Buildtastic

Driving innovation as part of National Construction Week

WEST SUFFOLK COLLEGE

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CONSTRUCTION CHALLENGE

NASCENT

PLACE 21

Connections, Qualifications and Character Strengths

Can you build a trebuchet?

European Union

European Social Fund

a blended learning challenge, for Key Stage 3 and up, at home or in school, developed by

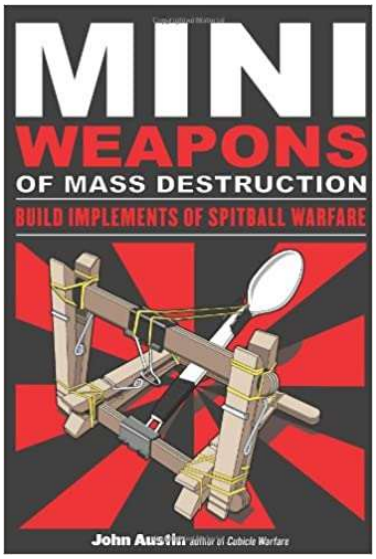
WEST SUFFOLK COLLEGE

Contents:

WHAT ARE YOU GOING TO DO?

You are going to make a mini trebuchet, a medieval siege weapon!

You may have made a catapult out of sticks and rubber bands, this will have worked by storing elastic potential energy, the type of energy you get from stretching something such as a rubber band or a spring, and rapidly converting it to kinetic energy (the energy of motion) of a projectile.



A trebuchet works differently. It relies on gravitational potential energy - the type of energy you get by raising something up off the ground. It has a lever arm with a large, heavy counterweight on one end and a smaller projectile on the other end. When the counterweight is raised up, it has lots of gravitational potential energy. Then the counterweight is allowed to fall, rotating the lever arm and converting that potential into kinetic energy in the projectile, which is flung through the air.

There are many online resources and video clips of brilliant and elaborate trebuchets built at home as large construction projects,

the one we are going to describe uses readily available materials and is inspired by the book *"Mini Weapons of Mass Destruction: Build Implements of Spitball Warfare"* by John Austin and abridged from the Scientific American https://www.scientificamerican.com/article/build-a-mini-trebuchet/.

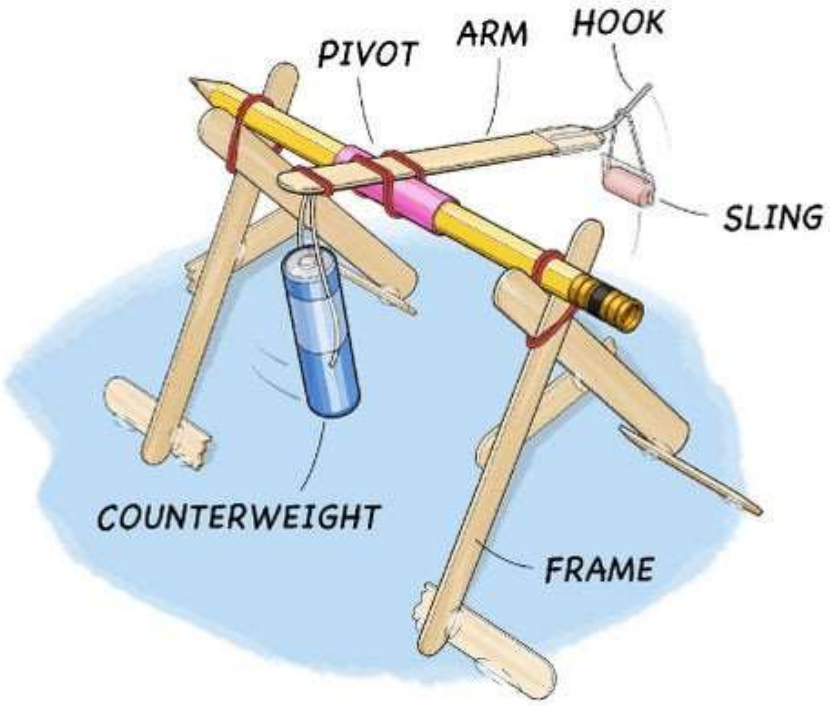
YOU WILL NEED:

- Corrugated cardboard, about 30cm square
- Wooden lolly sticks
- Scissors
- Pencil, with an eraser in the end
- Jumbo or "milk shake" straw
- Glue (a hot glue gun is best if available)
- Tape
- Rubber bands
- String
- Paper clip
- AA battery

NOW YOU'RE READY TO GET BUILDING!

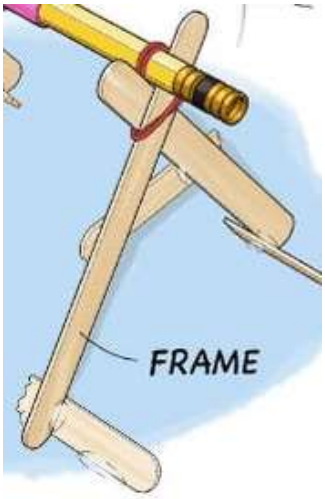
You are going to build a frame that looks almost like a swing in a children's play area.

It will have two "A-frame" shaped pieces on the sides and one crossbar on the top.



Credit: George Retseck image from https://www.scientificamerican.com/article/build-a-mini-trebuchet/

Begin by building the two side A-frame pieces



1) Take five lolly sticks and cut one of them in half.

2) Use two long pieces and one half-piece to form an “A”, making sure you cross the long pieces slightly at the top to form a "V" shape, for the pencil to rest in later.

3) Glue them together and repeat with the other pieces to create two A frames.

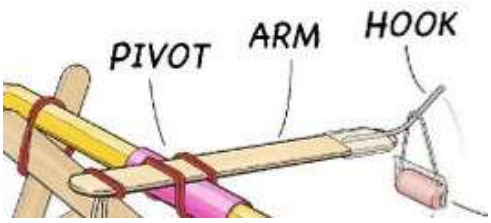
Create a cardboard base to strengthen the trebuchet

1) Carefully cut slots in your piece of cardboard that will support your two A-frame pieces so that they stand upright.

2) The two slots to support each A frame will need to be 10-15cm apart.

3) Insert the ends of the A-frame pieces into the slots and reinforce with glue, tape and some extra lolly stick pieces if necessary, so they remain standing on their own.

Build the trebuchet's arm



1) Carefully cut two small notches on either side of a lolly stick close to one end. The notches should be wide enough to slide in a piece of string. This will help hold your counterweight in place.

2) Attach a small loop of string to your AA battery using tape or rubber bands.

3) Hang the battery from the notches in the popsicle stick. If necessary, make the notches deeper or secure the string with tape, glue or rubber bands.

4) Unbend one end of a paper clip so it is almost, but not quite, straight.

5) Attach the remaining flat part of the paper clip to the other end of the lolly stick, with the straightened part pointing outward and up (away from the counterweight). This will serve as a hook to hold the "sling," which in turn holds the projectile.

6) Remove the eraser from the pencil and attach it to a small loop of string.

7) Hang the eraser from the paper clip hook you made in step 5).

8) Cut a small section of milk shake straw, about 3cm long (shown in pink in the diagrams).

9) Attach this perpendicular to the lolly stick arm using glue, rubber bands or tape. The straw is pink in the diagrams

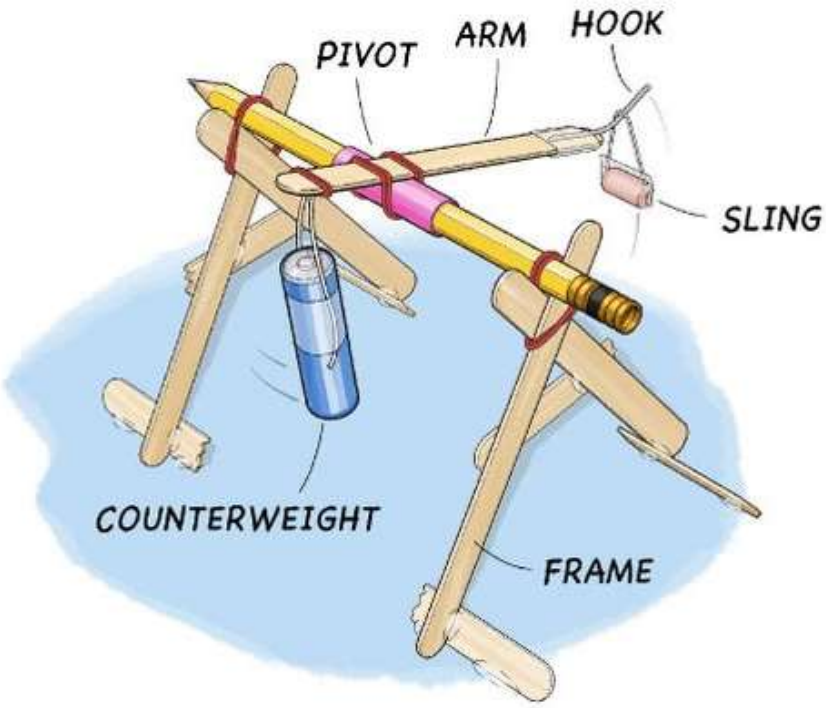
10) The straw should be much closer to the counterweight than it is to the hook. (This distance is something you can try adjusting later.)

11) Slide the pencil into the milk shake straw.

12) Place the pencil into the two V notches on top of your A-frame pieces. Secure it in place with rubber bands. This forms a crossbar and completes your trebuchet's frame.

The straw and pencil form a pivot and should allow the arm to rotate. (We do not recommend using glue for this step—that way you can remove the crossbar and swap out the arm to make changes.)

Make sure your trebuchet is sturdy and the frame holds together. Try rotating the arm with your hand. If any of the joints seem weak or the frame wobbles significantly, reinforce them with tape, glue or rubber bands.



Test your trebuchet

Use one hand to pull down on the eraser. This should raise the counterweight up in the air. Then, making sure no people, animals or breakable objects are nearby, let go.

What happens when you let the eraser go? Does it get launched forward? Does it go straight up in the air? Does it fail to release at all? Can you find the best starting point for the eraser? What makes it go the farthest?

Optimising your Trebuchet

Try changing variables to see how they affect the distance the eraser is thrown.

- Try using lighter (or heavier) batteries. *What impact do you think the weight of the counterweight will have on your projectile?*
- The length of the lever arm: *Both the overall length and the ratio between the distance from the pivot to the counterweight and the pivot to the sling.*
    - Move the pivot so it is exactly in the middle of the arm.

    - Glue multiple lolly sticks together to make a longer arm
- The length of the sling: *What happens if you make it longer or shorter?*
- The shape of the hook: *What happens if you bend the paper clip, so it is straighter or more curved or if it is cut to be shorter?*
- The weight of the projectile: *What happens if you use something other than an eraser, such as a small balled up piece of paper?*

What's happening? The Science

When you pull down on the eraser, this causes the battery to lift in the air, giving it (gravitational) potential energy.

When you release the eraser, the battery falls, and its potential energy is converted to kinetic energy of the eraser.

As the arm swings, the sling holding the eraser slides off the hook and the eraser's kinetic energy causes it to fly through the air as a projectile.

Depending on exactly how you built your trebuchet, the results you see will vary. Don't get discouraged if at first your trebuchet launches the eraser straight up in the air or fails to release it at all - inker with your design to get the best results!

CROSS-CURRICULAR LINKS:

You might think that construction is not part of the curriculum you are studying, well you'd be wrong, your curriculum topics are embedded in construction and in carrying out this activity you will be using your skills in the following topics

Science: this activity has given you the opportunity to develop your understanding of engineering and physics (potential energy, kinetic energy, conservation of energy). Working scientifically, in tinkering with your trebuchet you will have considered the impact of your adjustments.

English: you've read and understood this challenge

Maths: can you figure out what mathematical considerations would be involved in real life trebuchet design, what forces are acting on your trebuchet and how are they described in maths and physics.

History: a trebuchet is a medieval weapon of war; can you find out more?

Geography: where and why were trebuchets employed?

Modern Foreign Languages: trebuchet derives from the French, is there a literal translation of the word, were the French the first to use trebuchets?

Art, Design and Technology: you have carefully followed a design for your trebuchet, how might you improve the design, could technology help you to do this?

Computing: can you investigate what a CAD programme would add to this activity? could you create a replica of your finished trebuchet using Minecraft?

Citizenship: if you have worked as a group to create your trebuchet you will have been practicing your citizenship skills, you will have thought about the different strengths and weaknesses of each team member and recognised that everyone has a meaningful role to play.

FIND OUT MORE: USEFUL LINKS

These links of short videos and written resources should help you understand more about this construction challenge

WEB RESOURCE: The national curriculum in England
The entire national curriculum is available to all as a PDF or Word Document
https://www.gov.uk/government/publications/national-curriculum-in-england-primary-curriculum

WEB RESOURCE: Scientific American – Paper Bridge
An example of how to complete a similar challenge can be found at
https://www.scientificamerican.com/article/paper-bridges/

WEB RESOURCE: Arms and Men: The Trebuchet
A great article on the history of the trebuchet https://www.historynet.com/weaponry-the-trebuchet.htm

WEB RESOURCE: Trebuchet Physics
The physics of trebuchets (and many other excellent real world physics problems)
https://www.real-world-physics-problems.com/trebuchet-physics.html

WEB RESOURCE: Make a walking arm trebuchet
An easy to follow guide to making a walking arm trebuchet https://www.instructables.com/id/Worlds-Simplest-and-Newest-Trebuchet-Walking-Arm-T/

WEB RESOURCE: How to impact projectile distance
Details of a two week science project investigation https://www.sciencebuddies.org/science-fair-projects/project-ideas/ApMech_p013/mechanical-engineering/effect-of-trebuchet-arm-length-or-counterweight-mass-on-projectile-distance

WEB RESOURCE: Trebuchets, an enthusiast's essential website
Everything trebuchet is listed here http://www.stormthecastle.com/trebuchet/the-real-trebuchet-at-the-citadel-in-cairo.htm

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