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Catapult for AutoSTEM

Construction instructions and pedagogical guidelines

This guide includes:

- How the Catapult can be used to learn STEM subjects
- How to construct a Catapult

How the Catapult can be used to learn STEM subjects

What is the Catapult?

The Catapult is a toy that is extremely simple to make. It has the capacity to fire a small, lightweight projectile (payload) a short distance. The **AutoSTEM** Catapult is made from wooden sticks that are used for ice cream or for naming seeds in a garden, elastic bands, a bottle top and glue or a split pin. It can be used indoors or outside.

It results in a toy that can be used by the children in many ways and opens up a number of subject areas for further learning. Catapults are very motivating and exciting toys for children. It is fun for the children to be allowed to play with their Catapults, once they have made them.

Safety

The payloads and forces utilised by the catapult do not present any safety problems. Children can wear goggles if the teacher wishes but they are not really necessary as the size and weight of the payload projectiles is small.

Figure 1. An example of the Catapult with a volunteer

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Target group

The Catapult example described here is designed for children from 4 to 7 years old. Teachers can adapt the proposal to other ages.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Catapult several learning goals can be achieved:

- To learn Mathemativs including counting, addition, use of table, measuring. Simple statistics
- To learn about physics and mechanisms
- To develop engineering competencies of analysis and construction.
- Other soft-learning goals can be included; problem solving and creativity.

Guide on how to introduce STEM concepts

The catapult is a simple machine that can be used as a very effective tool to teach STEM, particularly Maths, Physics and Mechanics, the construction is very simple.

Observing

The first thing the teacher does is show a model of the Catapult and make it fire. The teacher can ask, 'Why did it fire?'

Exploring and learning about physics and mechanisms.

Children can observe the Catapult, make comments, and ask questions about how it functions.

The following concepts can be introduced and explored

- **Energy:** different types of energy:
    - Work (The child does work by pulling down the lever arm.)
    - Potential energy due to the deformation of the lever arm when it is pulled down
    - Kinetic energy due to motion of the lever arm when it is released
- **Force:** The child uses force to pull down the lever arm with the bucket. According to Newton's third law (action equals reaction), the force of

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the downwards pull creates an equal force in opposite direction on the Catapult (called the propulsion) that pushes the payload forwards.

- **Conservation of energy:** Energy can be converted but not destroyed.
    - The child's work is converted into potential energy,
    - The potential energy is converted into translational kinetic energy of the payload when the lever arm is released

- **Parts of a catapult:** Fulcrum, lever arm, bucket. payload

The Catapult and learning mathematics

The teacher talks with the children asking what is needed to make the Catapult. During the construction, many mathematical concepts can be used, introduced, or discovered.

- **Counting:** 13 wooden sticks divided into two parts for the fulcrum and lever arm, one bottle top, 3 large elastic bands
- **Locating:** use spatial concepts like rear, front, under, top, bottom, centre (find the centre of a circle), aiming
- **Measuring length:** children can use a ruler to measure how far the payload went, younger children can use fingerbreadth and handbreadth as units. It is also possible to decide by direct comparision which payload went furthest.
    - If fastening the bottle top with a split pin: to make a hole in the bottle top that is 'just' big enough for the split pin to pass through is direct comparison, too.
- **Measuring weight:** use a scale or balance depending on the childrens age. Different weight payloads can be used and children can see if the different weight makes a difference to how far the payload goes, Younger children can check which is heavier and which is lighter. Older children can use a measuring scale.
- **Using tables:** the catapult can be used to introduce a simple table within a game (see below).
- **Using a target:** the catapult can be used with a target, a target is supplied in this template, the simpler target used with the younger children upto 5, more advanced children use the one with numbers upto 10.

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- **Introducing statistics:** using the table the children can calculate a number of concepts, shortest, longest, average

How to construct the Catapult

To make the Catapult you will only need basic parts and tools that are found in every school or preschool. Below we list the parts needed and alternatives.

Parts and tools required

- For the Catapult
    - 13 x Frozen ice wooden sticks
    - 3 x Strong elastic bands
    - 1x plastic bottle top (Bucket)
    - Sticky tape
- For fixing the plastic bottle top either:
    - Hot melt glue gun OR
    - 1 x split paper fastener
    - A tool for making small holes in wood/ a nail can work
- The payload (any one or all can be used as payloads, or the children could select objects themselves)
    - A button
    - Plastacine
    - Any other soft small toy that will fit in the bucket
    - Counting bears
- Target if required (2x templates supplied below)
    - Simple piece of paper with circles (see page 8 and 9)
- Optional – a standard pencil

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Method

It is best to watch the video.
To make the Catapult watch this video

The catapult

1. Take 13 ice cream wooden sticks and divide them in to three piles, one has 3, the second 9, the third has 1. The pile of 9 will be the fulcrum. 3 stick will be the aiming device and include the Lever stick, the final stick will be the Aiming stick.
2. Pile the 9 sticks in to a tight pile with the ends matching at both ends. Tie the pile of 9 sticks at one end with one of the elastic bands. You will need to wrap the band around a number of times. Tie the other end with the second elastic band the same way.
3. Attach the plastic bottle top (bucket) to the middle of the Aiming stick and to the end of one of the remaining sticks (Lever stick).

Hot melt glue joining method	Split pin joining method
Stick the plastic top to the middle of the Aiming stick (find the middle)	Make a small hole in the bottle top big enough for the end of a split pin to go through
Stick the middle of the Aiming stick, with the top attached, to one end of the Lever stick	Make a hole in the centre of another stick, this will be the Aiming stick. (find the middle)
	Make a hole in one end of the Lever stick. It is helpful to wrap

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	some sticky tape around where the hole is made as the wood can split when making the hole.
	Push the split pin through the prepared holes in the Bottle top, Aiming stick and Lever stick. Once the pin has gone through push the 2 ends up so they fit tightly under the stick.

4. Pile up the remaining 3 sticks again and tie the end without the bottle top with the final elastic band.
5. Push the pile of 9 sticks between the Lever stick of the second pile at the untied end, and the other 2 at a right angle. This will result in the sticks being separated at one end while still tied together at the other. Push the sticks approximately half the distance of the sticks. The 9 stick pile can be stuck in to position but that is not necessary.
6. Alternatively, instead of the 9 sticks you can use the pencil to separate the Lever stick and the other 2.

The Catapult is now finished and can be used.

Using the catapult

There are a number of ways that the catapult can be used by children, we identify a number of 'Games' below with tables that can be used to record results were appropriate.

Maths Games using the catapult

Game 1. Each child fires the catapult 3 times and the group records the distance in a table. The next child in the group does the same and on.

Childs Name	Distance (hands or centimetres)
Fire 1	
Fire 2	
Fire 3	

Game 2. Each child fires the catapult 3 times and the group records the distance in a table. The next child in the group does the same and on. The

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tables are then taken and calculations completed on the results, depending on the age of the children.

Calculations are: total distance, the average, shortest and longest.

A video how to use this game can be seen here.

Childs Name	Distance (hands or centimetres)	Show the shortest/Longest
Fire 1		
Fire 2		
Fire 3		
Total distance (Fire 1 +2+3)		Average distance (Total distance/3)

Game 3: using different payload weights. The simplest way to use varying payload weights is:

1. Plasticine balls
2. Counting bears. They come in three different sizes (e.g. https://www.learningresources.co.uk/three-bear-familyr-rainbowtm-counters-set-of-96)

These can be weighed simply as heavier and lighter by the youngest children using a balance. Older children can use a scale. Children can also suggest different items, this may bring in air resistance later on.

Again the children take 3 goes with each weight, measure the result and then record in the table below.

Childs Name	Distance (hands or measurement)	Weight of payload
Firing payload 1		
Fire 1		
Fire 2		
Fire 3		
Firing payload 2	Distance (hands or	Weight of payload

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	measurement)	
Fire 1		
Fire 2		
Fire 3		

After the execise is complete the children have to explain why there is a difference. They may need to try this a number of times to find a significant difference.

Game 4: Aiming at the target. There are 2 targets supplied, one with numbers upto 3 and one upto 10. This is purely a competitive game that involves addition. The teacher can easily add additional elements if they wish. Again use tables to record results. It can be as simple as child with the highest total is the winner.

It might be an idea to use different coloured payloads so the children can identify their own goes.

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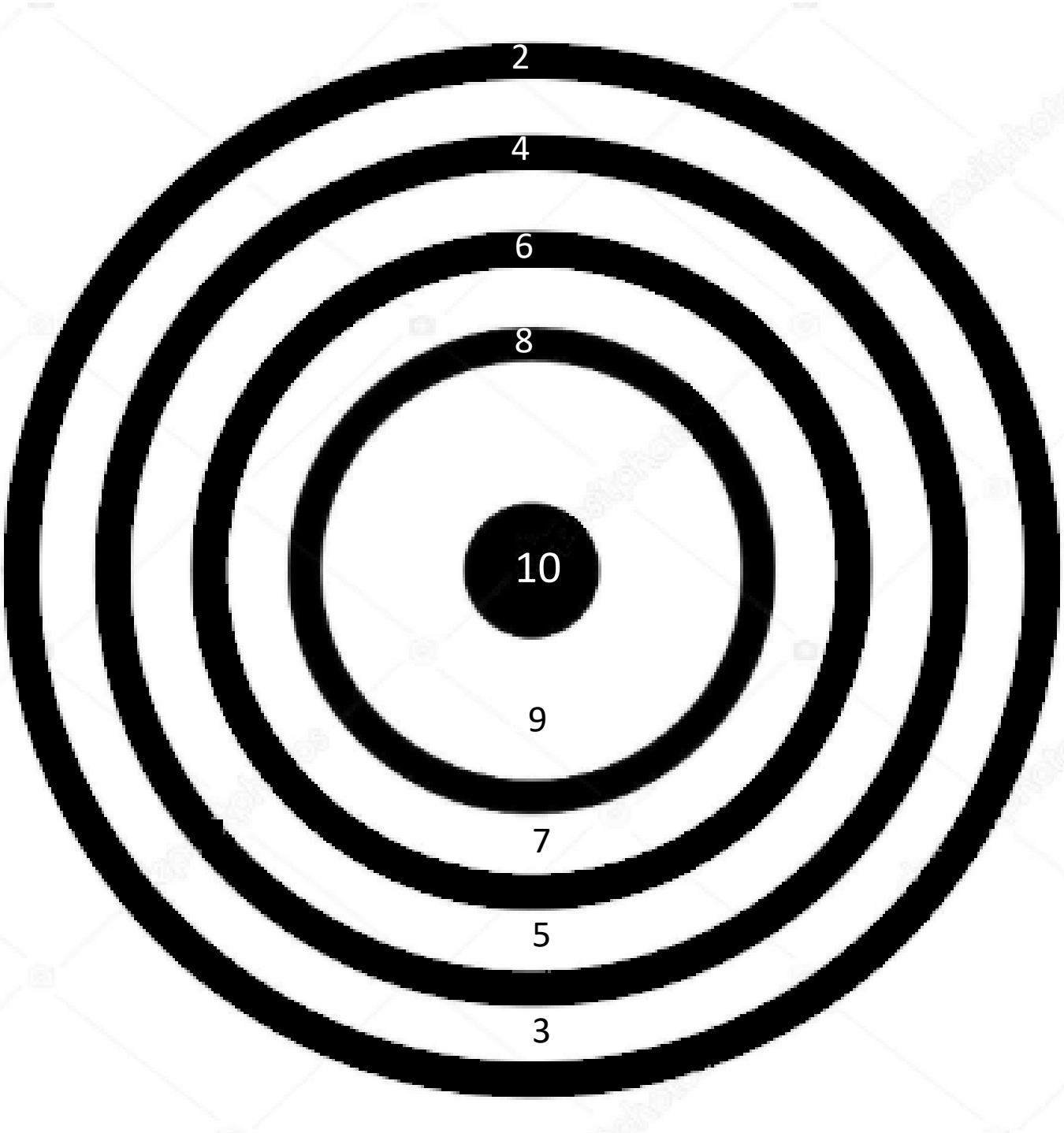
Target up to 10



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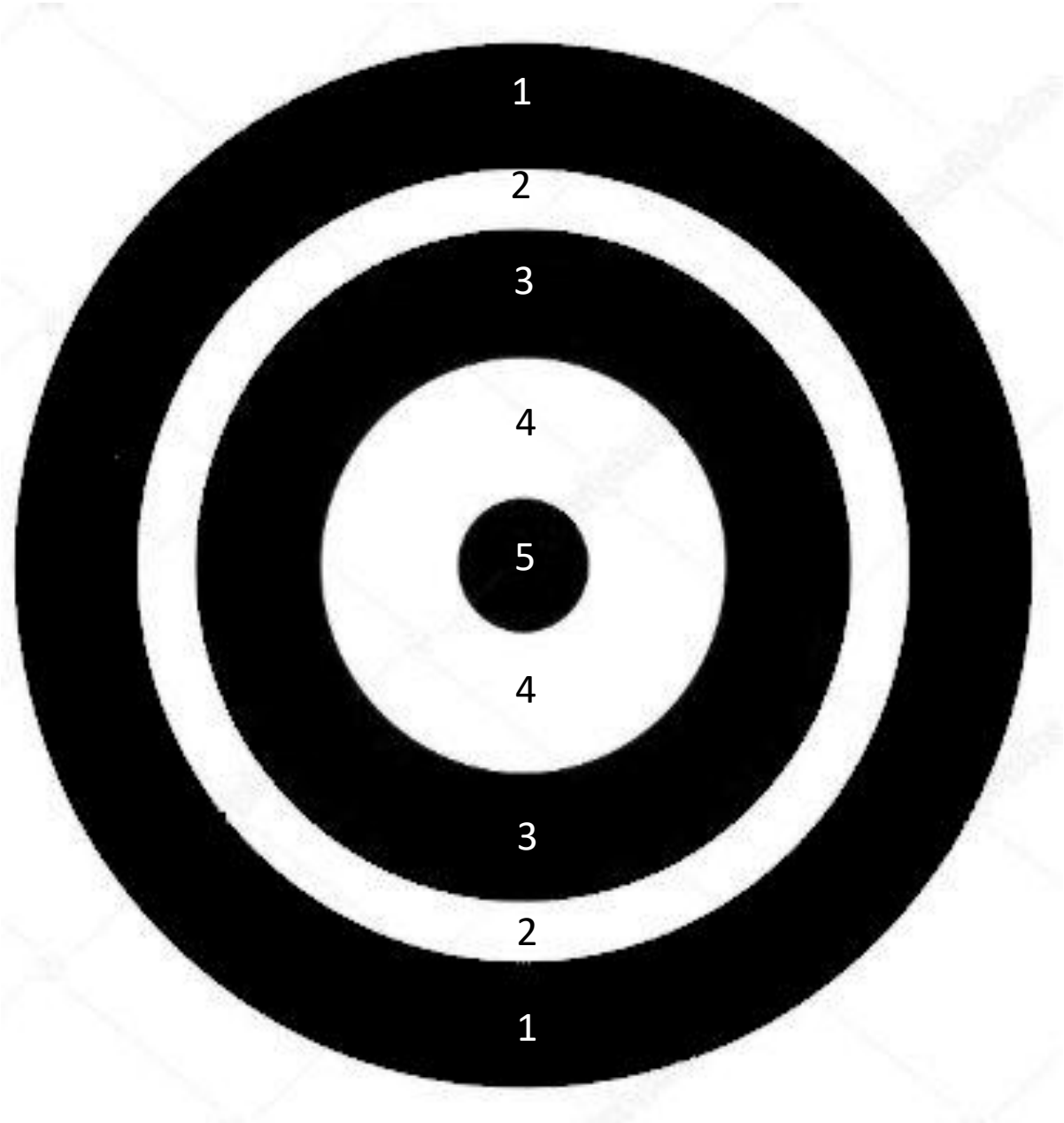
Target up to 5



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