Engineering Tomorrow

Name: _____
Date: _____

Algorithms & AI Lab Worksheet

Here you will find the instructions on how to design your own catapult and use it to learn about machine learning! Follow all the steps in this worksheet, fill in the blanks, and answer the questions as you go. Be sure to record your data and observations throughout the process.

INTRODUCTION:

Machine learning is becoming increasingly pivotal across various fields, from personalized recommendations on streaming platforms to medical diagnostics and autonomous vehicles, but what is machine learning? Machine learning involves using algorithms to analyze data, learn from it, and make informed predictions or decisions without being explicitly programmed for specific tasks.

Can you think of 3 examples of machine learning in your everyday life?

The Machine Learning algorithm creates a **mathematical model** that can answer questions like "Is that a dog or a cat?", "What number is that?", or even "Does this email look like spam?".

The mathematical model is created using data and becomes more accurate as it collects more data. The more data that the model is trained on, the more reliable it is to make the right decision, prediction, or assessment.

In today's lab, you will create a mathematical model of a simple machine (the catapult). You will do this by building a catapult and collecting data in order to answer the question: How can I predict the settings on a catapult needed to hit a specific target?

You will be using the **Engineering Design Process** to create a catapult that can accurately hit a given distance.

The **Engineering Design Process** can be broken down into 5 Steps:

1. Define the Problem
2. Research
3. Design a Solution
4. Build
5. Test
6. Analyze Data

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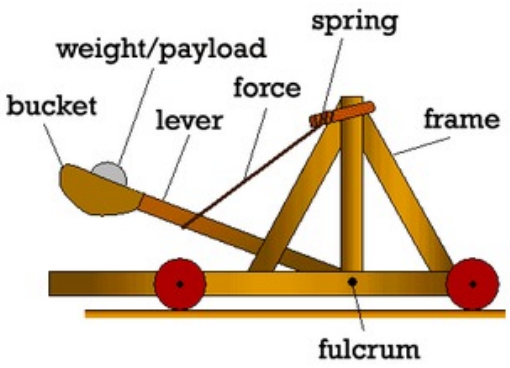
STEP ONE: DEFINE THE PROBLEM

What problem or challenge are you trying to solve?

STEP TWO: RESEARCH

Catapults come in different shapes and designs, but they typically all share the same parts:

Part	Description
Arm (Lever)	Lever used to launch a projectile
Fulcrum	Support that a lever rests on and pivots about
Projectile	Object that a catapult launches
Structure	Base and frame of the catapult
Spring	Where potential energy is being stored. For the lab, this could be rubber bands, binder clips, or an actual spring



Try to think about what kind of design you will be using. Brainstorm with peers or look around on the internet and try to find an example of a catapult that you think will help you accomplish your goal.

Tip: If you don't have a kit, sticking to household items like popsicle sticks, rubber bands, and spoons is generally a good idea.

What materials will you need for your design?

*Make sure that your catapult is freestanding (it should be able to support itself without you holding it up). If you need to put your hand on the base while pulling the lever back, that's okay, however this is the only support you can offer while testing.

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STEP THREE: Design a Solution

Now that you've done some research, what have you come up with?

Draw a diagram or insert a picture of your design

STEP FOUR: BUILD

It's time to implement your design. Gather your materials and start production of your first prototype. If your previous design isn't working, you may need to try a new idea.

Important: Prototyping is a massive part of the engineering design process, because it is where ideas formally written on a piece of paper come to life, but they don't always come to life exactly how you imagined them. If you decide to make some changes to your initial design, that is okay. Just make sure you document those changes so that you can always learn from your mistakes.

If needed, draw your new design or make notes of any changes that you made to your original design

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STEP FIVE: TEST

Before you start testing, there are a couple of concepts that will help you understand how to test your catapult in the most effective way and how to gather the best data:

Factor: "Cause"

- Variables that are manipulated or controlled in an experiment
- Independent variable
- Examples:
  - Height of catapult
  - Catapult angle

Response: "Effect"

- Variables that represent the outcome or result of an experiment
- Dependent variable
- Examples:
  - Distance projectile traveled
  - Max height of projectile

Question: Which items from the wordbox below best fit into each category?

Angle of catapult lever	Length of rubber band	Time of flight
Weight of projectile	Distance traveled	Launch speed

Factors	Responses
Answer here...	Answer here...

On the next page is sample data for the same lab you are performing. Some notes:

1. **Do not change more than one variable at a time.** This way you can clearly identify relationships between one particular factor and one particular response.
2. If you do not have the ability to measure exact angle, you can use approximations like "½ pulled" or "⅓ pulled"

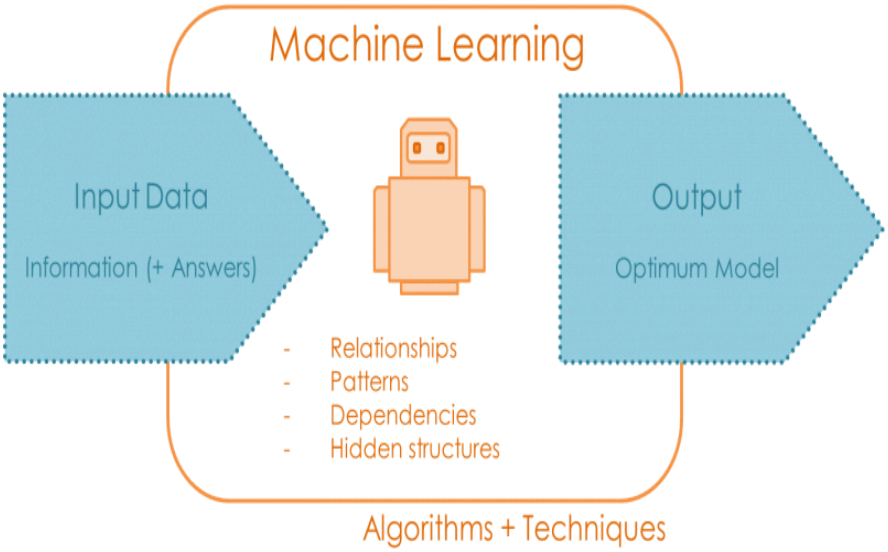
Height (cm)	Angle Pulled (degrees)	Distance (cm)
10	20	2
10	30	4
10	40	6
10	50	8
10	60	10
10	70	12
10	80	14
10	90	16

It is finally time to test your catapult! Fill out the table below with your data. Take at least **5 measurements**, but feel free to take more than that, particularly if you've adjusted your design during this step. The more data you have, the better.

Height (cm)	Angle Pulled (degrees)	Distance (cm)

STEP SIX: ANALYZE THE DATA

The idea here is that your catapult is machine learning. In just a moment, you will enter the data you have collected into Google Sheets and use the software to develop the mathematical model we talked about in the beginning of the lab.



Input
The data you collected is provided to the software. The more data provided, the more accurate the results of the process will be.

- Height
- Pulled Angle
- Distance Traveled

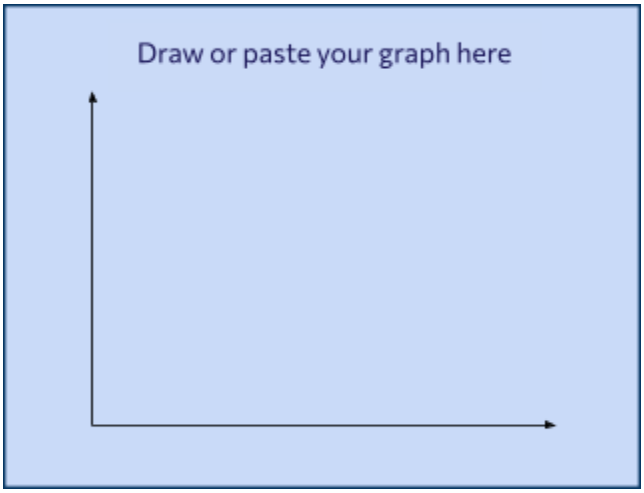
Analysis
The software analyzes the data it has been given and develops a mathematical model using attributes such as:

- Relationships
- Patterns
- Dependencies
- Hidden Structures

Output
The software provides predictions derived from the analysis previously performed like:

- Farthest distance projectile could travel
- Angle required to reach a particular distance

Let's get started!
Follow this link to a spreadsheet with instructions on how exactly you will be analyzing your data. If you are completing this on paper, scan the QR code or ask your teacher about the spreadsheet that accompanies the lab. Once you have completed the spreadsheet, return to this worksheet.



The spreadsheet should have provided a trendline which illustrates the relationship between "Angle Pulled" and "Distance" based on the data you provided it. With this in mind, feel free to test the accuracy of the model.

1. Find a target
2. Measure the distance to your target from your catapult
3. Reference your model to see how far back you should pull your catapult arm
4. Launch your projectile

How close was your projectile to your target?
How close was your models prediction?

According to your model, at what settings will your projectile land **40 cm away** from the base of your catapult?	What is the **max distance** your catapult can launch the ball?

In summary

Congrats! Hopefully by now you have successfully built a catapult, gathered performance data, and used that data to make predictions about your catapult through machine learning! You have also gotten some experience using the Engineering Design Process. By analyzing your data and making informed predictions, you've seen firsthand how machine learning can be applied to solve real-world problems. Keep exploring and experimenting to deepen your understanding of these exciting concepts!

If you're interested...

There are plenty of ways to learn more about machine learning all over the internet. Consider looking into things like "Google's Teachable Machine" or the "Neural Network Simulator" in TensorFlow if you want something a little more in depth.

STEP SEVEN: STUDENT EXIT SURVEY

Once you've finished the lab, please complete the student exit survey to share your feedback.