Catapult Project

A catapult is a mechanism used to throw missiles in ancient and medieval warfare. At first, catapults were specifically designed to shoot spears or other missiles at a low trajectory. They were originally distinguished from ballistae and trebuchets, both of which were large military engines used to hurl stones and other missiles, but these distinctions later blurred. Soon after, larger catapults mounted on a single arm also hurled stones, pots of boiling oil, and incendiaries at a high trajectory. They were used to attack or defend fortifications. Catapults were widely employed in siege warfare, but with the introduction of artillery they passed from use. In the 20th century catapults using hydraulic pressure were reintroduced to launch aircraft from warships.

OBJECTIVE/ DESIGN PROBLEM:
The goal of the project is to increase your understanding of motion in two dimensions by designing and building a catapult to launch a small rubber ball over a 0.5 meter high wall placed 1 meter away from your catapult and hit a target whose center is located at 2.5 meters away.

AM Class- 4 groups of four students and one group of five students
PM Class- 2 groups of three students and one group of four students

ALLOWED BUILDING MATERIALS: (No other materials can be used in your design)
- K’NEX
- Springs
- Rubber Bands
- Masses as weights

All designs will be table-top models that will be clamped or weighted down to a table to test performance

WORK PRODUCTS:
- Work Logs- all work must be logged and submitted to instructor at the end of each work session
- Catapult itself
- Presentation Prior to Performance Testing and Cost Estimate
- Formal Lab Report

You will be given class time to work on your project. At the end of each work session, each group will need to submit evidence of its progress and maintain a work log.

IMPORTANT:
- While you may come into lab and work on your design, all designs and building materials must stay in the lab. NO EXCEPTIONS!
- IN ORDER TO FINISH THIS PROJECT SUCCESSFULLY, YOU'LL NEED TO WORK OUTSIDE OF CLASSTIME AS WELL.
- Total in class work time= 4.5 hours
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| 12/8 AM Class| 12/9 PM Class  | (45 minutes of work time) | One Work Period  
Lab Session #1- Project overview with catapult basics and getting familiar with materials and building your initial frame. (1 lab hour) |
|              |                |                       | **Evidence of Progress:** In your logs- A description of your launching mechanism (arm) and stopping mechanism at the end of lab with initial frame design. **Description due by 12/17.** Work on Catapults on Your Own time Before 12/17 (Have 4-5 periods to work on catapults in class total) |

**TENTATIVE DATES- 12/17 AM Class AND 12/18 PM (90 minutes of work time)**  
Class MAIN DESIGN SESSION- One Work Period  
Lab Session #2- Problem Solving Meets Reality  
Adjusting your frame to meet performance specifications.  

**Evidence of Progress: WORK LOG AND NEED TO SUBMIT YOUR MEASURED FLIGHT TIME AND YOUR INITIAL VELOCITY, X and Y COMPONENTS OF YOUR VELOCITY AT THE END OF THIS WORK SESSION.**

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| 12/21 and 12/22 | 2nd part of class for AM Class | (90 minutes of work time) | Lab Session #3- Revision Session  
Fine-tune frame and work using trial and error on meeting performance criteria  

**Evidence of Progress: Work Log Documentation**

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| 12/23        | (45 to 90 minutes of worktime) | Lab Session #4- Design Refinement and Cost Estimate | This is the last opportunity you’ll have in class to refine your design and calculate the cost of your final product. **USE TIME IN CLASS TO WORK ON REPORT!**  
**Evidence of Progress: Cost Estimate by listing design parts and cost**

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<th>Date</th>
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<tbody>
<tr>
<td>January 5th</td>
<td>Presentation of Work- Power Point, Submission of Drawings and Cost Estimate, and Testing of Catapult Performance</td>
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<td>January, 9th</td>
<td>Final Report Due (One report per group)</td>
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Formal Lab Report Requirements:

1. This report must be typed on plain paper (type on one side only).
2. The names of all members of your lab team and the date of submission is to be written in the lower right hand corner of the first page of the report.
3. An appropriate and descriptive title for the report should be placed in the center of the first page of the report.
4. Each of the following sections of the laboratory report should be prefaced with the section names.

Presentation Requirements:
- A scaled drawing of your design with dimensions and major parts labeled (can be done neatly by hand or using a computer program) OR properly labeled top, front, and side view pictures that includes dimensions.
- The rational behind your design and problems that needed to be overcome in the design process (trouble shooting)
- Submit your cost estimate
- Everyone needs to be involved in the presentation and performance testing

LAB REPORT FORMAT-

Use these descriptors as headers for each section of your paper

I. Purpose (5 points)
This is a statement of the problem to be investigated. It provides the overall direction for laboratory investigation and must be addressed in the conclusion.

EXPECTATIONS:
- Performance of catapult discussed
- Performance of your catapult based on your expectations and knowledge of physics versus reality is discussed
- Describes the design project with goals
- Includes how theoretical calculations and physics will be used to inform design

II. Equipment (5 points)- What you used
- A list of all laboratory equipment used in the investigation.
- A detailed and labeled diagram to illustrate the configuration of the apparatus.

III. Procedure (20 points)- How you solved your design problem
- Identify and name all the crucial parts of the catapult
- Describe how you tested and revised your design
Someone who was not present during the lab should be able to understand how the experiment was performed and be able to
reproduce the results by reading your procedure.

**EXPECTATIONS:**
- Describes your design process in a way that your procedure could be replicated
- Describes the major components of a catapult and how they work
- Describes your process to building, analyzing, and revising your design based on your understanding of catapults and projectile motion

**IV. Data (20 points)** - Record of trial and error data with design for each modification (angle of attack, initial velocity, and average range for a given angle of attack)
- Data measured directly from the experiment. THIS INCLUDES ANGLE OF ATTACK, HEIGHT OF LAUNCH, FLIGHT TIME, AVERAGE RANGE FOR SPECIFIC ANGLE OF ATTACK, AND INITIAL VELOCITY OF PROJECTILE BASED ON THE DATA
- Include data in properly labeled data tables with units.

**EXPECTATIONS:**
- Includes preliminary design data and final design data to standard requested: Launch angle, height of launch, range, initial velocity, and flight time
- Data tables clearly titled and labeled using units in the body of the report
- Observations, insights, or comments included
- Cost analysis included

**V. Data analysis (30 points)** - Analyzing angle of attack with initial velocity and average range.
- Include all graphs, analysis of graphs, post laboratory calculations and percent errors. How far were you on average from your target?
- Sample Calculations with units are used
- All graphs should have a title, labeled coordinate axis and units.
- Unusual results or trends should be noted and explained if possible.
- State the meaning of any graphs if included

**EXPECTATIONS:**
- Evidence of using data and observations to inform design process
- Equations and sample calculations included in your report
- Precision and accuracy of your final design is calculated and discussed
- Scaled drawing OR labeled top, side, and front pictures with dimensions are included in report
VI. **Conclusion (20 points)**

- Discuss any questionable data or surprising results.
- Explain the possible source of any error or questionable results.
- Reflection: What would you change given the opportunity to do this again?

**EXPECTATIONS**

- Performance of catapult discussed
- Performance of your catapult based on your expectations and knowledge of physics versus reality is discussed
- Students include a reflection on what they learned by participating in this design process

**Scoring**

This project is worth 500 points (about half of your lab grade this quarter).

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<tr>
<th>Project Component</th>
<th>Point Value</th>
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<tbody>
<tr>
<td>Work Log and Professionalism (work ethic, meeting deadlines, teamwork, etc)</td>
<td>200</td>
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<tr>
<td>Formal Lab Report</td>
<td>100</td>
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<td>Quality- Correctness of Theoretical Design and Cost Estimate</td>
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<td>Presentation and Performance of Catapult</td>
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