Date:

Design Challenge: Kinematics & Catapults

Name:

Notebook Title:

Course Title:

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Brainstorm

Directions:
Answer the following questions.

Draw an initial sketch of the problem.

Draw in the ideal trajectory to clear the wall and achieve the furthest range.

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Given the ideal trajectory, estimate the best launch point for your catapult.

What are the real-world conditions which might impact your ideal trajectory?

How will you compensate for these conditions to allow for a margin of error for each launch?

Sketch an initial plan for your catapult design using the approved materials. Document and label the location of glue joints, attachment points for any rubber bands and your intended launch angle.

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Construction

First Prototype

Build the first iteration of your catapult. You may need to change your design from your original plan if you realize there are problems and be prepared to test as you go.

Sketch the build showing how you constructed the prototype by documenting and labeling the location of glue joints, attachment points for rubber bands and launch angle. Explain how your design changed when you started building with the real materials.

Take a photo from the side, front and above to document your construction.

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List the materials used.

Number of popsicle sticks:

Number of rubber bands:

Other materials:

Measure and document the launch angle of the prototype.

Preliminary Design Review

Once the first iteration of your catapult is completed and ready for testing, you will reconvene with your work group for a preliminary design review (PDR). A PDR is a meeting to ensure all the design parameters have been met and the prototype will meet functional requirements. The goal of the review is to determine if the design is worth investing more time and resources.

For your PDR, present both your initial sketch and prototype to your lab group. Answer the following prompts and explain your reasoning:

- Show your initial sketch and first prototype. Explain how they compare and what might have changed when you went from your sketch to the physical prototype.
- Will the catapult launch reliably and remain structurally sound?
- Does it meet the parameters with respect to materials?
- What is the launch angle of your catapult?
- Where is your launch point (distance from the wall) going to be?
- Estimate how far it will throw the projectile.
- Estimate how high the projectile will reach at the apex of its flight.

Finally, ask for questions/suggestions from your peers. Take notes below about their feedback.

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Summarize the advice and things you learned from your work group into three main takeaways.

1.

2.

3.

Prototype Testing #1

You need to test your first prototype. Your work group will need to work together to ensure you have proper measurements. Before you begin, watch the **Student Testing Procedures** video segment. For your performance testing, you will need to use a measuring tape.

1. Check with your instructor to ensure you are cleared to test and to obtain three of the foam balls to use as test projectiles.
2. Select a space where you will have enough area to measure the entire range of the projectile. You may be able to use your instructors' official performance evaluation area for testing, or you may need to make a test area for yourselves by creating or marking an imaginary wall which goes across your course 45 cm high.
3. Start by launching a projectile in a straight line where you have enough space to measure the entire range of the projectile. Record your range and launch angle in the *Quantifying Performance* table below.
4. Calculate the initial velocity and record your result in the table.
5. Calculate the projected maximum height and the time of flight for your launch and record the results.
6. You will now be testing the performance of your prototype. Measure 60 cm away from your wall and select your launch point anywhere beyond this point. Measure and document your launch distance in the *Performance Testing* table below.
7. Launch your projectile. Your lab partner should measure the distance from the front edge of your catapult to the point where it first hits the ground. If the projectile does not clear the wall, mark an X for the distance.
8. Repeat twice more for a total of three trials and document the results in the table below.

Quantifying Performance Prototype #1

Measured Launch Angle	Measured Range	Projected Apex	Projected Time of Flight

Calculate how far the prototype will throw the projectile under ideal circumstances. Show your work.

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Calculate how high the projectile will reach at the apex of its flight under ideal circumstances. Show your work.

Determine where your launch point will be from the wall and explain your choice.

Performance Testing Prototype #1

Launch Angle	Launch Position (distance from wall)	Trial 1 Distance	Trial 2 Distance	Trial 3 Distance	Parameters Met in all Trials? (Yes/No)	Average Successful Launch Distance

Second Prototype

Now revise your first prototype to see if you can improve performance. Start with the basic parameters and think about how you can fix anything which caused an immediate failure.

How well did your catapult perform? Explain what went well and what needs improvement.

List three things you are going to change and provide your reasoning.

1.

2.

3.

Construct a second prototype incorporating these changes.

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Sketch your new build showing how you constructed the prototype by documenting and labeling the location of glue joints, attachment points for rubber bands and launch angle.

Take a photo from the side, front and above to document your construction.

List the materials used.

Number of popsicle sticks:

Number of rubber bands:

Other materials:

Measure and document the launch angle of the prototype.

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Prototype Testing #2

Repeat the testing procedure and record the results below.

Quantifying Performance Prototype #2

Measured Launch Angle	Measured Range	Projected Apex	Projected Time of Flight

Calculate how far the prototype will throw the projectile under ideal circumstances. Show your work.

Calculate how high the projectile will reach at the apex of its flight under ideal circumstances. Show your work.

Determine where your new launch point will be from the wall and explain your choice.

Performance Testing Prototype #3

Launch Angle	Launch Position (distance from wall)	Trial 1 Distance	Trial 2 Distance	Trial 3 Distance	Parameters Met in all Trials? (Yes/No)	Average Successful Launch Distance

Third Prototype

Your catapult should be able to meet the functional requirements and reliably launch a projectile over the wall. Now you will look at optimizing your design.

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Performance

Draw the ideal trajectory of the ball which would meet all the functional requirements while maximizing the range beyond the fortress wall. Label any values you have determined during your performance testing.

Describe at least one aspect you can change on your next prototype to ensure it meets the ideal trajectory. If you think your catapult already attains the perfect trajectory, explain your reasoning.

Design for Assembly

Write the current instructions for someone else to construct your catapult for you.

How can you improve this process to make your catapult easier to assemble?

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Describe or sketch at least one way you will improve the assembly process.

Budget

Minimizing the material usage is one of the more important ways to solve budgetary concerns. You need to justify your choice of materials when it comes to weight concerns. Write an inventory of materials you need for your catapult to function as you have designed and provide justification for each material.

Describe or sketch a new design with at least one change to your prototype for an equivalently functional catapult using fewer materials.

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Style

Style and appearance can matter to a design, provided it does not alter the functionality of the design. Describe or sketch at least one way you can make your catapult cleaner, sleeker and more stylish without compromising performance.

Construct your third and final prototype. Then test the final prototype.

Prototype Testing #3

Repeat the testing procedure and record the results below.

Quantifying Performance Prototype #3

Measured Launch Angle	Measured Range	Projected Apex	Projected Time of Flight

Calculate how far the prototype will throw the projectile under ideal circumstances. Show your work.

Calculate how high the projective will reach at the apex of its flight under ideal circumstances. Show your work.

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Determine where your new launch point will be from the wall and explain your choice.

Performance Testing Prototype #3

Launch Angle	Launch Position (distance from wall)	Trial 1 Distance	Trial 2 Distance	Trial 3 Distance	Parameters Met in all Trials? (Yes/No)	Average Successful Launch Distance

Performance Evaluation

Your instructor will conduct the official performance evaluation for your design.

Have a partner from your working group record the following measurements for you.

Quantifying Performance Final Evaluation

Measured Launch Angle	Measured Range	Projected Apex	Projected Time of Flight

Performance Testing Final Evaluation

Launch Angle	Launch Position (distance from wall)	Trial 1 Distance	Trial 2 Distance	Trial 3 Distance	Parameters Met in all Trials? (Yes/No)	Average Successful Launch Distance