GARAGE PHYSICS

by eisco

High Power Catapult Kit

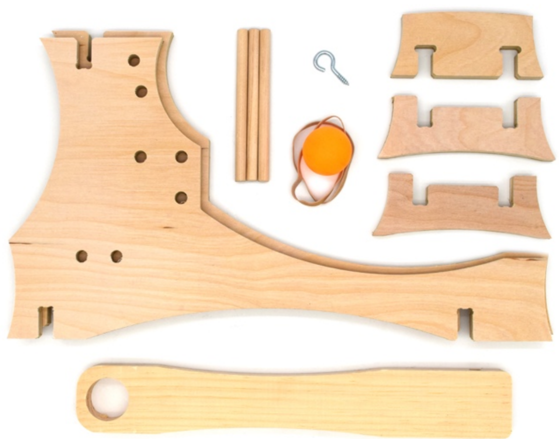
GP00018

Guide for Educators

Learn physics through play! This kit builds in a snap – no tools required! Once built, students can launch ping pong balls up to 30 ft and explore 48 different catapult configurations. Launch angle, fulcrum position, pulling direction and pulling force – all can be simply varied in a repeatable way. Launch your way into a tactile exploration of fundamental concepts of physics!

Educational topics covered in the kit include force, acceleration, center-of-mass, vector components, Hooke's law, parabolic trajectories, and class 2 levers.

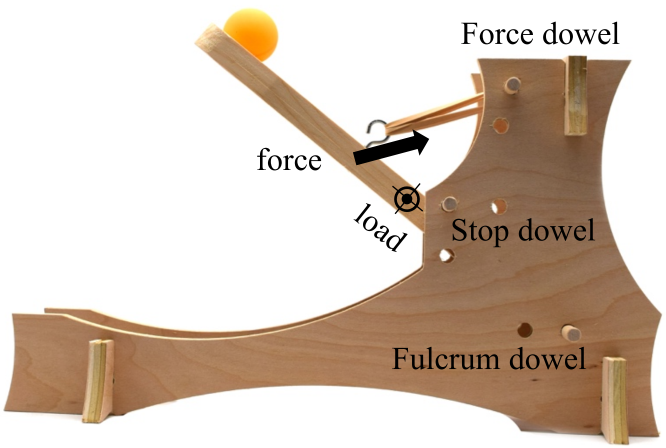
Contents of Kit



Catapult sides (2), side supports (2), top brace, catapult firing arm, Hardware (2 rubber bands, 3 dowels, 1 c-shaped screw hook, and 1 ping pong ball)

Background

Catapults were one of the most influential elements of siege warfare over the last 2500 years. This model is closest in design to the Onager catapult which was used by Romans to launch combustible projectiles at their targets.



This type of catapult is a simple class 2 lever since the load (the center of mass of the firing or lever arm) is between the fulcrum and the force (location of the c-shaped hook).

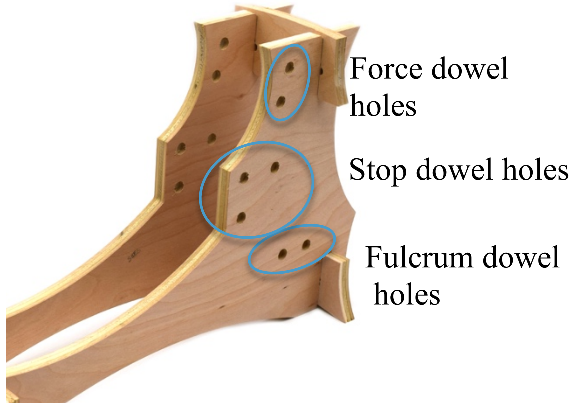
The rubber band pulls on the lever arm with a force proportional to the stretched length (Hooke's law). The component of force in the direction perpendicular to the firing arm accelerates the lever arm until it hits the stop dowel. The stop dowel sets the launch angle (for a given fulcrum position). Once the ping pong ball leaves the firing arm it travels along a parabolic trajectory (ignoring air resistance).

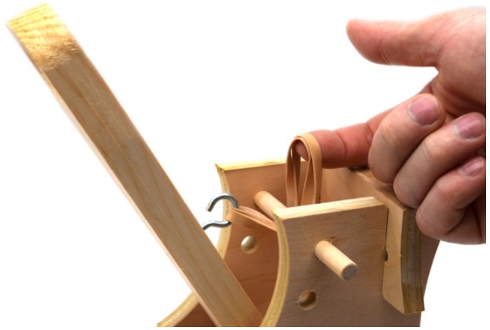
Assembly

1) Insert the side supports and top brace into the side pieces to assemble the catapult frame.

2) Screw the c-shaped hook screw into the firing arm and loop the rubber bands around it. Make sure the open part of the c-shape hook is toward the large hole.

3) Attach the firing arm to the catapult frame with a dowel through one of the two fulcrum dowel holes.





4) Pull back the firing arm and insert the stop dowel. This controls the catapult launch angle. The catapult is now ready to fire.

WARNING!!!
THE CATAPULT CAN CAUSE INJURY TO FINGERS IF FIRED INCORRECTLY.
WARNING!!!

5) To launch the ping pong ball, hold the base with one hand, load the ping pong ball and pull back the firing arm with the other hand. Release to launch.

Be sure to hold the base securely toward the rear of the catapult. This will keep your fingers out from getting pinched and increase the repeatability of the catapult.

Exploration

By changing the positions of the force, stop, and fulcrum dowels, various catapult geometries can be explored.

1) Set up a target and see how far away you can get before the target is out of range. Which dowel settings give the largest range?

2) Set your target up high, such as in a tree or on a play structure. Which dowel settings give the highest trajectory?

3) Make your target more and more sturdy. For example, try stacking paper cups or soda cans filled with water. Which dowel settings give the hardest impact?

Explain your observations during the previous three scenarios.

The dowel setting changes the launch angle (stop dowel), the initial tension in the rubber bands (force dowel), and the angle at which the rubber bands pull on the firing arm (fulcrum dowel). Which do you think is the most important factor in determining the largest range? Why?

For a projectile launched with constant speed at varying launch angles, the largest range is achieved at a launch angle of 45°. Is the largest range for this catapult achieved at a 45° launch angle? Why or why not? Can you explain why 45° is optimal for a projectile having a constant launch speed traveling in a parabolic trajectory?

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Draw a force diagram of the catapult.

Try removing the stop dowel. What does this do to the trajectory?

This catapult is classified as a simple machine, because it uses only a single lever. Catapults can also be made out of compound machines, such as the trebuchet. These types of catapults are generally more efficient. Can you think of a way to modify this design that will result in a larger range using the same frame and firing arm?

<u>NGSS Standards</u>

Motion and Stability: Forces and Interactions

3-PS2-1&2

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