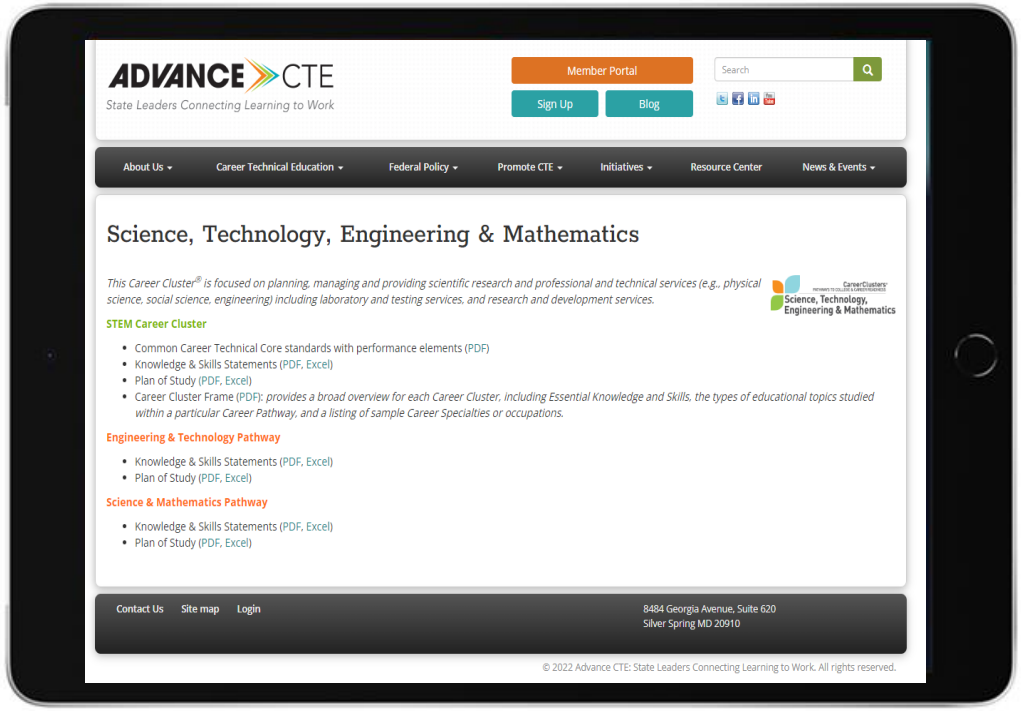
Driving toward STEM Education through CTE



- 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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The Career Clusters and Sample Related STEM CAREERS

Career Cluster	Samples of Stem Careers[25]
Agriculture, Food & Natural Resources	• Agriculture Technicians • Agriculture Engineers • Forest and Conservation Workers • Foresters • Food Science Technicians • Veterinarians • Marine Biologists • Water Resource Specialists v
Architecture & Construction	• Architects • Civil Engineers • Civil Engineering Technicians • Surveyors • Drafters • Cost Estimators
Arts, A/V Technology & Communications	• Graphic Designers • Telecommunications Engineering Specialists • Multimedia Artists & Animators • Audio Technicians
Business Management & Administration	• Accountants • Auditors • Operations Research Analysts
Education & Training Finance	• STEM K-12 or postsecondary Teachers • Speech-Language Pathologists • Actuaries • Financial Analysts • Financial Planners • Loan Officers • Investment Bankers
Government & Public Administration	• Patent Officer • Cryptographers • Policy Analysts • Climate Change Analysts • Intelligence Analysts
Health Science	• Physicians • Nurses • Geneticists / Biotechnology Researchers • Biologists • Dietitians and Nutritionists • Dental Hygienists

Career Cluster	Samples of Stem Careers[25]
Hospitality & Tourism	• Museums/Zoos/Aquariums Personnel • Parks and Gardens Rangers • Brewers • Pastry and Specialty Chefs
Human Services	• Developmental Psychologists • Personal Trainers • Mental Health Counselors • Massage Therapists
Information Technology	• Programmers • Hardware, Software Engineers • Computer Support Specialists • Information Security Analysts • Database Administrators • Webmasters • Video Game Designers
Law, Public Safety, Corrections & Security	• Emergency Medical Technicians • Firefighter/Inspectors • Fire-Prevention and Protection Engineers • Brownfield Redevelopment Specialists and Site Managers
Manufacturing	• Aircraft Mechanics and Service/ Avionics Technicians • Automotive Mechanics • Mechanical Engineers • Electronics Engineers • Electronics Engineering Technicians • Wind Turbine Service Technicians • Welders
Marketing	• Interactive Media Specialists • Market Researchers • Forecasting Managers • Inventory Manager/Analysts
STEM	• Any/all of careers listed
Transportation, Distribution & Logistics	• Transportation Planners • Transportation Engineers • Occupational Health and Safety Technicians • Transportation Vehicle, Equipment and Systems Inspectors

***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.

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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.

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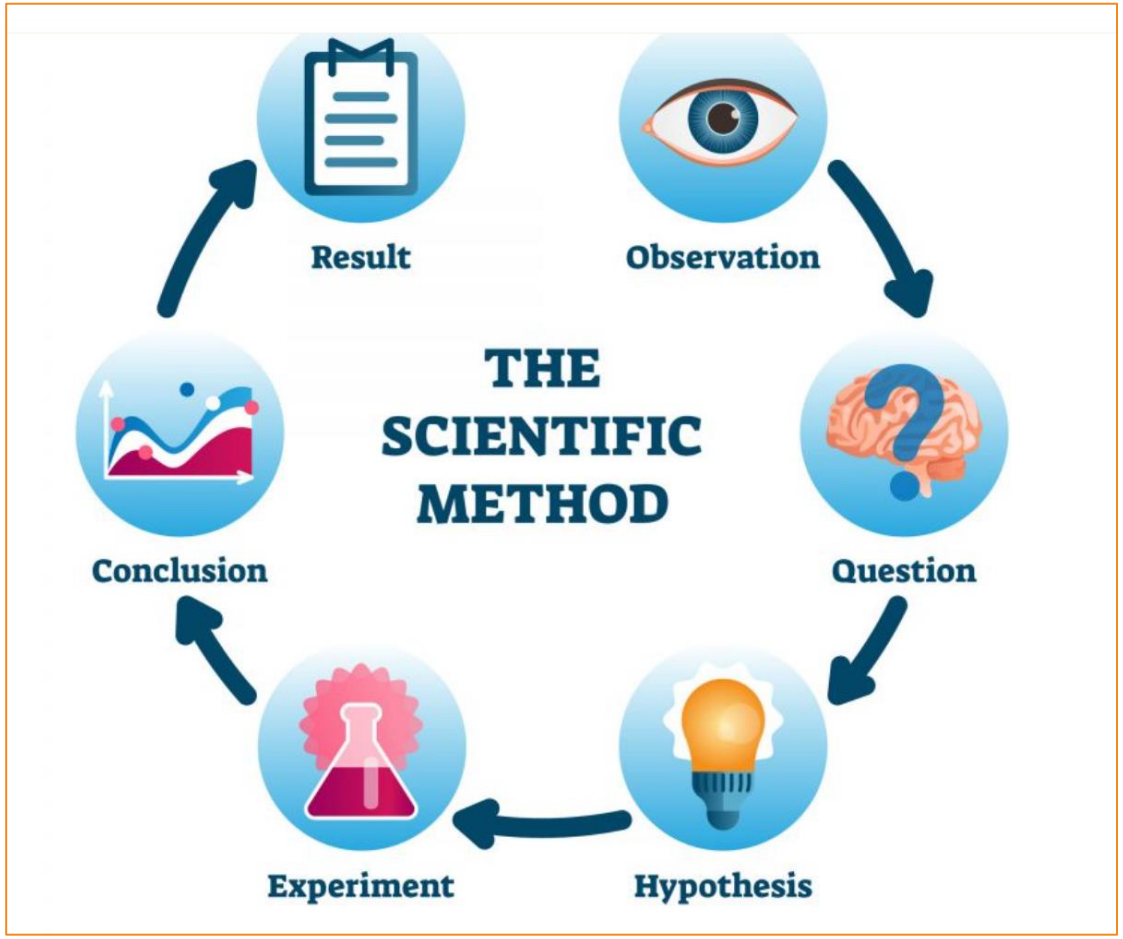
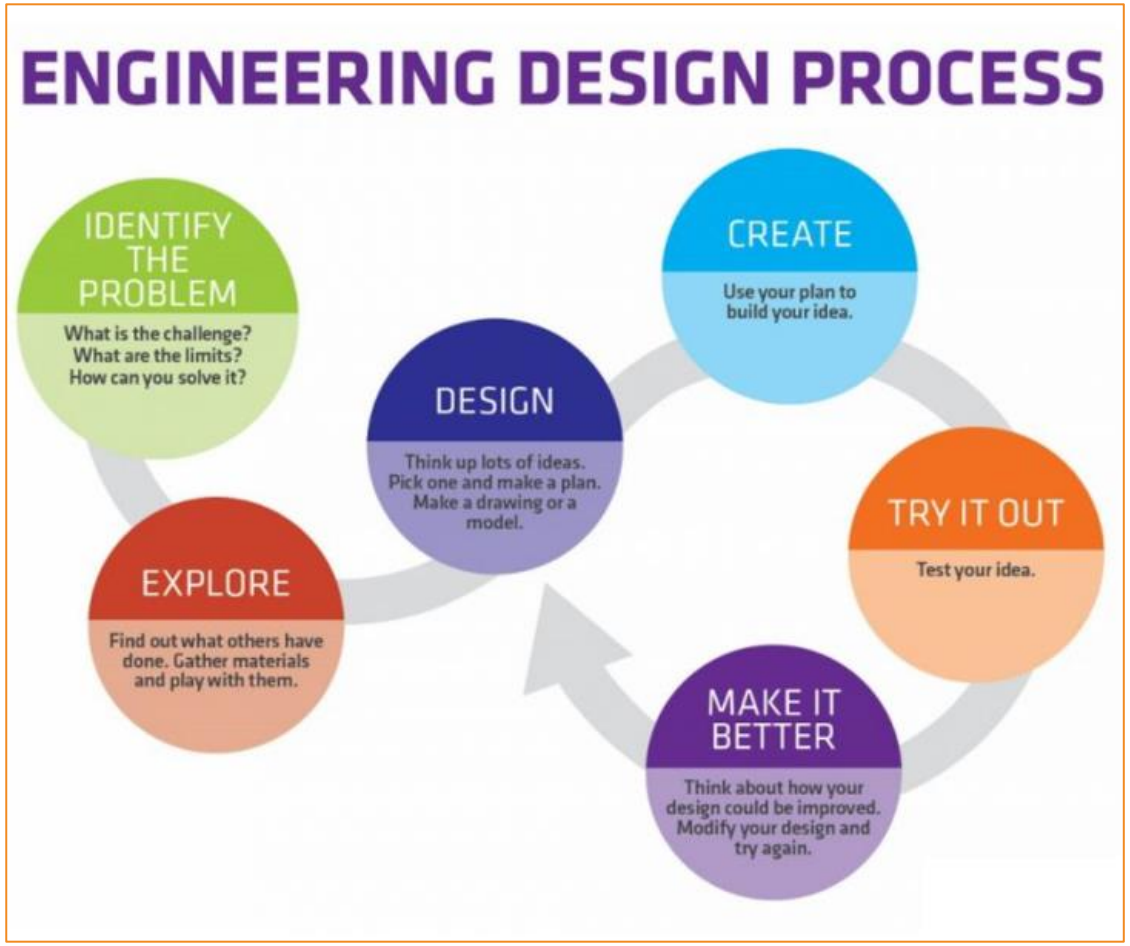
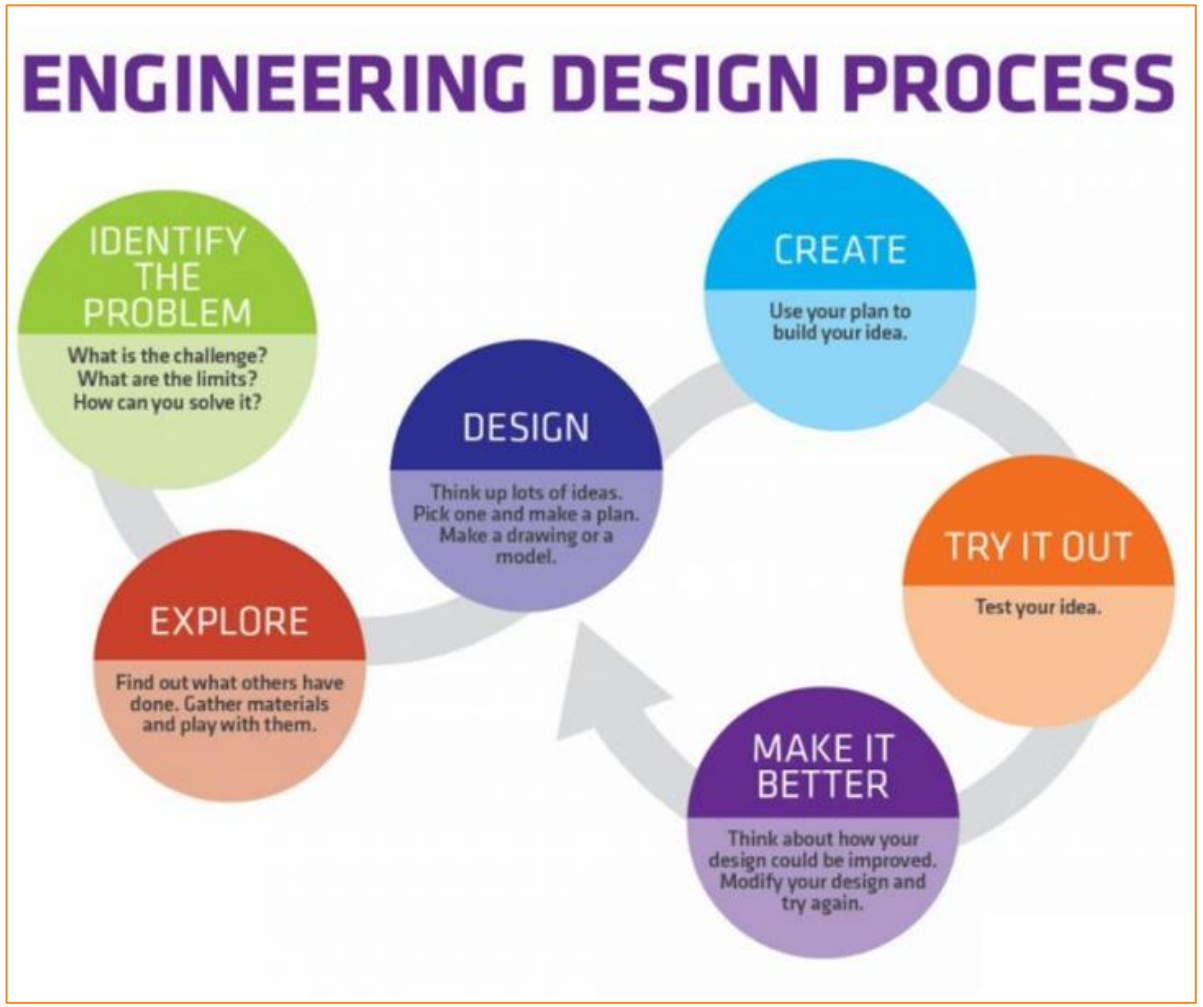
Method to the Measurement





How do we use this design for our classrooms?

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



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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) Responses	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) Responses	22.22%

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

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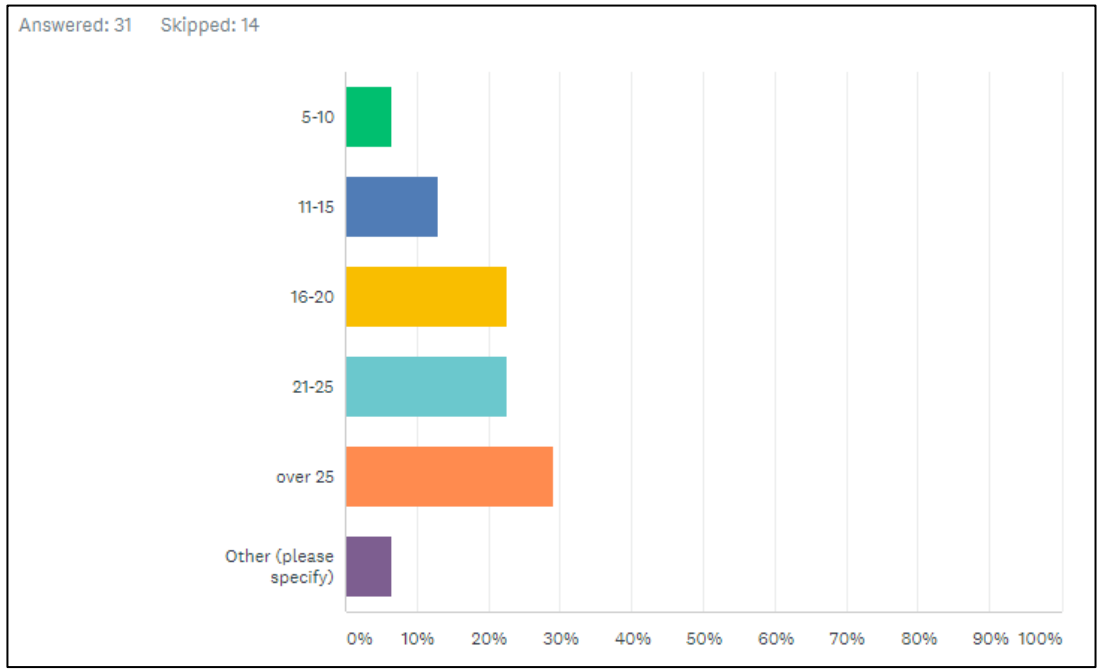
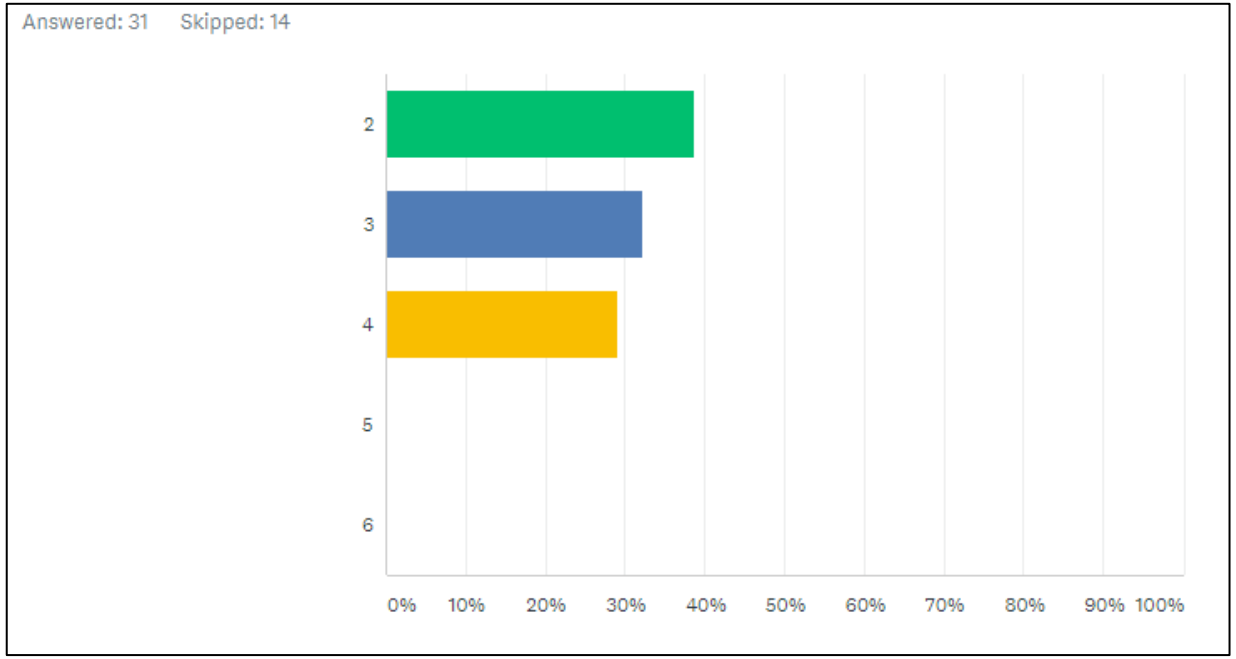
Number of students in class?
Number of students for group work?

Individual Learning | Team Learning | Learning in Action

Students in STEM classes

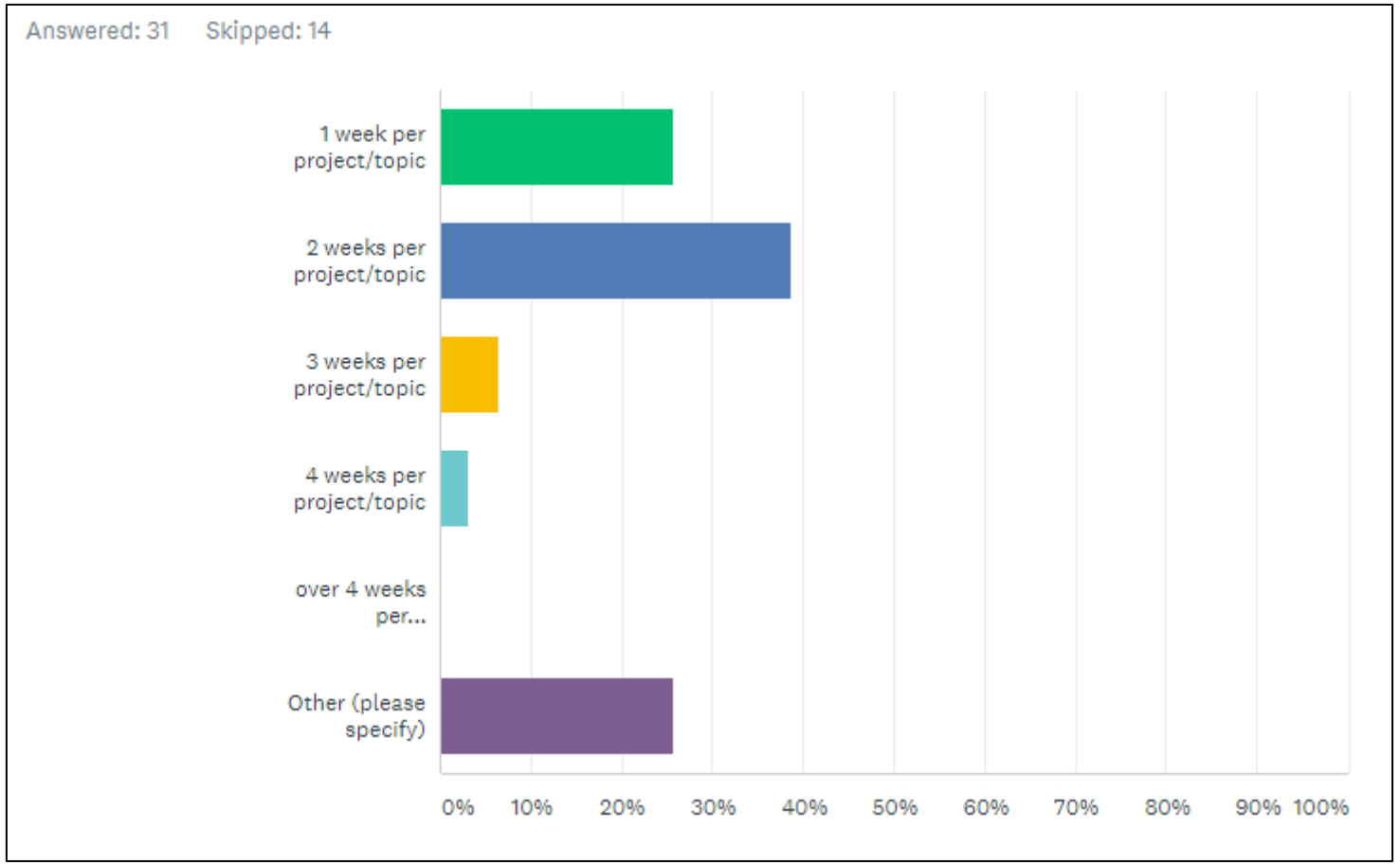


Students for STEM group work



Average “Time on Task” for STEM Projects

Individual Learning | Team Learning | Learning in Action



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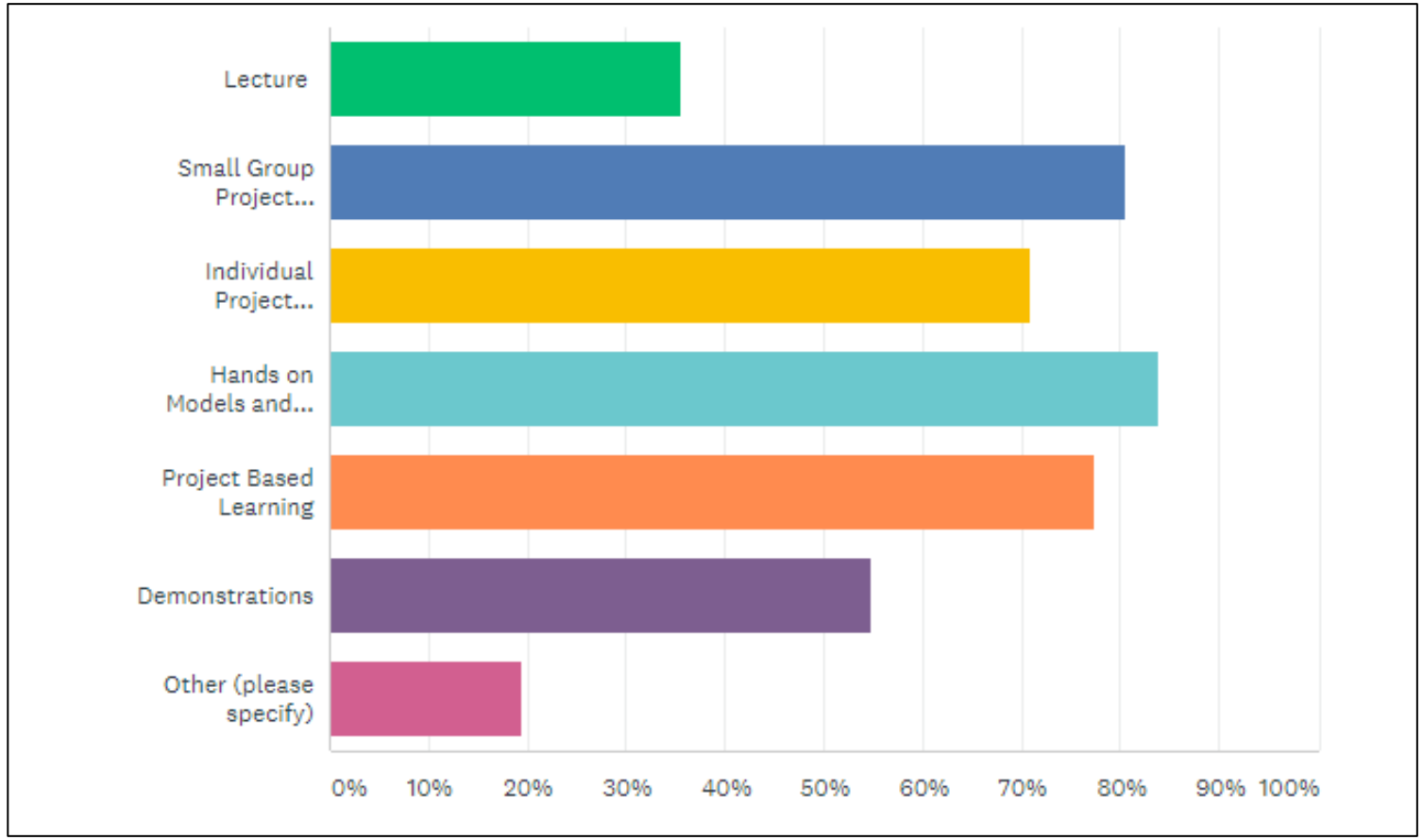
Types of teaching models work best in STEM

Individual Learning

Team Learning

Learning in Action



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STEM Methodology based off of Engineering Design

Individual Learning	Team Learning	Learning in Action

• 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
	• 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
		• 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

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RC Tractor Pull Challenge

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BLOG

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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

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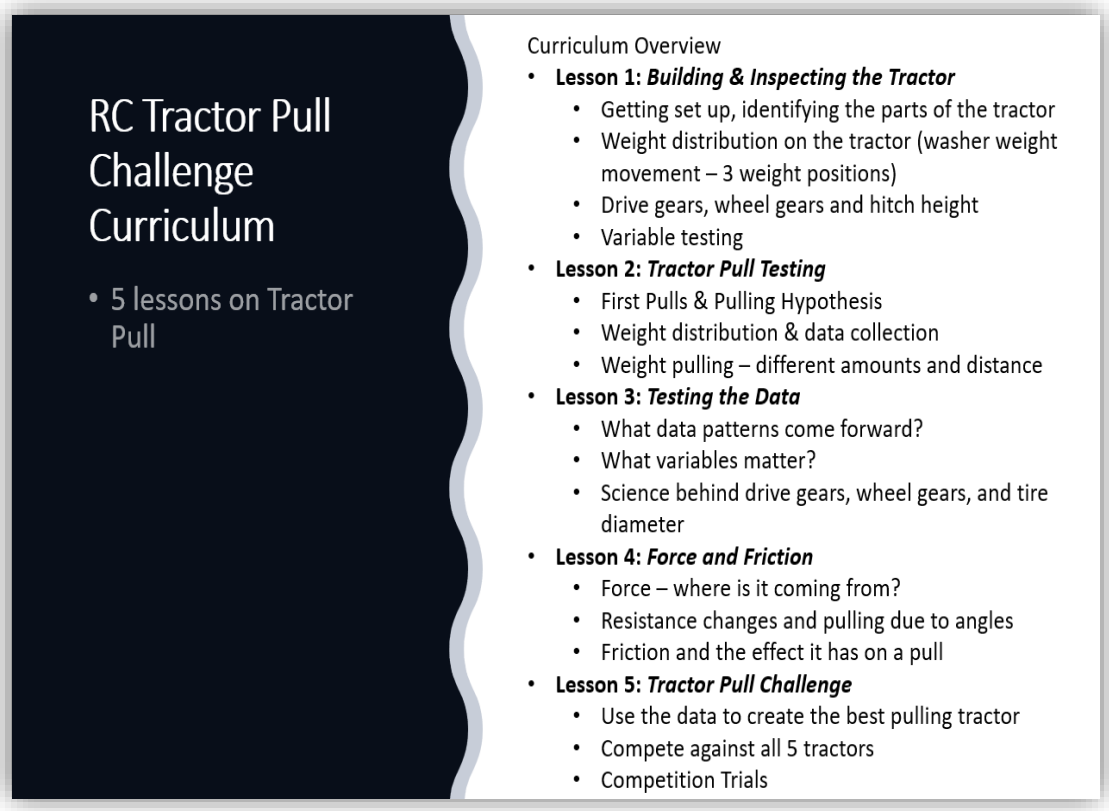
Rules of Engagement



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

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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.

e are only 6 N of friction and 20 N of
rom the motor, we only max out at 6
ush against the ground because
ll the friction will allow

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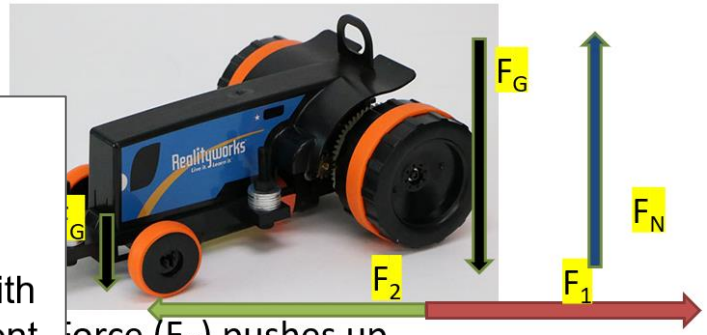
Gravity and Normal Force

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



orce (F_N) pushes up
F_G) pulls down.
u

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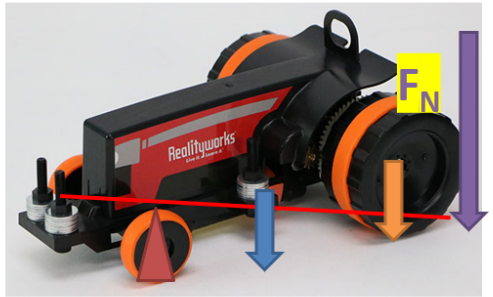
How Much Difference Do the Weights Make?



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

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*).

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Physics of the Tractor Pull 8 Realityworks

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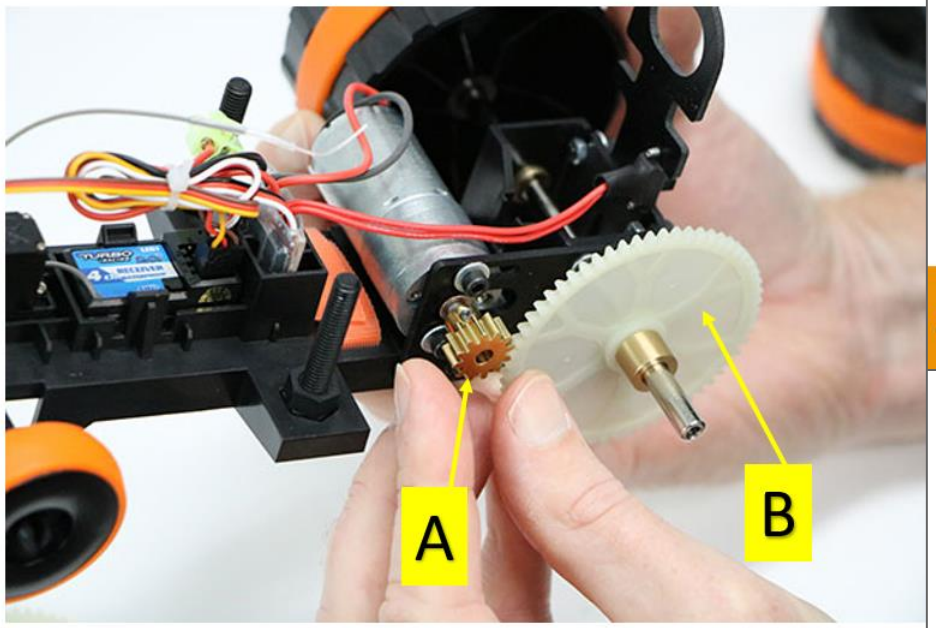
Tires

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

Gears

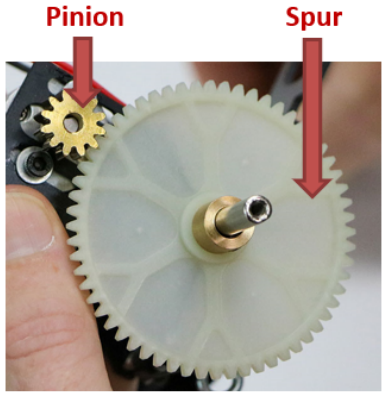
A: 2 pinion gears adjusted with the small hex key
B: 3 spur gears (small and large) adjusted with the small hex key
C: **Gently** slide the gears on the motor rod and axle



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

Gears



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

- $MA = \frac{Teeth\ on\ spur\ gear}{Teeth\ on\ pinion\ gear}$
- 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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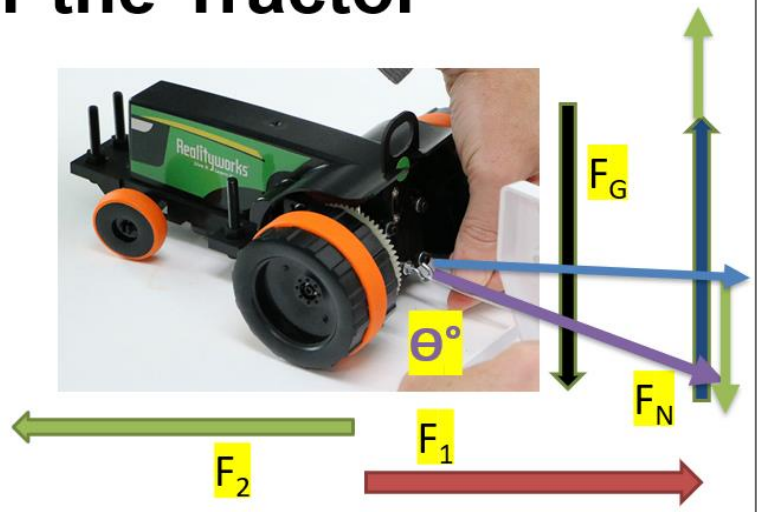
For the Tractor

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

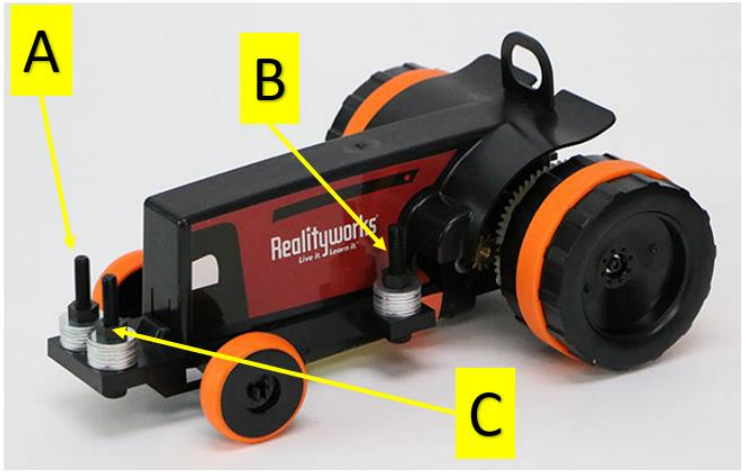


to increase by the same amount. This increases F_1 (Friction) and the F_2 (the push forward).

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

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	
Small[1]	Small	Small	Low	Even	
Large	**Large[2]**	Small	Low	Even	
Large	Small	**Medium[3]**	Low	Even	
Large	Small	**Large[3]**	Low	Even	
Large	Small	Small	**Medium[4]**	Even	
Large	Small	Small	**High[4]**	Even	
Large	Small	Small	Low	**Front max[5]**	
Large	Small	Small	Low	**Middle max[5]**	
Large	Small	Small	Low	**None[5]**	
Small[1]	Small	Small	High	Even	
Large	**Large[2]**	Small	High	Even	
Large	Small	**Medium[3]**	High	Even	
Large	Small	**Large[3]**	High	Even	

Name: _____ Class: _____

Gears and Tires

Directions: Solve each problem as directed in the presentation.

1. 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	

2. 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 $Force_{out}$ = MA x $Force_{in}$	RPM $Speed_{out}$ = $Speed_{in}$/MA
Small	Small			
Small	Large			
Large	Small			

3. 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 MA = D_{in}/D_{out}
Small	Small	
Small	Medium	
Small	Large	
Large	Small	
Large	Medium	
Large	Large	

4. After slide 12, if your small spur gear was turning with and 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?
   a.
   b.

5. 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	SpurGear	Tire	(a) MA total $MA_T = MA_1 \cdot MA_2$	(b) Force out $F_o = F_{in} * MA_T$	(c) Speed out $S_o = S_{in}/MA_T$
Large	Medium	Large			
Small	Large	Small			

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STEM Concepts

What Is Friction?

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

  $F_{Static\ Friction} = F_{Normal} \times \mu_s$
  $F_{Kinetic\ Friction} = F_{Normal} \times \mu_k$
- 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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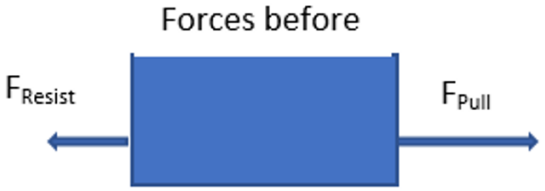
Force Diagram of Sled: Start



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

$F_{Pull} > F_{Resist}$

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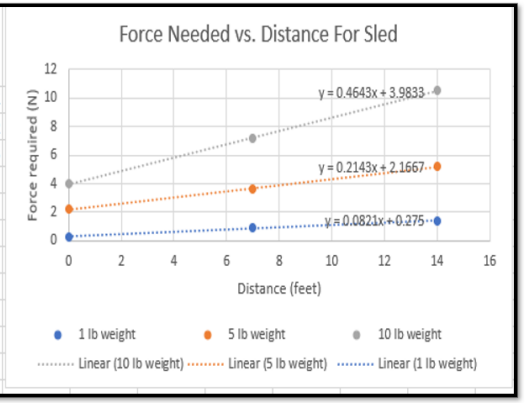
Force Required To Pull the Sled at Various Distances

Distance pulled (feet)	Force (N) for 1lb weight	Force (N) for 5lb weight	Force (N) for 10lb weight
0	0.25	2.2	4
7	0.9	3.6	7.2
14	1.4	5.2	10.5



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Measurement Math Kit

Shown: Lesson example on a tablet screen

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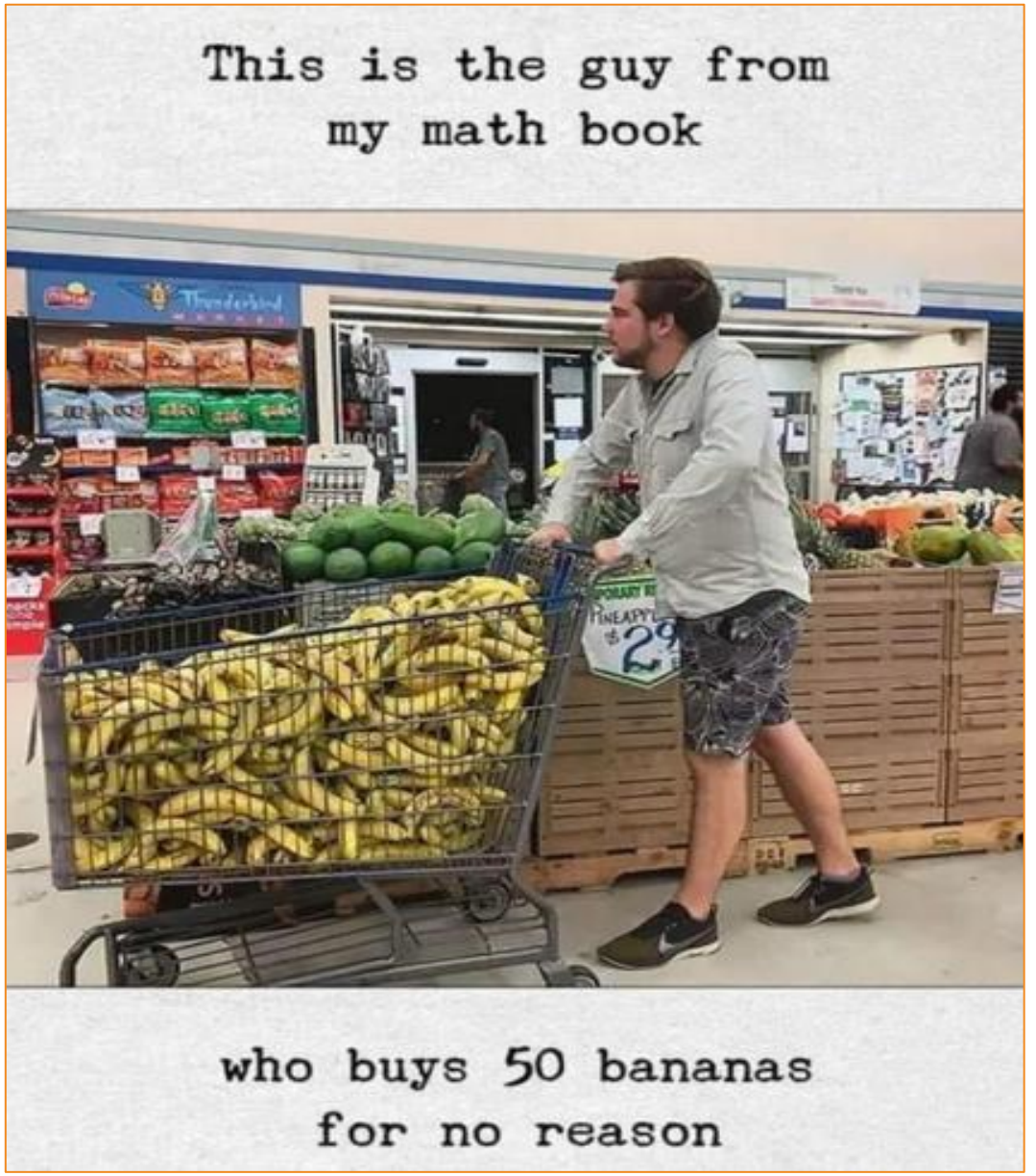
BLOG

What Do They Need to Know?

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



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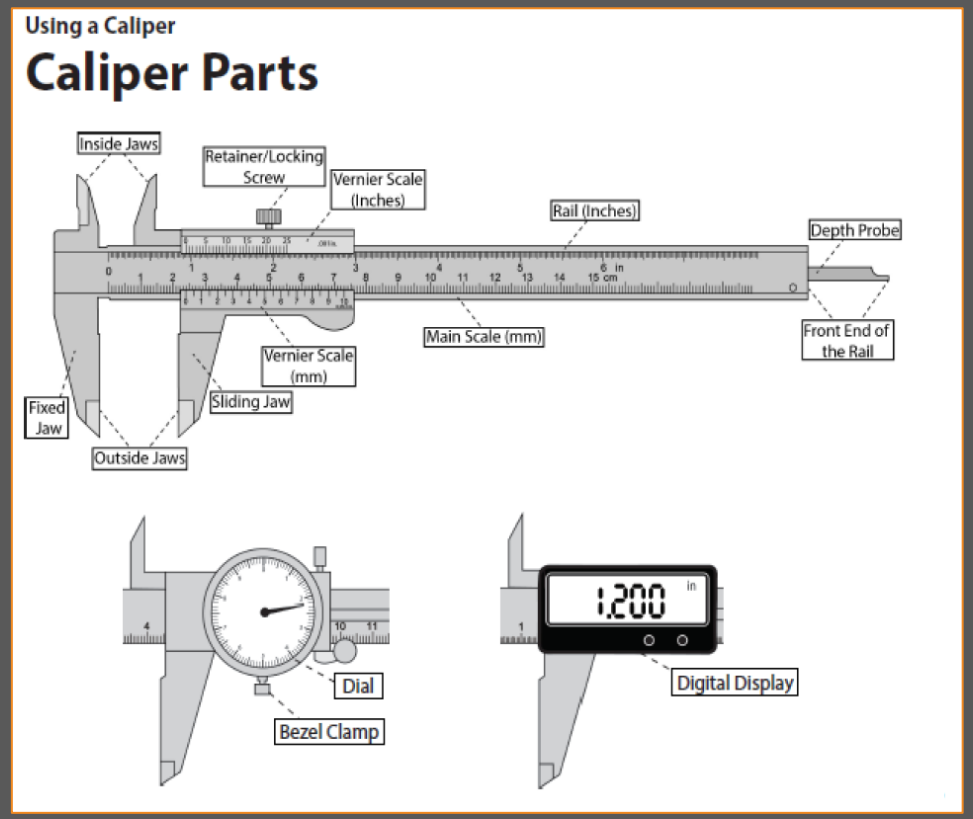
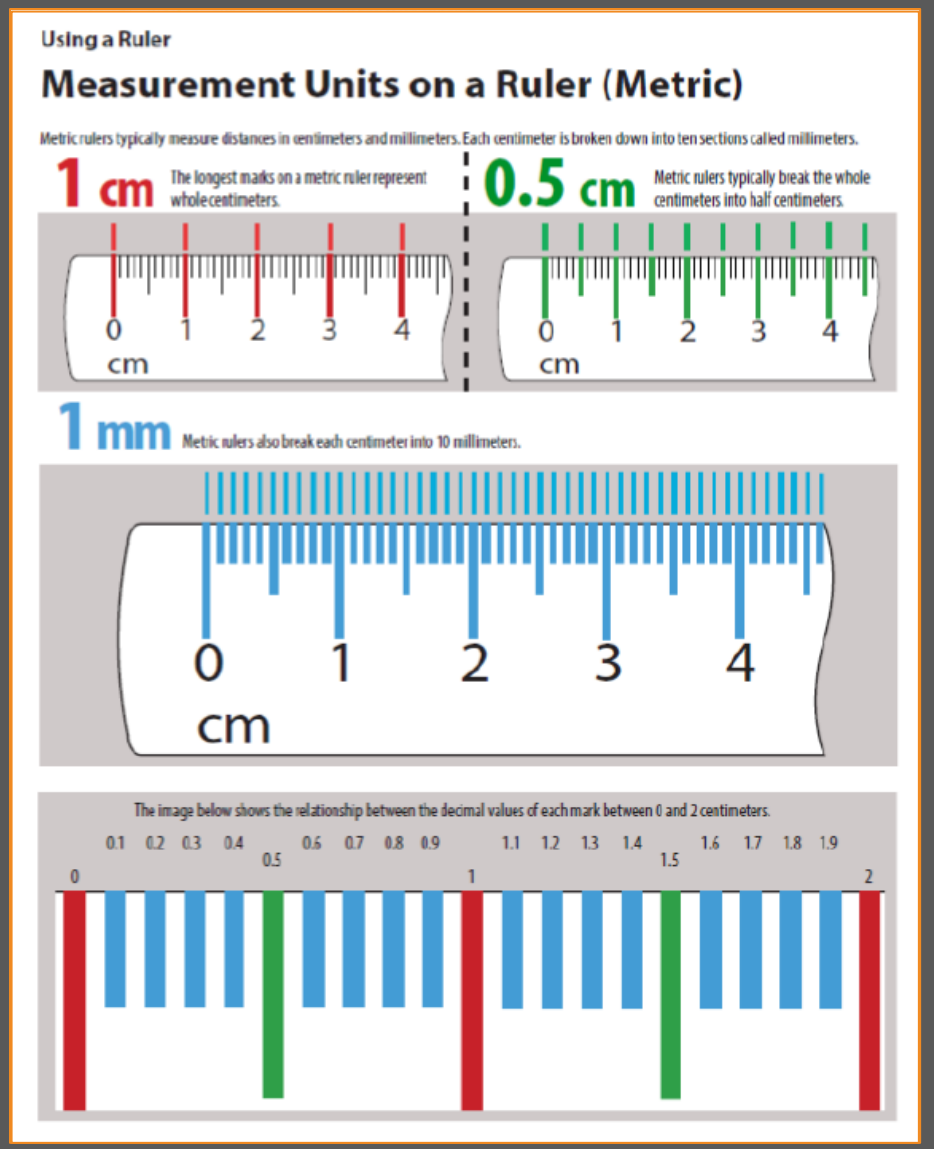
Bite Sized Chunks





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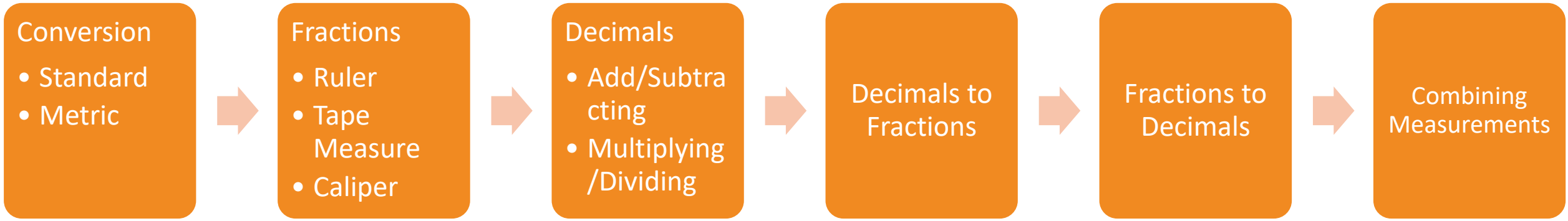
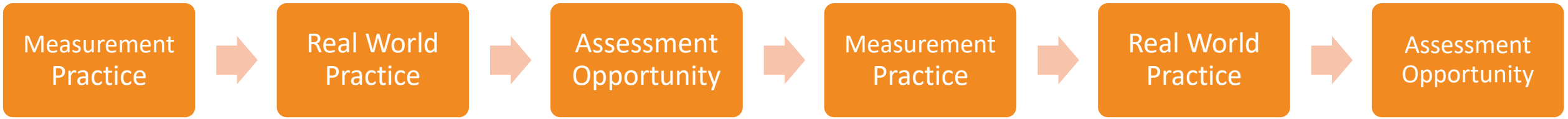
Integration





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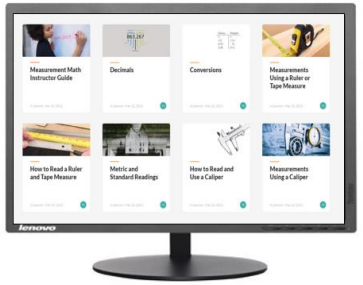
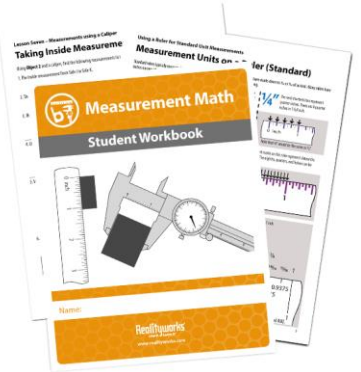
Multiple Modalities

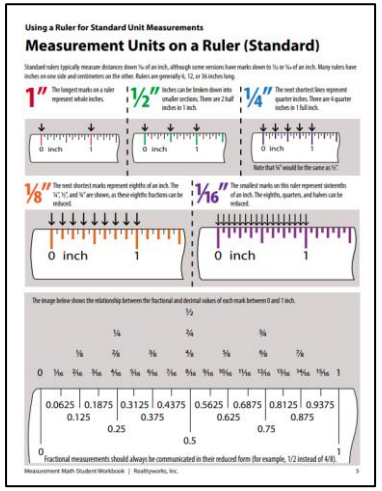




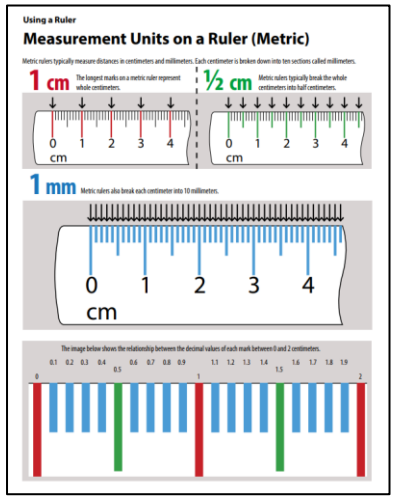
Measurement Math Lessons

- 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

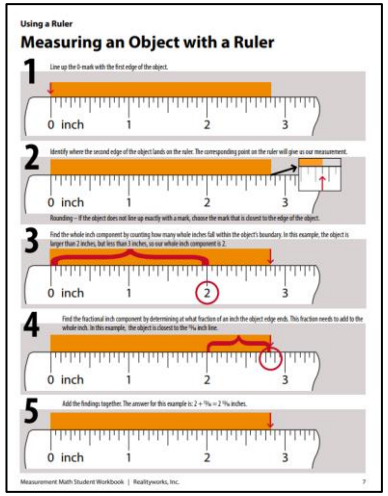
Student Workbooks


Using a Ruler for Standard Unit Measurements

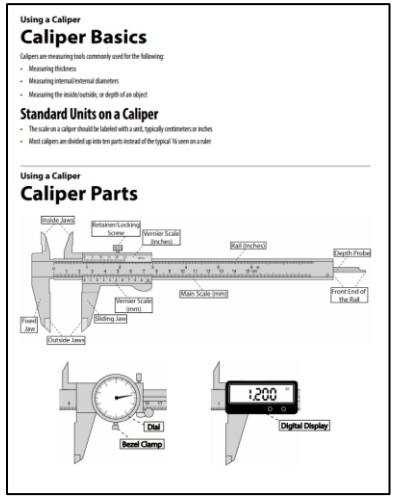
Measurement Units on a Ruler (Standard)


Using a Ruler

Measurement Units on a Ruler (Metric)


Using a Ruler

Measuring an Object with a Ruler

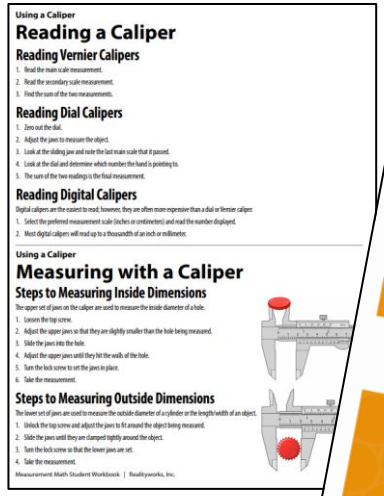

Using a Caliper

Caliper Basics

Standard Units on a Caliper

Using a Caliper

Caliper Parts


Using a Caliper

Reading a Caliper

Reading Vernier Calipers

Reading Dial Calipers

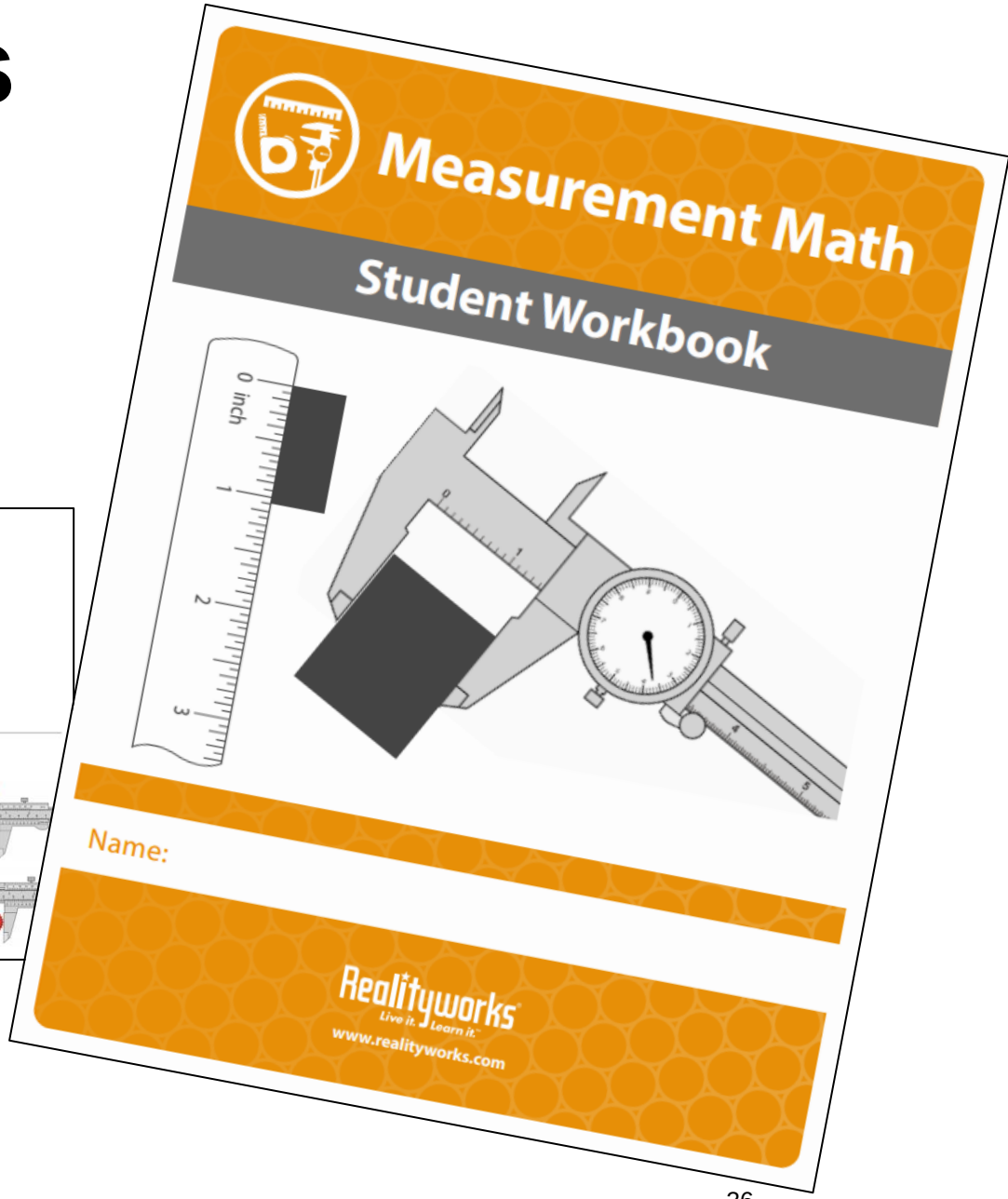
Reading Digital Calipers

Using a Caliper

Measuring with a Caliper

Steps to Measuring Inside Dimensions

Steps to Measuring Outside Dimensions



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Electrical Wiring Kit

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
- (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

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)

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BLOG

Components

Electrical Wiring Assessment Kit:
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Electrical Wiring Kit

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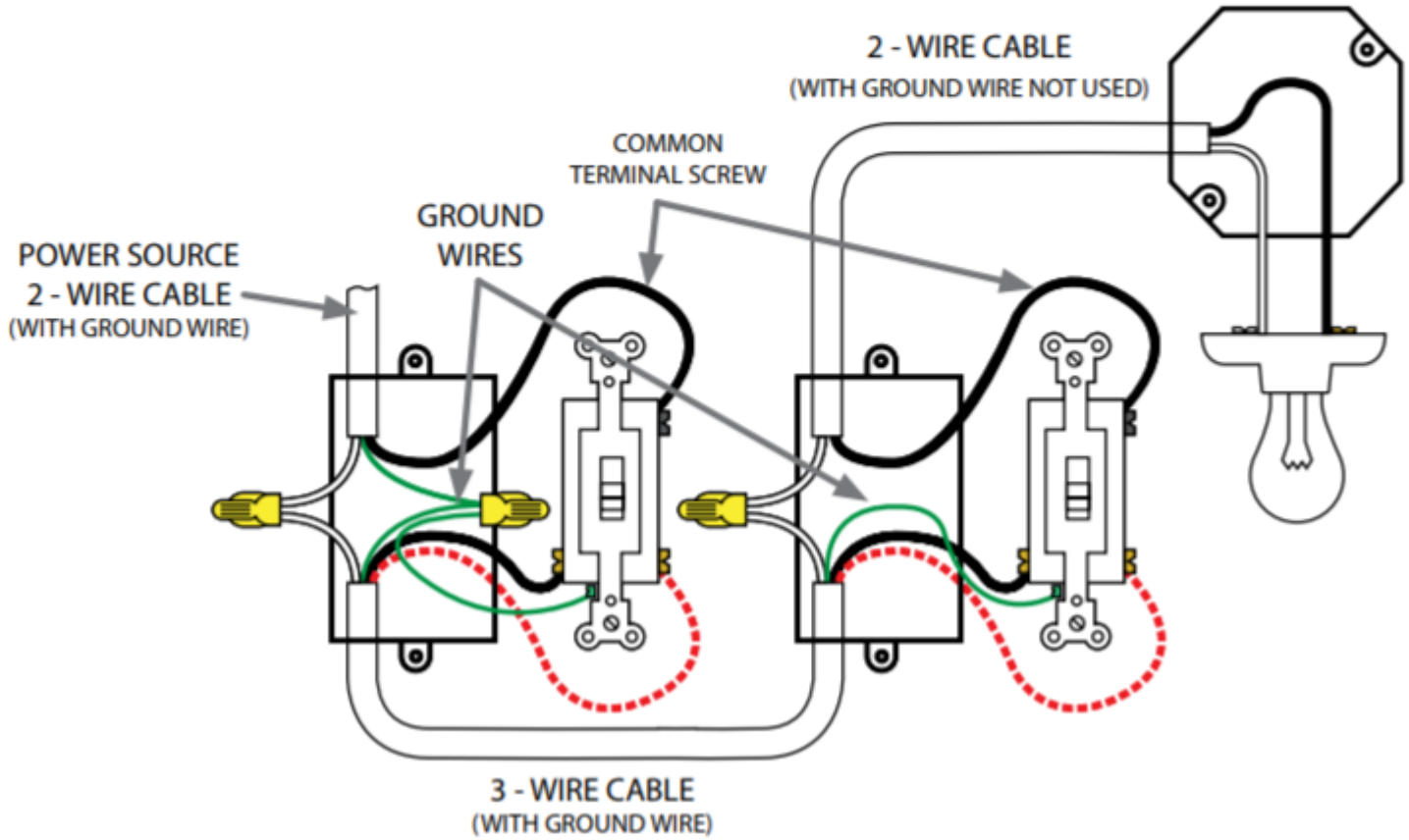
Exercise Eleven – 3-Way Switches with a Light, Power Entry through both Switches First



How Does Electricity Get to T

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

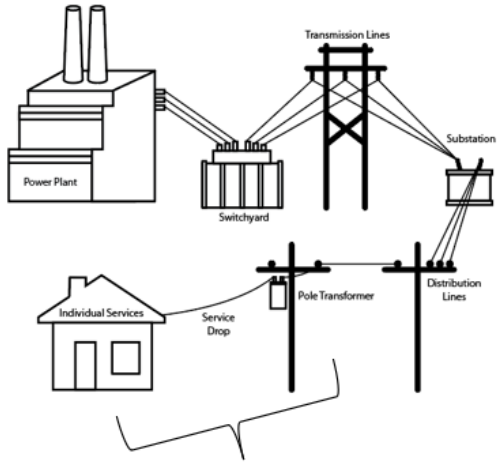
- Electricity is produced b such as a hydroelectric plant, wind turbine, sola plant.
- The voltage is stepped u transmitted. This lowers (remember P = V x I). T lost by resistance in the which can add up over e

How Does Electricity Get to The Home?

- Once electricity nea manageable voltage
- Distribution lines tak neighborhoods and

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).



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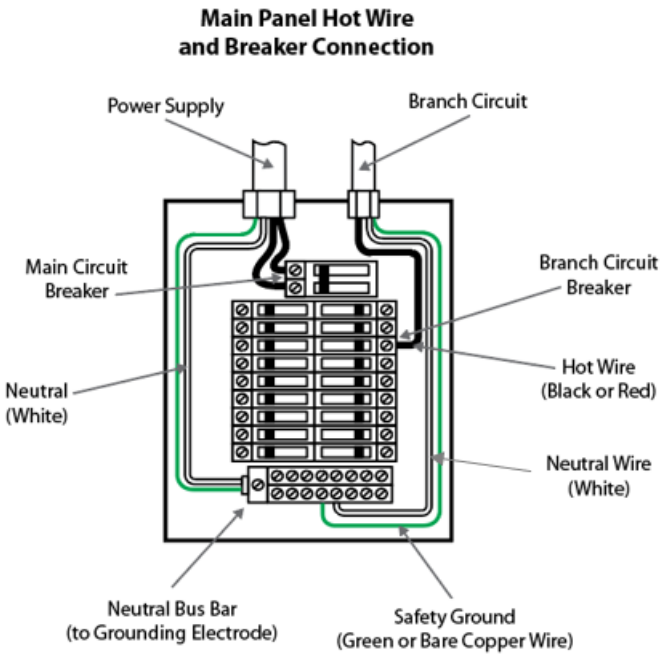
How Is Electricity Distributed Within a Home?

- Electricity enters your home as 240
- It goes through a meter, so the utilit company can get paid for electricity you use.
- It enters your main panel as two 12 service lines.
- Household circuits can be split between these service lines.
- 240V loads can be placed across th service lines to get the higher voltag

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.



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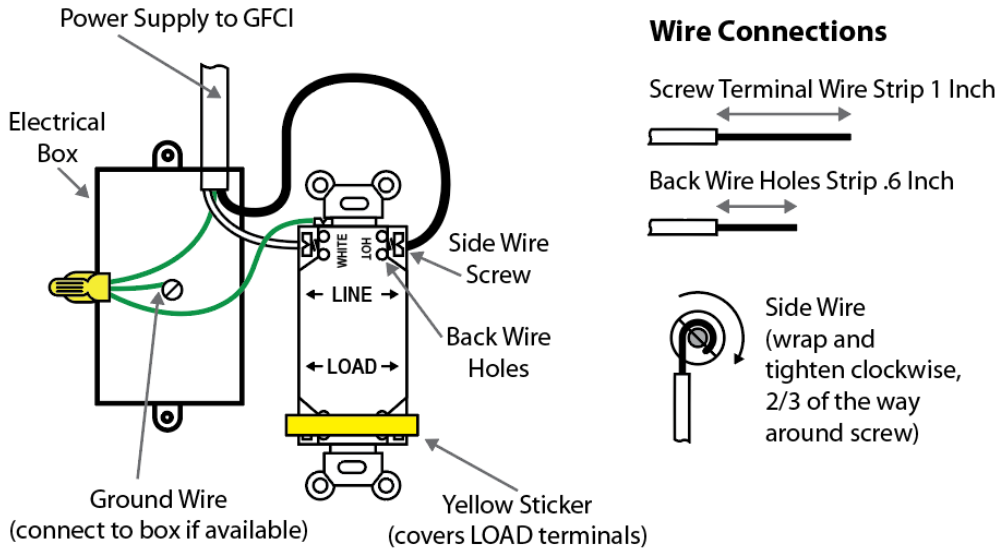
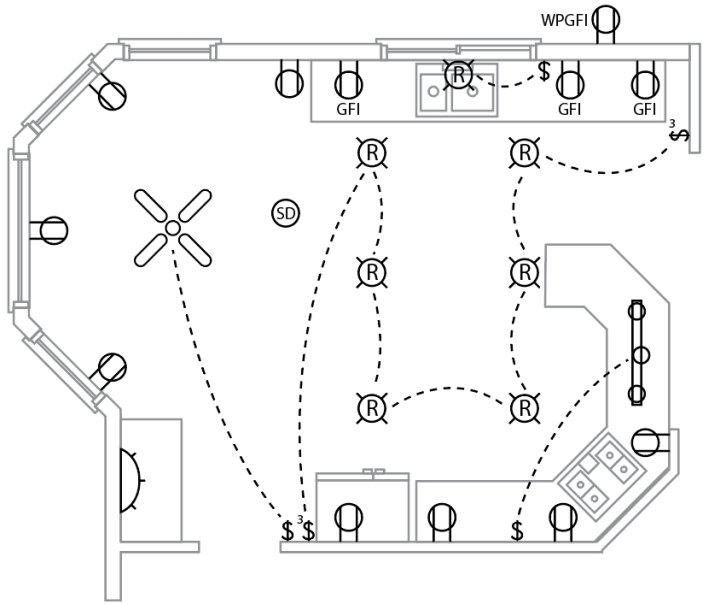
Wiring Diagrams

- 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

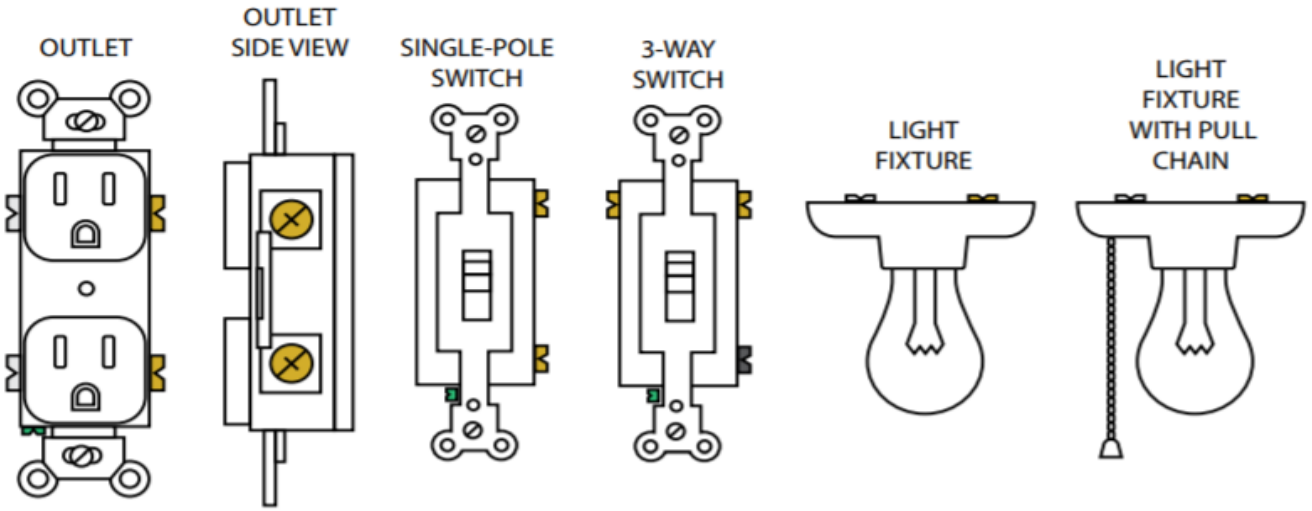
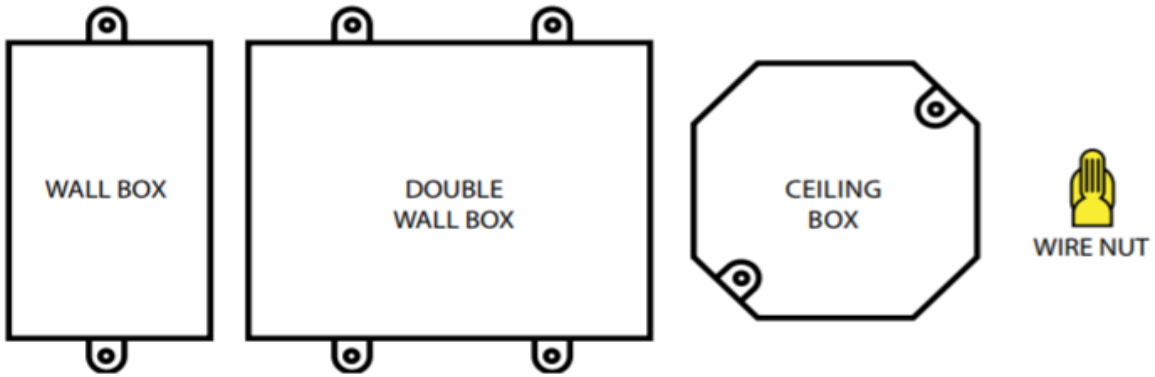
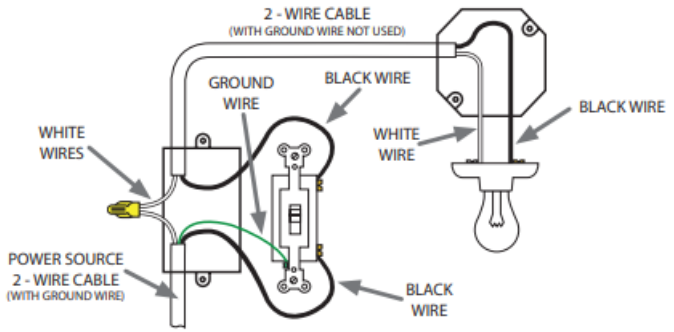


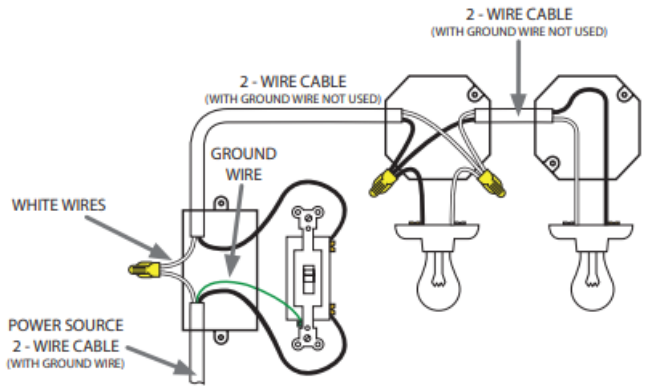
Diagram Legend



Exercise 3: Single-Pole Switch Controlling 1 Light

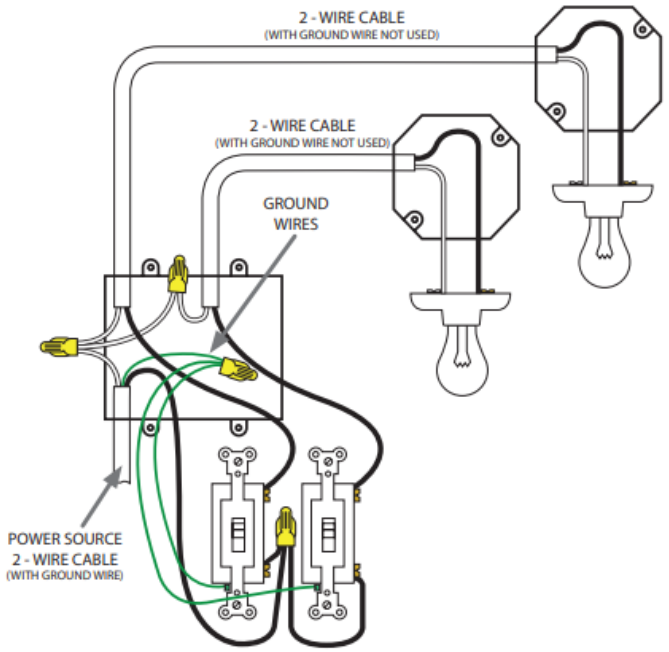


Exercise 4: Single-Pole Switch Controlling 2 Lights



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

Exercise 5: 2 Single-Pole Switches Controlling 2 Lights



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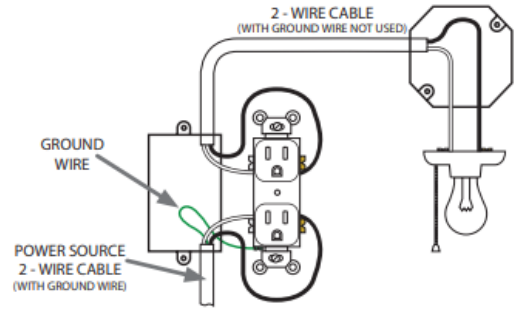
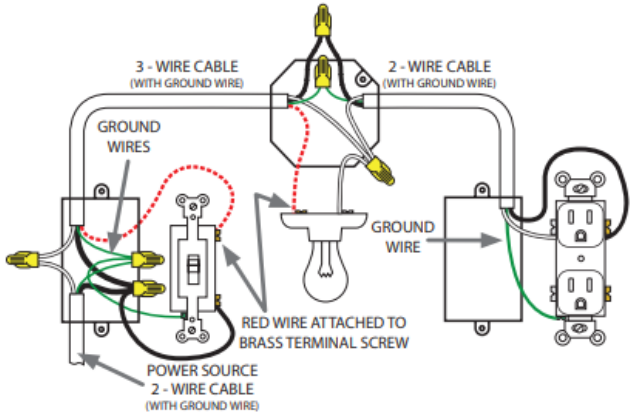
GREEN WIRE (GROUND)	GREEN GROUNDING SCREW

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



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



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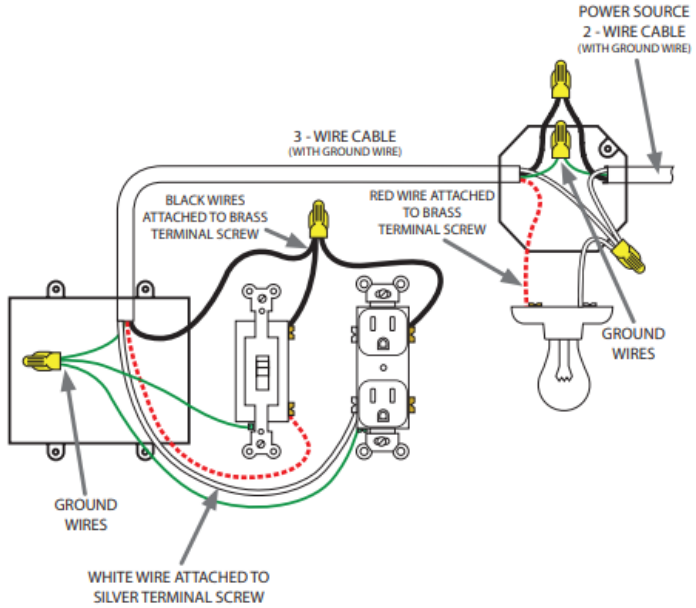
Exercise 8: Switch in a Double Gang Box w/Light in Another Box, Power From Light



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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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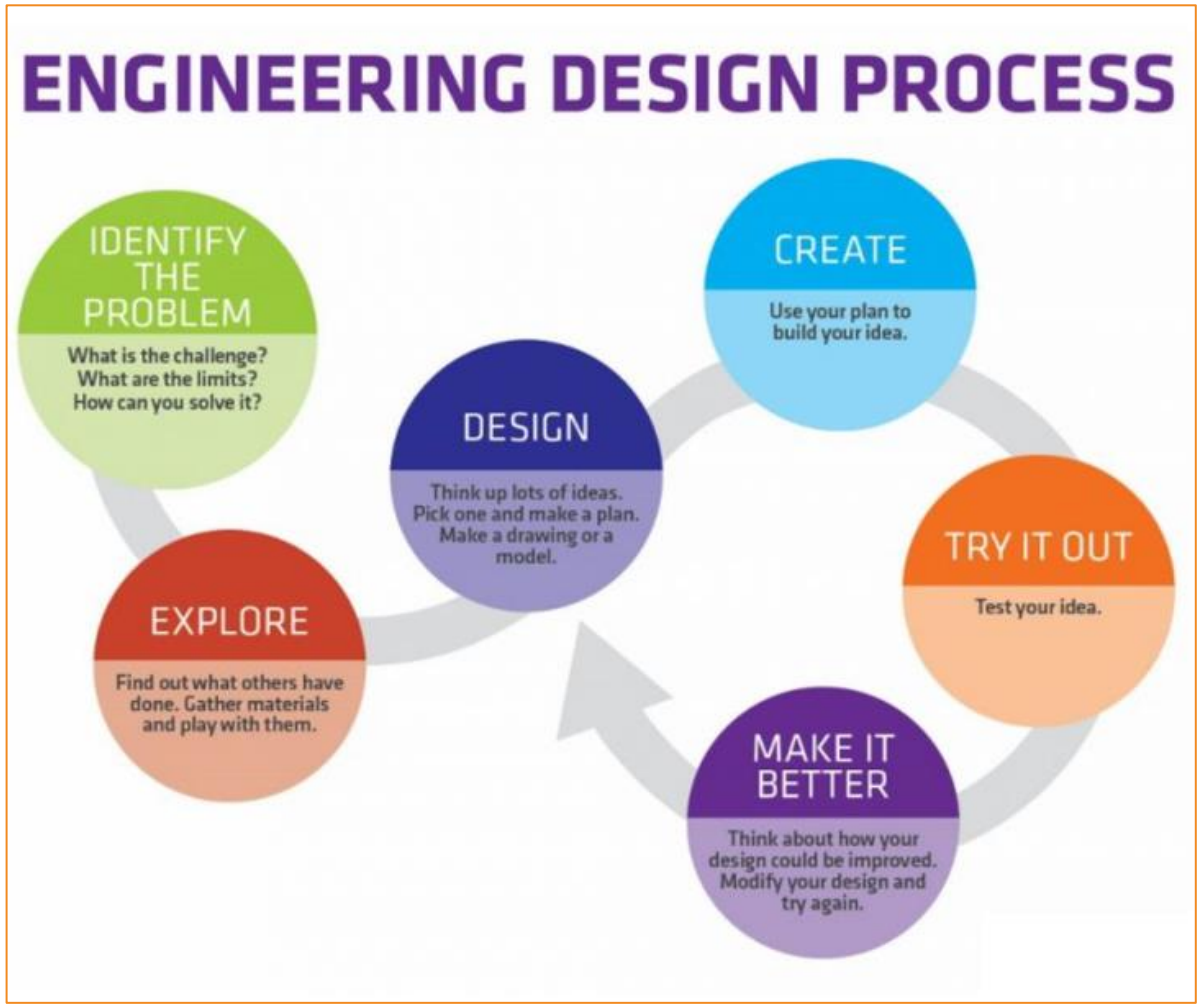
Create learning like we designed it that way

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



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