Principles of Engineering Updates

2/15/2024

PROVEN STEM ALLY
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Project Lead The Way

Agenda

- Network Survey Data
- Discuss Global Changes
- Review New Additions in Unit 1 & 4
- Review New Unit 3: Energy In Action
- Discuss Opportunities for Support

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Network Survey Data

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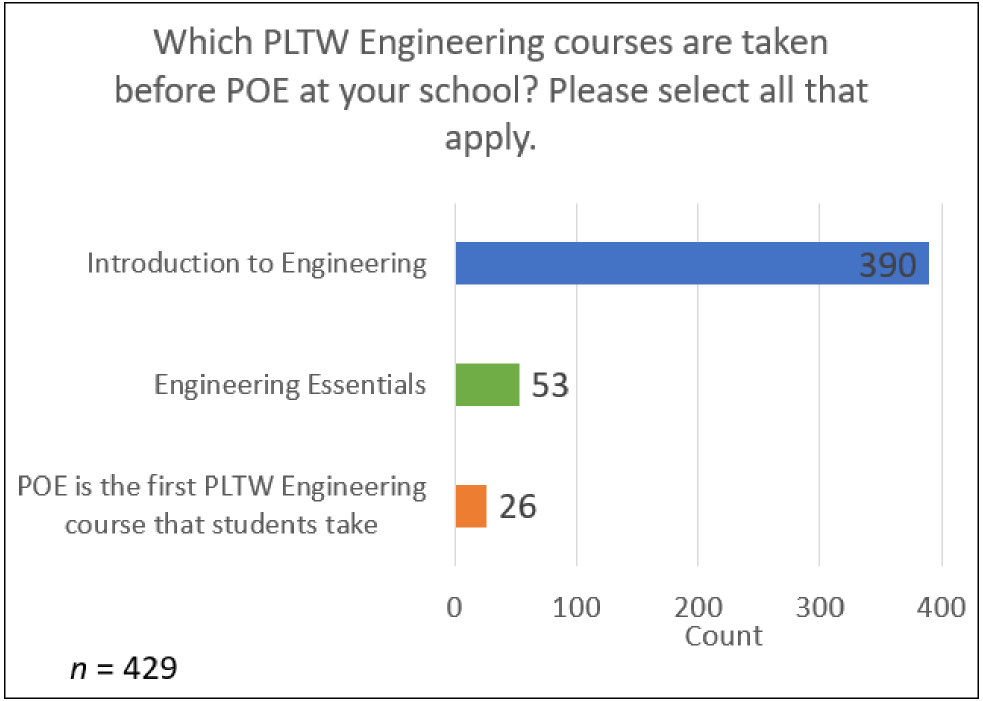

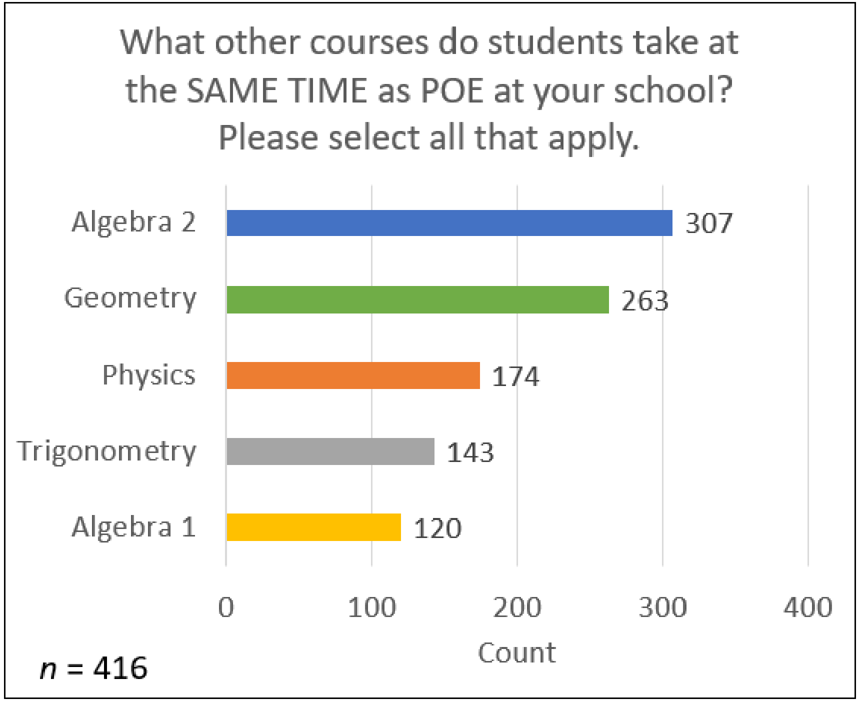

Note: Totals may add to more than the sample size for "select all that apply" questions.

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Top 5 Definitions of Academic Rigor

How do you define academic rigor? If possible, please provide an example of a rigorous activity that demonstrates your definition. *(open-ended question, with themes coded and summarized)*

Themes	**Counts**
Practical application/demonstration of learning/performance-based	109
Challenges students to expand thinking and problem-solving skills	82
Challenges students beyond their current abilities/pushes students outside of their comfort zone with scaffolds	56
High expectations/high academic standards	53
Involves advanced high school math/physics/theoretical math/multi-step problems	41

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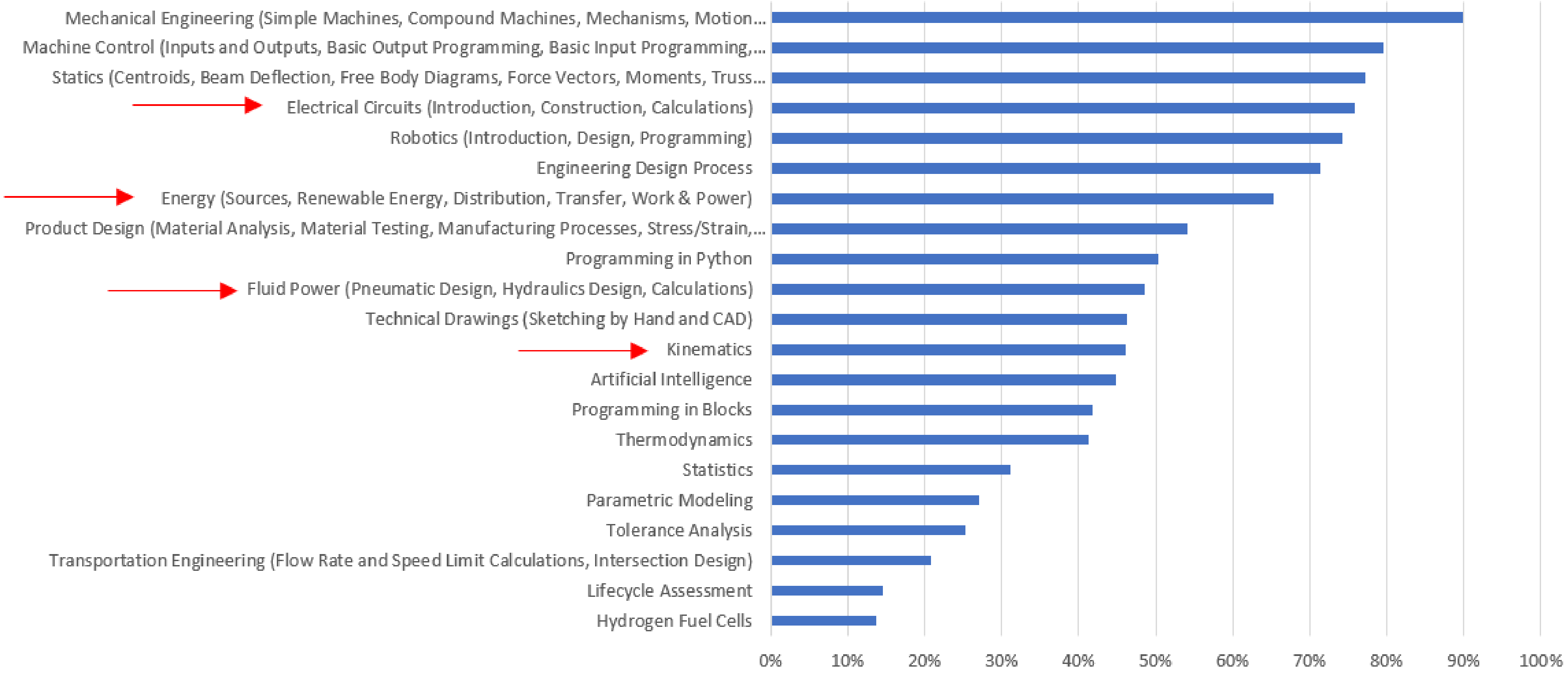
Please help us identify the most important topics to cover in a broad survey course like POE by rating the following topics based on their value to student learning.: % Extremely High/High Value



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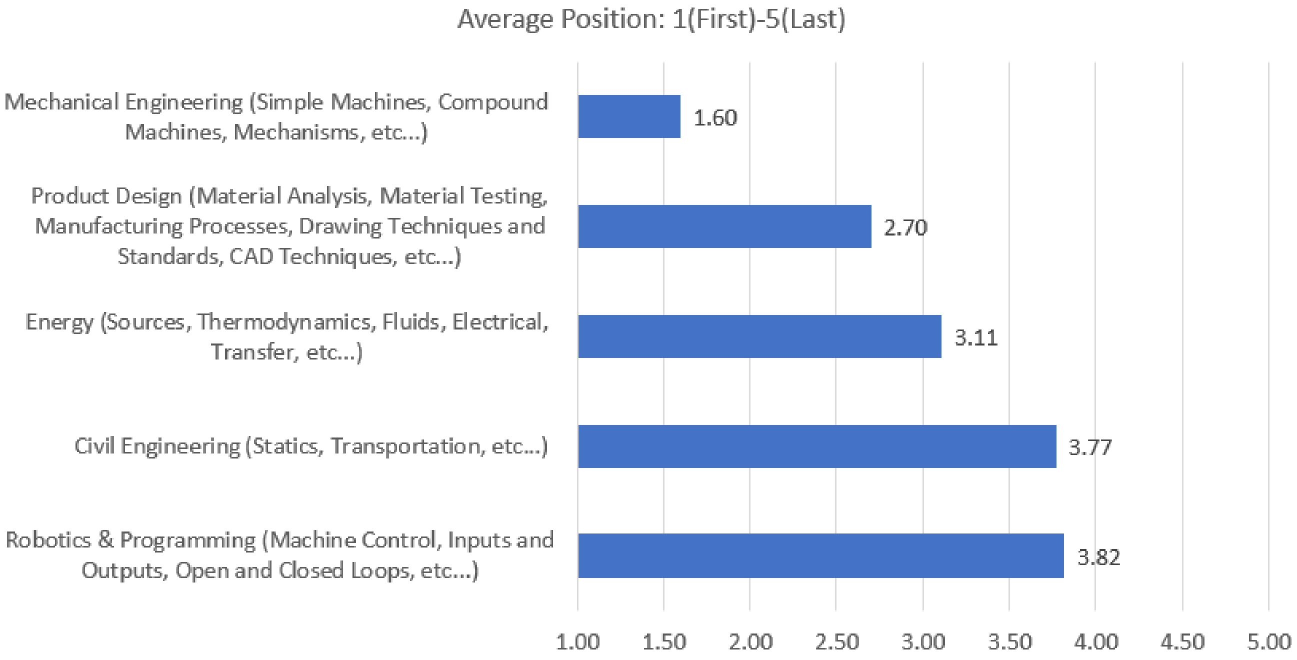
Please indicate your preferred sequence of POE topics by ordering them from 1 (topic should be introduced first) to 5



- Respondents indicated that mechanical engineering topics should be presented first
- Civil engineering and robotics should be presented later in the course

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Course Updates

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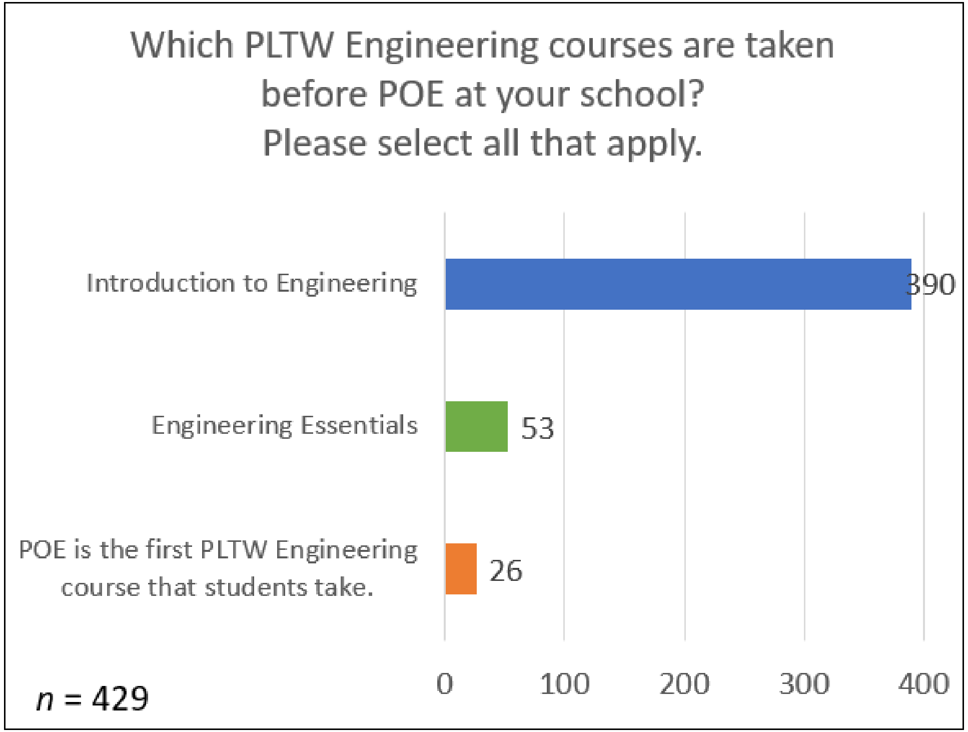
POE Updates



- Open Ended survey questions and Solution Center Tickets indicated concerns of repeated material IED students
- Change Product Design and Development to an option unit

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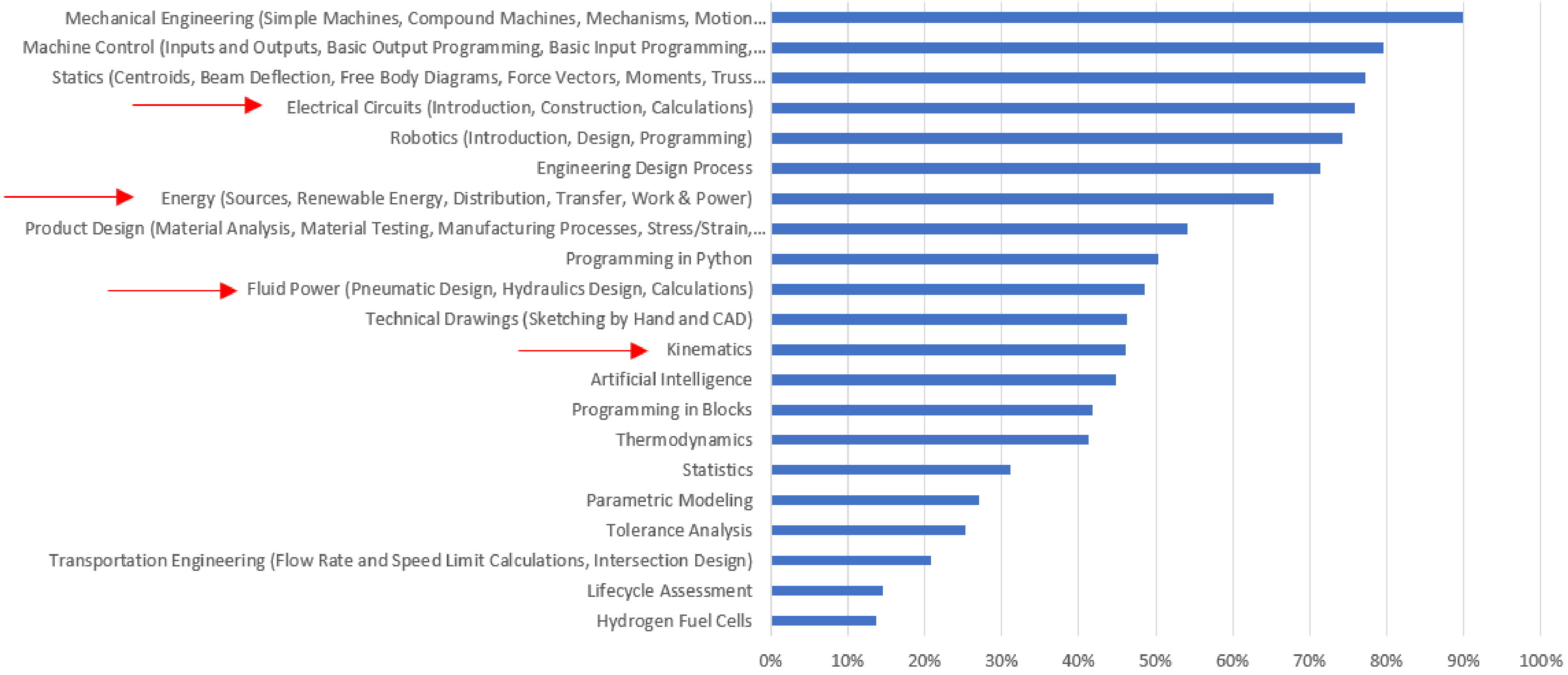
Please help us identify the most important topics to cover in a broad survey course like POE by rating the following topics based on their value to student learning.: % Extremely High/High Value



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POE Updates

Top 5 Definitions of Academic Rigor

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Open-ended comments indicated need for rigorous topics:

- Electrical
- Work & Power
- Kinematics
- Hydraulics and Pneumatics

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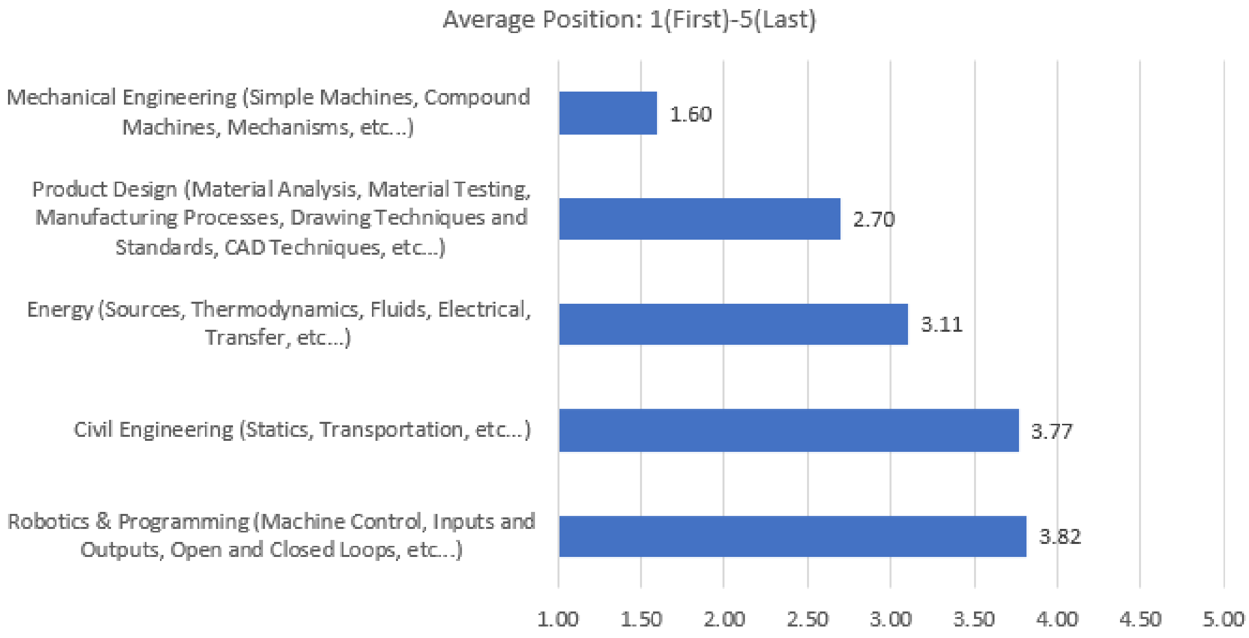
POE Updates



New Sequence

Introduction to Product Design and Development (optional)

Unit 1 – Mechanical Design

Unit 2 – Application of Robotics

Unit 3 – Energy in Action

Unit 4 – Designing Infrastructure and Developing Sustainability

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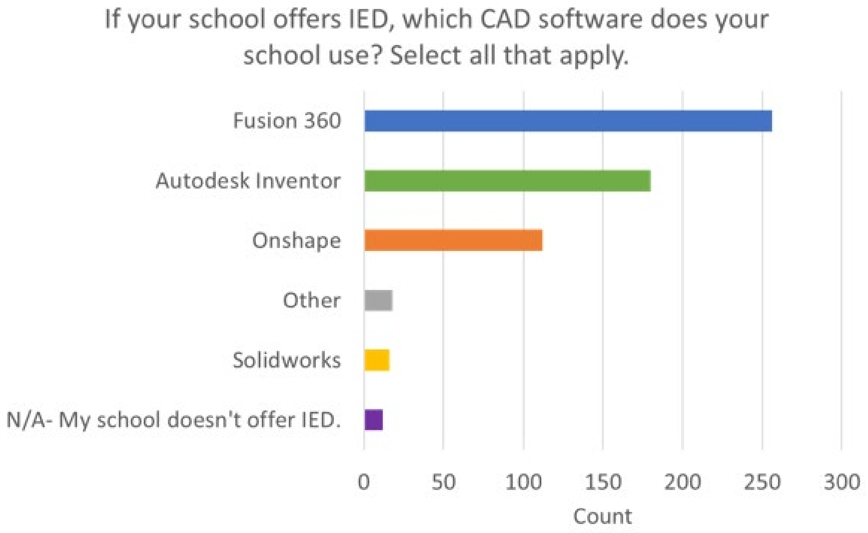
POE Updates



End of Course Assessment

- Both Legacy POE and the updated POE will have EoCs

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POE Updates

E

Piezo Buzzer with Male Pins, 10 pack

View Details 3 $16.00 ea.

NEW PRODUCT REQUIRED DURABLE

Available in PLTW Store

Hookup Wire, 100', White *	2700122WH	1	Box 2 of 2
Plastic Cups, 16oz. (20PK) *	44PWPOE21	1	Box 2 of 2
Fish Line *	44PWPOE22	1	Box 2 of 2
Wood Glue, 4oz. (10PK) *	44PWPOE23	1	Box 1 of 2
Food Color, 0.3oz. (4PK) *	44PWPOE24	1	Box 2 of 2
“D” Cell Batteries *	2800AKD	24	Box 1 of 2
Carbon Transfer Paper, 50PK *	44PWPOE25	1	Box 2 of 2

****Note:*** These items were added on 1/1/2024. Kits ordered prior to this did not include this item but are readily available from various in-store and online retailers.

ANTICIPATED SHIP DATE: 02/2/2024

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Additions to POE

New Additions

Updated Activities from Legacy POE

1.1.3 – Mechanical System Efficiency
Introduction to Energy, Work and Power resource

1.1.6 – Maximizing Power
Maximizing Motor Power resource

4.1.4 – Stressed and Strained
Solving for Stress & Strain resource

4.1.5 – Tensile Testing
Material Testing resource

Activity 1.1.3 Mechanical System Efficiency

3 Build the winch and mass using the POE Gearbox Motor Winch Construction Guide and the POE Winch Mass Construction Guide.

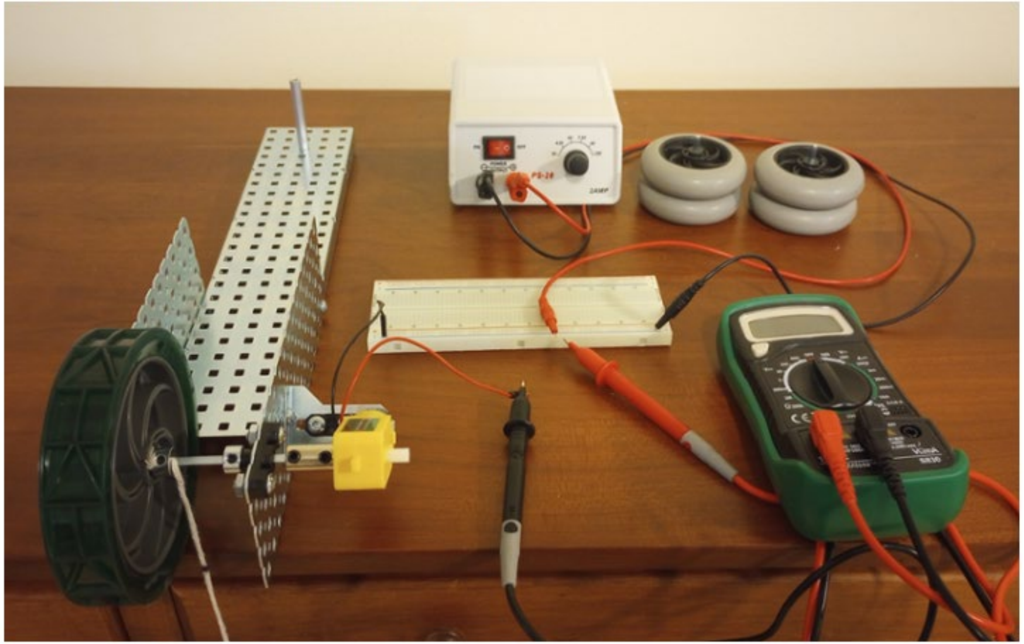

Figure 1. POE Gearbox Motor Winch Assembly

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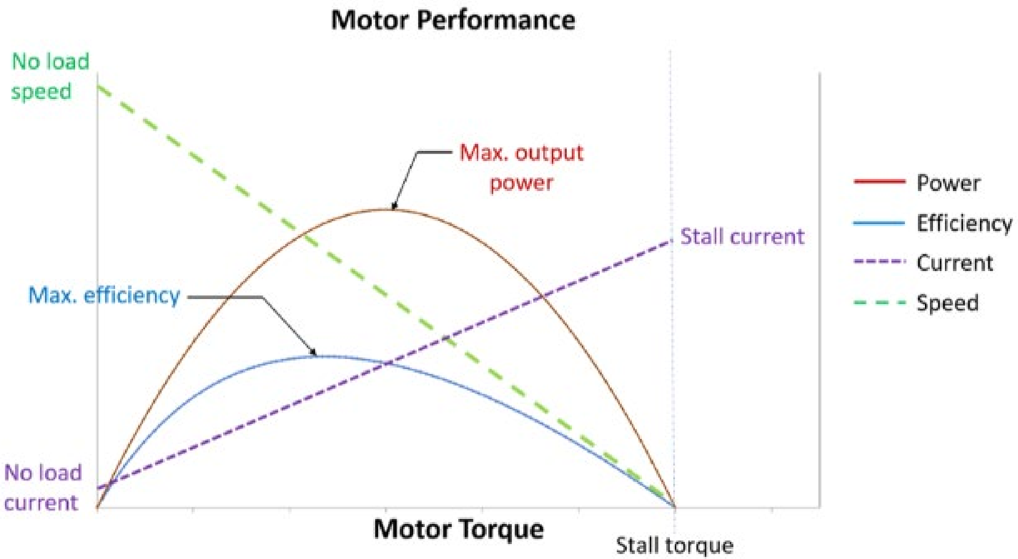
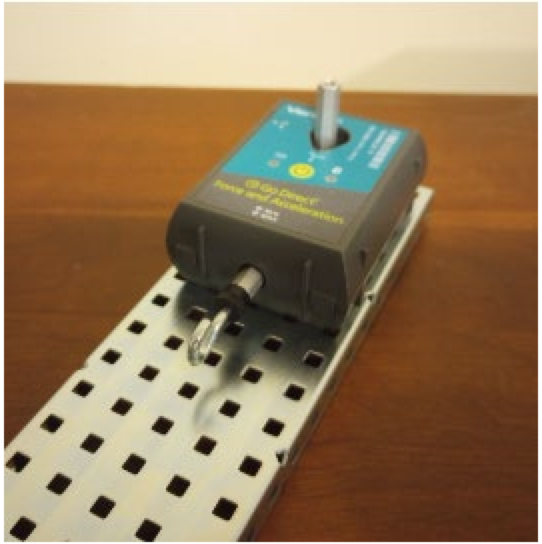
Activity 1.1.6 Maximizing Power





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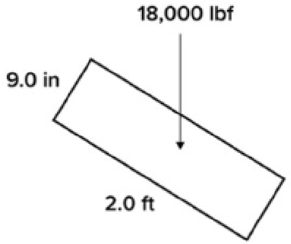
4.1.4 Stressed and Strained

Δ (uppercase
δ (lowercase
σ (sigma)
ε (epsilon)
τ (tau)
P
E
F
A
L
L_0
r
d

9

Knowns:	Draw:	Substitute and Solve:
W = 9 in.	 	A = L x W
L = 2 ft		A = (2 x 12 in.) x 9 in.
F = 18,000 lbf		A = 24 in. x 9 in.
Unknowns:		A = 216 $in.^2$
Area (A)		σ = F/A
Stress (σ)		σ = 18,000 lbf / 216 $in.^2$
Equation:		σ = 83.33 $lbf/in.^2$
A = L x W		**Final Solution**
σ = F/A		σ = 83.33 $lbf/in.^2$

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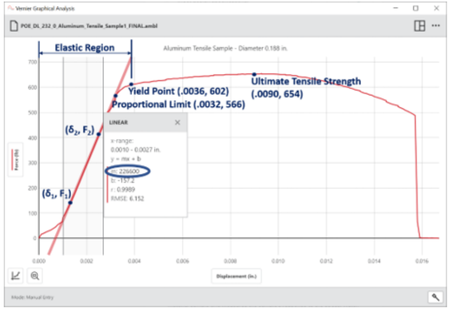
4.1.5 Tensile Testing

6 Calculate

Activity 4.1.5 Tensile Testing Answer Key

2. Aluminum Sample 1 Analysis

Answers will vary. A sample response follows.



7 On the gr... and corresponding coordinat...

8 Calculate

9 Label the ... mation.

10 Calculate

4. Proportional Limit

$$\sigma = \frac{F}{A_0} = \frac{566\ lb}{\pi(\frac{.188\ in.}{2})^2} = \frac{566\ lb}{.0278\ in.^2} = 20360\ psi$$

6. Yield Point Stress

$$\sigma_{yp} = \frac{F}{A_0} = \frac{602\ lb}{.0278\ in.^2} = 21654\ psi$$

7. Ultimate Tensile Stress

$$\sigma_{ult} = \frac{F}{A_0} = \frac{654\ lb}{.0278\ in.^2} = 23525\ psi$$

Note that any two points on the straight-line portion of the graph can estimate the slope of the linear portion of the curve in the elastic region. However, using the slope of the best fit line (using the Curve fitting feature of the software) results in a better estimate of E.

Lesson 3.1 Electrical Circuits

3.1.1 Illumination Creation

3.1.2 Ohms Law Lab

3.1.3 Series vs. Parallel Circuits

3.1.4 Equivalent Resistance

3.1.5 Kirchhoff's Laws Lab

3.1.6 Volts Vaults (Project)

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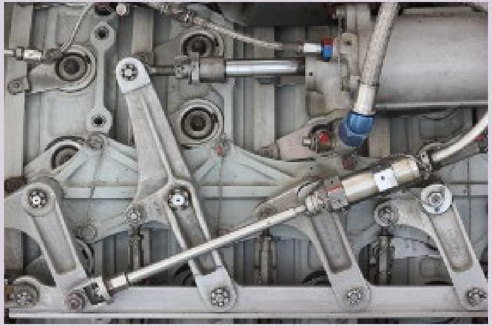
3.1.1 Illumination Creation

2

Problem Introduction



Physics helps us understand the rules that govern the universe, covering everything from subatomic particles to the vastness of space. Successful engineers are able to apply physics principles to solve problems, design innovative technologies, and create systems that control our built environment. In this unit, you'll be asked to think like an engineer, answering questions like:

lly

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3.1.2 Ohm's Law Lab

Effect of Voltage

If

M

1 Using Tinkercad, bu

Opportunity for Differentiation

This activity assumes students have basi
Tinkercad, as well as drawing electrical s
these topics, you may need to spend extr

For a more in-depth, hands-on approach,
steps 1–5 instead of modeling in Tinkerca
more circuit modeling to actual circuit bui
step 10 and omit step 11.

For more in-depth mathematical practice,
require manipulating Ohm's Law to solve

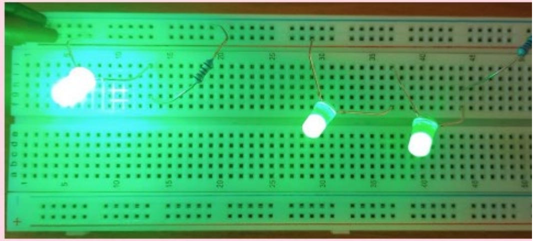
For students who have strong math skills
resistance values (such as 1.5 kΩ, 2.2 kΩ,

Figure 2. Tinkercad C

18 Determine the individual LED brightness when using
LEDs, as compared to just one LED. Consider taking
of each circuit configuration to compare brightness le

Individual LED brightness in the single LED circuit i
greater than that of the double LED circuit.

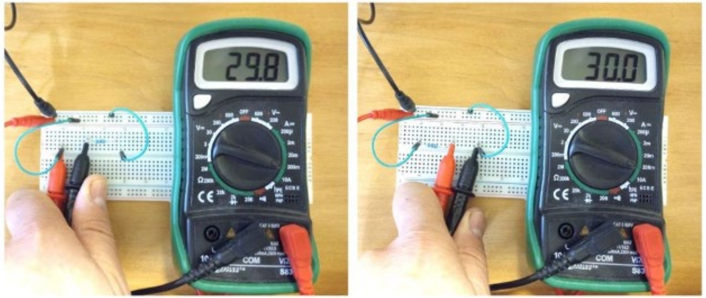
The image below shows both the single LED circuit (left) and double LED circuit (right) together on the same breadboard. While students are not required build this, the image is provided to show a compar of LED brightness.



LED Circuit Comparison

Measuring Current

Students should finish step 9 with an understanding that the current through a series circuit is the same no matter where the current is measured. The following images show where to measure current before and after the resistor.



Current Measured Before and After Resistor

Experimental data may have some slight variation, which provides an opportunity for discussion. Multimeter precision, the quality of the electrical contacts, and voltage fluctuations from the power supply all contribute to variations in experimental data.

3.1.3 Parallel vs. Series

Teacher Resources

[View Student Course]

RESOURCES

R

- Series vs. Parallel Circuits (Microsoft Excel) Answer Key
- Series vs. Parallel Circuits (Google Sheets) Answer Key

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F

- Activity 3.1.3 Framework

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3.1.4 Equivalent Resistance

Deriving the Equation

9 Recall and record how to calculate the total current in a parallel circuit.

$$I_T = I_1 + I_2 + I_3$$

10 In your equation from step 9, substitute an expression for current in terms of voltage and resistance.

Students must algebraically manipulate Ohm's Law to solve for current (I = V/R).

$$\frac{V_T}{R_{eq}} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

11 Divide each side of your equation by voltage (V).

> **Note**: Remember, the voltage across each branch of a parallel circuit is equal to the total voltage.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

’s total resistance. Record these values in the Total

12 Now solve for R_{eq}.

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Time to Practice

13 Calculate the equivalent resistance of a parallel circuit with 330 Ω, 500 Ω, and 1500 Ω resistors.

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

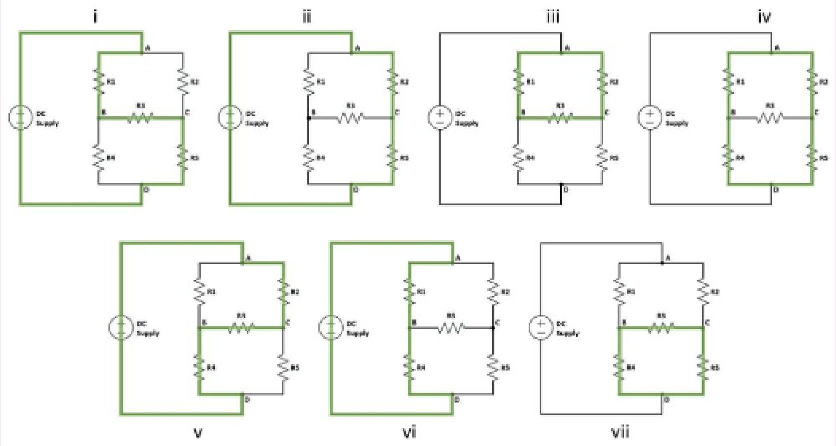
$$R_{eq} = \frac{1}{\frac{1}{330\ \Omega} + \frac{1}{500\ \Omega} + \frac{1}{1500\ \Omega}}$$

$$R_{eq} = 176\ \Omega$$

3.1.5 Kirchhoff's Laws Lab

Kirchhoff's Voltage Law

14 In the circuit you made using Figure 7, how many closed loops (circuits) are there through which current can flow?



The current can flow in seven different closed loops.

3.1.6 Volt Vaults

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Opportunities for Differentiation

This is an open-ended design challenge. Encourage students to explore a variety of potential design solutions before they commit to a specific design.

For a different challenge, consider changing the specifications such that the green LED turns off when the vault door is opened. One solution is to use a double pole, double throw (DPDT) switch. While this switch is not supplied with the course materials, the switch is readily available online and could provide for a meaningful discussion.

Lesson 3.2 Fluid Power

3.2.1 Under Pressure

3.2.2 Mathematics of Pressure

3.2.3 Pressurized Power (Project)

3.2.1 Under Pressure

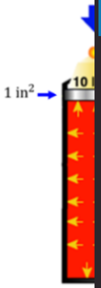
Com

All fluid
valve

Hydrau

Pneum

Example Problem: In Figure 3, a 10-pound force acting on an area of 1 square inch generates a pressure of 10 pounds per square inch (psi) acting equally on all surfaces throughout the container. To successfu … over a large distance.



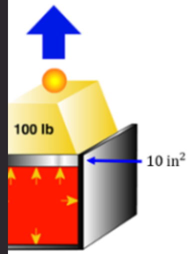


Figure 3. Multip

Source: National Flu

In this scena … ge force over a small distance. Ma

- Activity 3.2.1 Under Pressure
  - Hydraulics
  - Pneumatics
- Activity 3.2.2 Mathematics of Pressure
- Project 3.2.3 Pressurized Power

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{10\text{ lb}}{1\text{ in}^2} = \frac{100\text{ lb}}{10\text{ in}^2}$$

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3.2.2 Mathematics of Pressure

Practice Problems

1. A pneumatic system produces 100 lb/in^2 of gauge pressure. A cylinder is needed to press an adhesive label onto a product. It has been determined that 5 lb of force is optimal to complete this task.

   a. What is the required area of the pneumatic cylinder?

Formula	Substitute/Solve	Final Answer
$p = \frac{F}{A}$	$100 \frac{lb}{in^2} = \frac{5\ lb}{A}$ $A = \frac{5\ lb}{100 \frac{lb}{in^2}}$	$A = 0.05\ in^2$

   b. What is the required diameter of the pneumatic cylinder?

Formula	Substitute/Solve	Final Answer
$A = \pi r^2$ $d = 2r$	$0.05\ in^2 = \pi r^2$ $r = \sqrt{\frac{0.05\ in^2}{\pi}} = 0.13\ in$ $d = 2(0.13\ in)$	$d = 0.26\ in$

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3.2.3 Pressurized Power

4 Build a

The t

Hydraulic Jack-in-the-box video (This video has no sound.)

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Lesson 3.3 Kinematics

3.3.1 Gravitate to Greatness

3.3.2 Horizontal Projectile Motion

3.3.3 Application of Kinematics (Project)

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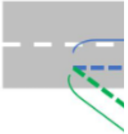
3.3.1 Gravitate to Greatness

Background Voc 5

Before taking a deep dive
to have a working underst

Displacement describe
from the distance somethi
then 3 km south, the car ha
displacement is 5 km, beca
position to its final position



6

Displace
= 5 k

Figure 2. Distan

17 Save your experiment to your computer.

a. In the top left corner, click your filename to open the File menu.

Figure 8. Filename Location

b. Select **Save As...**

c. Name and save your file according to your teacher's instructions.

d. Note the location of the saved file so you can access it in [Activity 3.2.2 Horizontal Projectile Motion](#).

mathematical

e. In mathematical

ded by time:

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Set Scale video

Add Points video

3.3.2 Horizontal Projectile Motion

The horizontal velocity has no effect on the time the acorn is in the air. If the horizontal velocity is 4 m/s, the time the acorn is in the air would still be 1.5 s. Time is a function of the acceleration due to gravity, the vertical displacement, and the initial vertical velocity.

$$\Delta y = v_{y1}t + \frac{1}{2}a_y t^2$$

Since the initial velocity is 0 m/s, the first term cancels out, which leaves:

$$\Delta y = \frac{1}{2}a_y t^2$$

Now solve for time:

$$t^2 = \frac{2\Delta y}{a_y}$$

$$t = \sqrt{\frac{2\Delta y}{a_y}}$$

$$t = \sqrt{\frac{2 \times -11.04\ \mathrm{s}}{-9.81\ \mathrm{m/s^2}}}$$

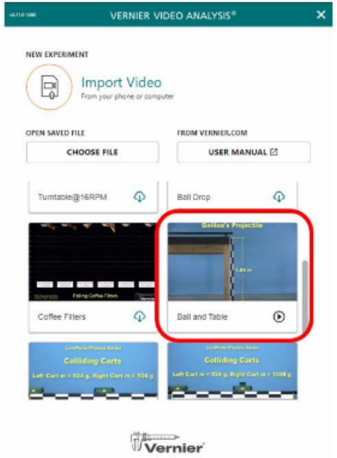
$$t = 1.5\ \mathrm{s}$$

Put It to the Test

Opportunities for Differentiation

If you have access to photogate sensors, you can use them instead of video analysis to determine the horizontal velocity of the golf balls.

If students are unable to set up the experiment to capture video, or unable to make accurate predictions, they can use the Ball and Table video in Vernier Video Analysis®. They will not be able to make a prediction they can use in the classroom, but they can work through the process of calculating a horizontal displacement.



Ball and Table Video in Video Analysis Software

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3.3.3 Applications of Kinematics

Rearrange this equation so that it equals 0.

$$\frac{1}{2}a_y t^2 + v_{y1}t - \Delta y = 0$$

You'll notice this is a quadratic equation. Students can use the quadratic formula to solve for time.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

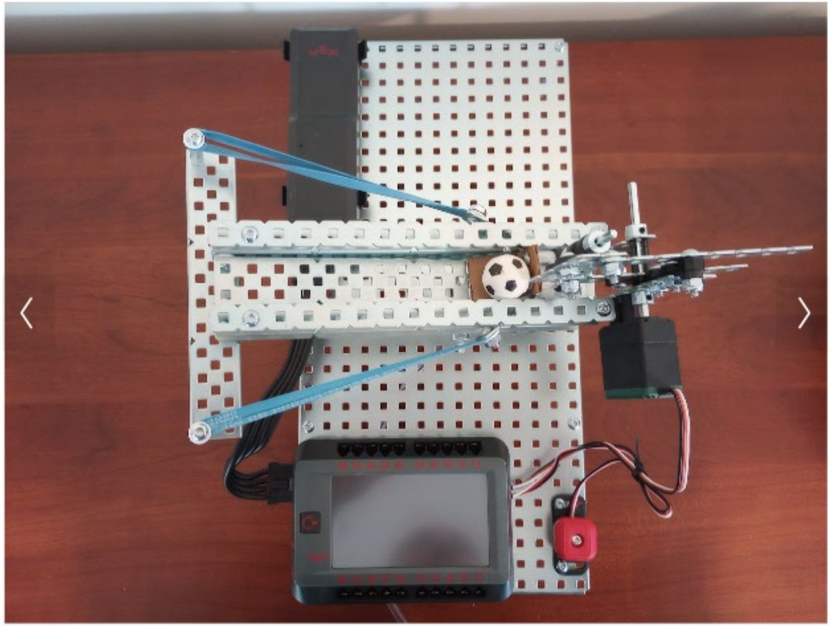
$$t = \frac{-v_{y1} \pm \sqrt{(v_{y1})^2 - 4(\frac{1}{2}a_y)(-\Delta y)}}{2(\frac{1}{2}a_y)}$$

If students are familiar with using the quadratic formula, they should manually solve for time. If students do not have exposure to the quadratic formula, you can either prepare them to use it or use an online quadratic equation solver.

In either case, students must be vigilant with signs. For example, the vertical velocity, acceleration, and displacement are all negative values. These quadratic equations have two solutions: one negative and one positive. Because we are solving for time, the positive solution is the correct answer.

Problem 3.4 Auto Golf

Prototype 1

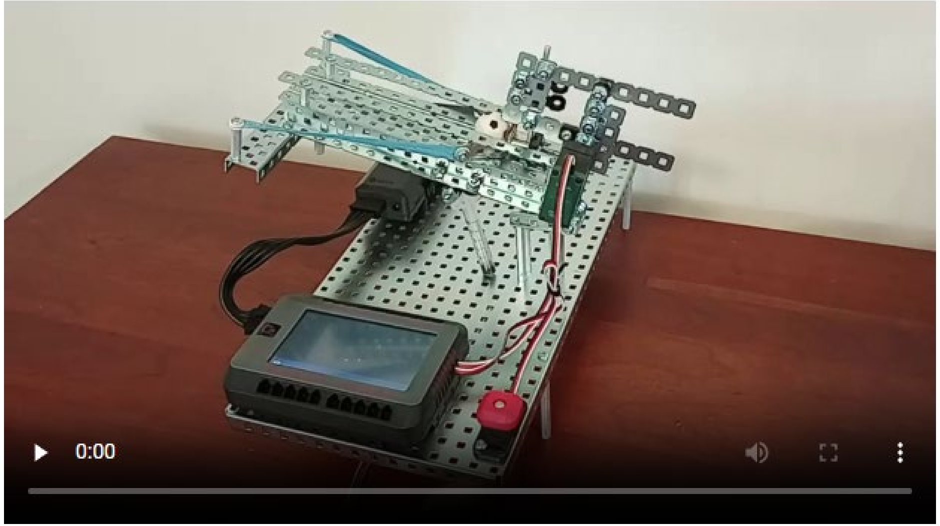


Top View

OPTION 3

THE "CROSSBOW"

proposed player design solution



Player Prototype 1 (This video has no sound)

TO CHANGE
ANGLE/
DISTANCE

What's Next?

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Closing

Thank you!

PLTW