

NEW FOR 2025-2026!

- Lab has been renamed to Algorithms & Machine Learning
- Expect new changes in the fall

SUGGESTED LESSON PLAN - 50 minute periods

Total Time ~90-120 minutes

- 35 minutes to watch the lab introduction video
- 30-45 minutes for students to design, build and test their catapult.
- 15-20 minutes for students to analyze their data and apply their predictions to the problems in their workbook or worksheet.
- 10-20 minutes for a closing activity or discussion

Optional Extension Activities

- 0-10 minutes Google Teachable Machine (Optional Activity #1)
- 0-20 minutes TensorFlow (Optional Activity #2)

(Note: An optional 30-45 minutes can be scheduled to do a Wrap-Up and QA with an Engineer and College Mentor at Teacher's discretion).

Hook/Essential Question	How do machine learning models like ChatGPT learn from their users?				
Resources to Have in Class	ET Algorithms & Machine Learning Kit materials can be found at the end of this file. Standard household/classroom materials should work for catapult construction. Additional Items to Consider Having on Hand: • Additional Popsicle sticks (structure) • Cotton balls (as an alternate projectile to limit bounce) • Plastic spoons (basket) • Tape measure or yardstick to measure distance for gathering data NOTE: Some sites referred to in the workbook may be blocked by school internet protocols. Please request admin access for the sites below in advance so that you students will have access before they begin working through the student workbook/worksheet				
	 Collecting and Graphing Data Google Sheet for data collection & graphing 				
	Teachable Machine Sorter • https://teachablemachine.withgoogle.com/ (Optional- If completing the extension)				



	 Part I: TensorFlow Playground and Challenge (Student Workbook pg. 54 and 67-69) https://playground.tensorflow.org/ 		
	The videos below should be unblocked for teachers-only if presenting the student workbook to the whole class OR for all students if they are completing the student workbook on their school devices Main Workbook • https://www.youtube.com/watch?v=f uwKZIAeMO (Optional- If completing the extension) • https://www.youtube.com/watch?v=X9ZES-fsxgU • https://www.youtube.com/watch?v=aircAruvnKk		
Optional Pre-Work	Have students watch the first 21 minutes of the introvideo providing the background for the challenge and answer the questions through slide 6 of the student workbook.		
Class #1 Introduction, Research, and Design	Watch the Engineering Tomorrow: Algorithms & Machine Learning Intro Recording on the Algorithms & Machine Learning webpage either as a class or assign background section as pre-work (see above). → Have students answer the questions in the first 6 slides of the student workbook → Watch the rest of the video that outlines the instructions for the challenge. Students begin to design their catapult→ research designs, review materials, generate an initial design concept and describe in their workbook (slides 1-13) or worksheet (1 workbook or worksheet per team suggested)		
Class #2			
Building, Testing, and Analyzing	 → Students build their initial design → Students test their design and document catapult performance data → Students use Google Sheets or Microsoft Excel to analyze the data they recorded → Students use the analysis they just performed to complete their workbook or worksheet 		
Part of Class #3 Possible Closing	*Students may not have completed the analysis of their data or their workbook/worksheet. Data analysis and subsequent notebook completion could be moved to a third class period, followed by a thought provoking question and group discussion*		
Questions and Activities	Class Discussion Question: How do ethical considerations impact the development and deployment of machine learning models?		
	Machine learning systems, while beneficial, can perpetuate biases, lack transparency, and raise privacy concerns. These issues highlight the importance of developing ethical ML practices to ensure fairness, accountability, and respect for privacy.		

INTRODUCTION TO ENGINEERING TOMORROW:

• Click <u>here</u> to see an introduction of what Engineering Tomorrow can do for your students.



INTRODUCTION TO THE ENGINEERING DESIGN PROCESS:

- Students should complete the Engineering Design Process Introduction Activity before starting the lab
 - NOTE: This activity only needs to be completed before the student's <u>first</u> ET lab, not repeated for every lab.

TEACHER NOTES:

- Students will work through the Algorithms and Machine Learning <u>Student Workbook</u> or <u>Abbreviated Student</u> Worksheet.
 - When assigning this lesson on Google Classroom, <u>first make a copy</u> of the slides to save within your Google Drive, <u>then assign so that each student has their own copy</u>.
 - The workbook and worksheet are designed to be interactive so that students can type directly into the files. It is suggested that the workbook or worksheet be completed over a few class periods (as the information is delivered to students).
 - Students may work individually or within groups (at the discretion of the instructor).

ASSESSMENT:

- Informal assessments can be completed by looking at the reflection slides within the Student Workbook and/or the discussion questions in the Abbreviated Worksheet.
- **Answer Keys** can be found here for:
 - Abbreviated Worksheet Answer Key
 - Student Workbook Answer Key

OPTIONAL EXTENSION ACTIVITY #1:

Create an AI sorter using Google's Teachable Machine

- Students will decide on two classes (or categories) of items they want to identify and sort. Students upload pictures to provide the machine data for classifying the objects.
- [Note the 'train' function is similar to short videos that provide multiple pictures of an object].
- Once the computer is "trained", the students will test the computer's ability to sort various objects. Students will also calculate the machine's efficiency based on the number of correct answers and the number of trials completed.

OPTIONAL EXTENSION ACTIVITY #2:

Explore a simple neural network using <u>TensorFlow Playground</u>, a free, open-source software simulation that gives students a chance to tinker with a real machine learning program.

- Students will see the connections between the catapult challenge they just completed and the machine learning algorithm used in the Playground
- Students will adjust the number of Features and the number of Neurons to build a simple neural network capable of classifying data consisting of colored dots
- Students will record the error loss for their neural network model for each of the four data sets built into the TensorFlow Playground simulation.

OTHER EXTENSION ACTIVITIES:



- Watch the video to learn more about the physics of catapults
- Read this <u>article</u> to learn about machine learning and artificial intelligence

ADDITIONAL TEACHING RESOURCES:

Curriculum Connections:

- Physics: 2D-Motion; Projectile Motion
- <u>Freshman Computing</u>: Predictive Analysis; Using computers to analyze data and make predictions based on patterns and relationships
- <u>Statistics</u>: Plotting Trendlines; Modeling based on sample data

Students will be able to:

- Define machine learning and provide real world applications for where it is used.
- Describe the engineering design process and apply it to the design and construction of a catapult.
- Develop a mathematical model that describes the performance of the catapult.
- Create an algorithm based on the performance analysis of the catapult.

Content Vocabulary/Terms:

- <u>Machine Learning</u>: a type of artificial intelligence that allows computers to learn from and make predictions based on data without being explicitly programmed
- <u>Mathematical Model</u>: a representation of a system using mathematical concepts and language to describe and predict its behavior
- <u>Factor</u>: an independent variable that is manipulated or controlled in an experiment to observe its effect on the response
- Response: the dependent variable that represents the outcome or effect measured in an experiment as a result of changing the factor

ENGINEERING DESIGN STANDARDS:

• Next Generation Science Standards:

HS-ETS1-3 Engineering Design: Evaluate a solution to a complex problem based on prioritized criteria and trade-offs that account for a range of constraints.

HS-PS3-3 Energy: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

• Computer Science Standards:

3A-AP-13: Create prototypes that use algorithms to solve computational problems by leveraging prior student knowledge and personal interests.



3B-AP-08: Describe how artificial intelligence drives many software and physical systems.



MATERIALS:

TEACHER'S KIT						
distributed throughout class						
Item/Link	Quantity	Photo				
<u>Duct Tape</u>	1	DUCK TAPE				
<u>Masking Tape</u>	1	Control Contro				
<u>Plastic Spoon</u>	3					

UTILITY KIT					
1 kit: 10 students					
Item/Link	Quantity	Photo			
<u>Hot Glue Gun</u>	6				
Hot Glue Sticks	12				
Ruler	1	00 62 52 52 52 52 52 52 52 54 54 54 54 54 54 54 54 54 54 54 54 54			
Permanent Marker	1	Sharple, FINE POINT			
Scissor	1				



STUDENT KIT ITEMS						
	1 kit: 3 students					
Item/Link	Quantity	Photo				
Ping Pong Balls	2					
<u>Measuring Tape</u>	1	THE STATE OF THE PARTY OF THE P				
<u>Popsicle Sticks</u>	50					
<u>Rubber Bands</u>	20					
<u>Plastic Spoon</u>	1					