



## Field Goal! The Science Behind a Perfect Football Kick

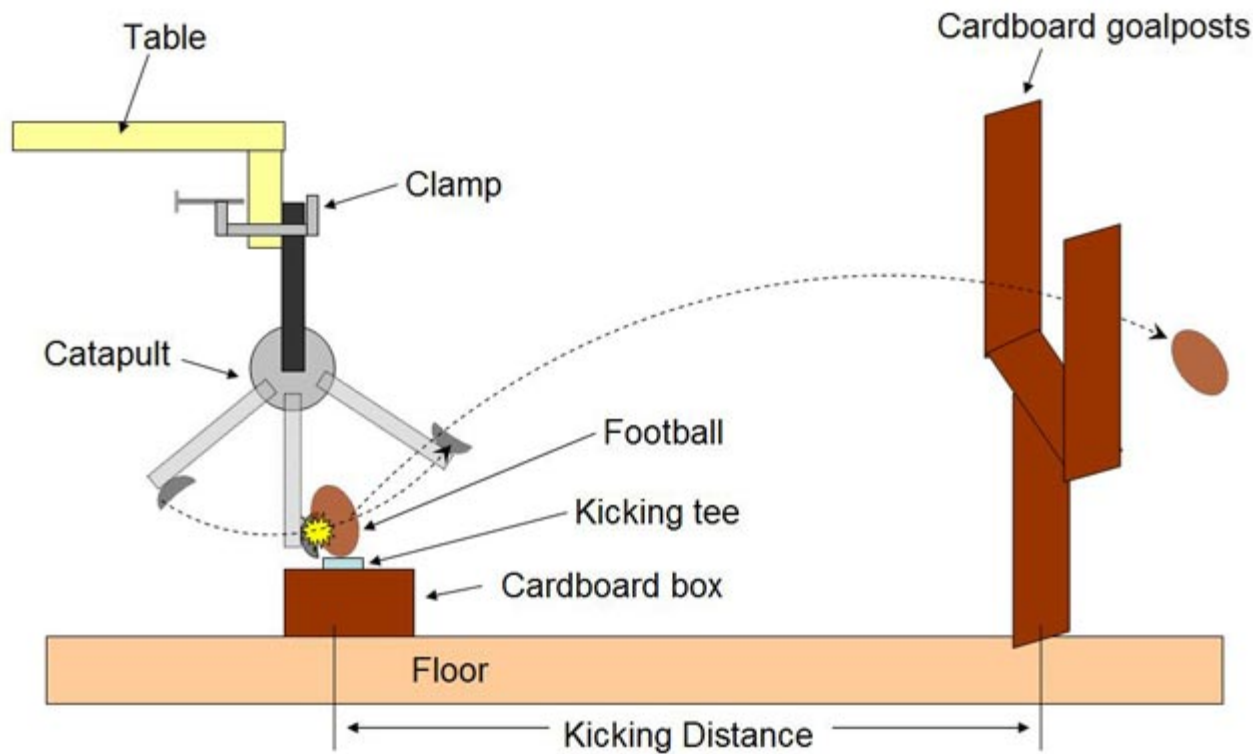
[https://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports\\_p059/sports-science/science-behind-a-perfect-football-kick](https://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports_p059/sports-science/science-behind-a-perfect-football-kick) ([http://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports\\_p059/sports-science/science-behind-a-perfect-football-kick](http://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports_p059/sports-science/science-behind-a-perfect-football-kick))

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### Experimental Procedure

#### Set Up Your Experiment

1. In this section, you will set up your experiment like the setup in Figure 2. Read the steps for detailed directions.



**Figure 2.** The experiment setup for this science project.

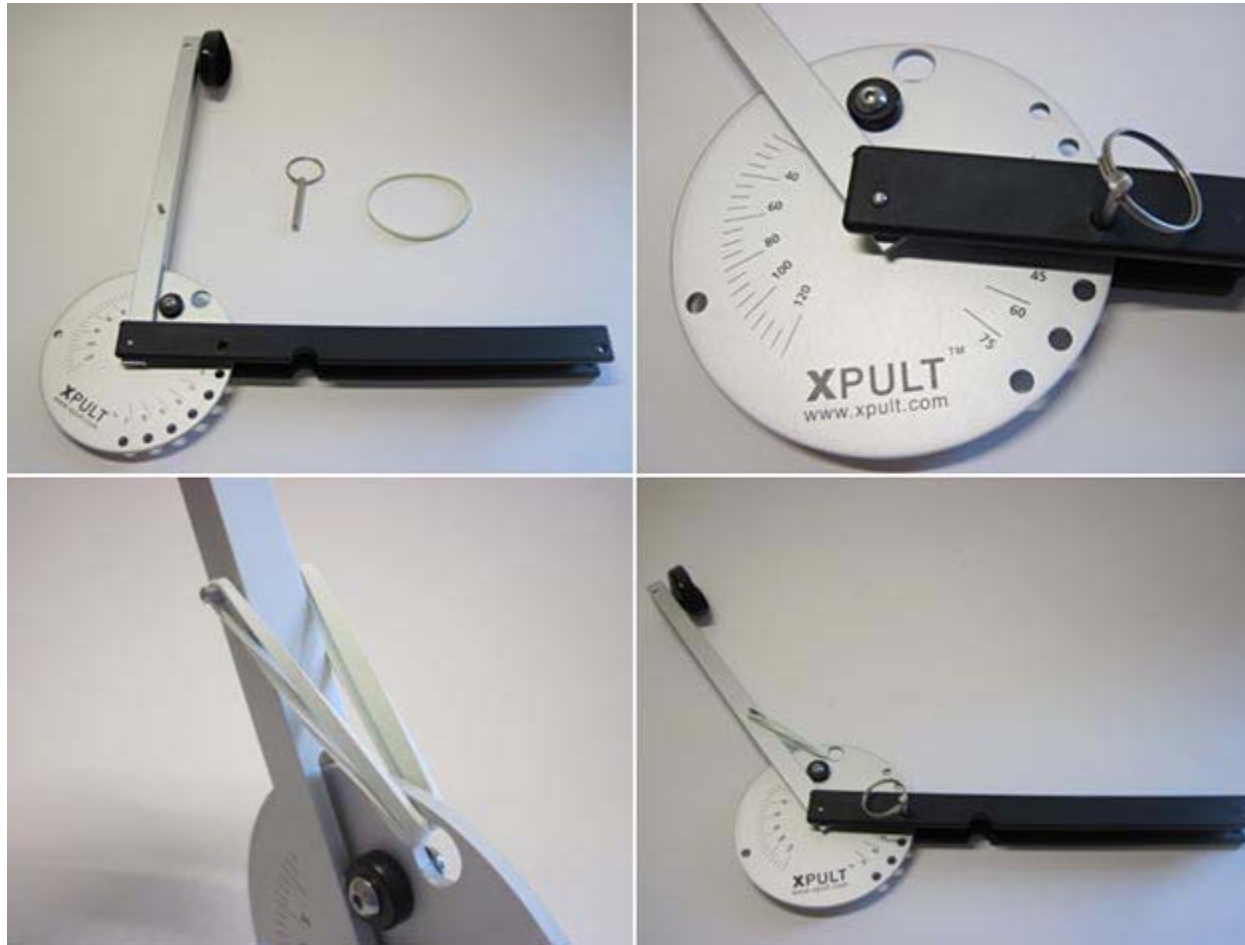
2. Watch this video to learn how to set up your catapult. Note that in this project, you will mount your catapult upside-down.

Video instructions for using your ping pong catapult.  
<https://www.youtube.com/watch?v=pIEjwMhnAGo> (<https://www.youtube.com/watch?v=pIEjwMhnAGo>)

3. Set up your catapult.

- a. Get the catapult, metal pin, and a single rubber band from your catapult kit, as shown in the top left picture of Figure 3.
- b. Push the pin through the hole in the base of the catapult (the black part) to lock the circular metal disc in place, so the 45 on the disc is showing just below the black bar (see Figure 3, top right). Notice that the metal disc has multiple holes, so you have to push the pin through the correct hole to line up the 45.
  - i. *Note:* This pin sets the "follow-through angle", or how far the catapult arm will keep moving after it makes contact with the ball. For this experiment, you will keep the follow-through angle constant. If you want to find out what happens when you change this angle, see the tab.
- c. There is a large hole in the top of the metal disc. Push a rubber band through this hole and hook it on both sides of the pin that sticks through the catapult's launch arm (see Figure 3, bottom left).

d. When you are done, the assembled catapult should look like the bottom right image in Figure 3.



**Figure 3.** The catapult, rubber band, and pin (top left). Use the pin to lock the metal disc in place relative to the base of the catapult (top right). Loop a rubber band through the large hole in the metal disc, and hook it on both sides of the pin sticking through the launch arm (bottom left). The assembled catapult (bottom right).

4. Clamp your catapult to a piece of furniture.

- a. Use a clamp (either the spring clamp that came with the catapult kit, or a C-clamp; a C-clamp will probably work better) to clamp your catapult hanging upside-down from a piece of furniture, like a table or a desk, as shown in Figure 4.
- b. Remember that you may need to move around some furniture in your house to have enough room for the experiment. Make sure you have at least 4 or 5 meters (m) of open space in front of the catapult.
  - i. *Note:* In NFL games, distances are measured in English units: yards, feet, and inches. However, scientists always use metric units, so for your science project, you should always measure distances in meters.
- c. *Important.* If you do not watch to scratch the furniture, use paper towels or a small dish towel as padding between the furniture and the clamp.



**Figure 4.** Catapult clamped to the bottom edge of a workbench.

5. Build your goalpost.

- a. Use household materials like cardboard and duct tape to build a goalpost that is roughly 0.3 m wide, like the one shown in Figure 5. The exact size of your goalpost does not matter for this science project; just make sure it is a reasonably sized target for your toy football.



**Figure 5.** This goalpost is made from cardboard, duct tape, and a small trash can.

6. Set up your goalpost in front of your catapult.
  - a. Set up your goalpost as far as possible from the catapult. When you do the experiment, you will start out at the farthest distance and gradually move the catapult closer.
  - b. Ideally, you should set your goalpost up 5 m from the catapult. If you go much farther than that, you may go out of the catapult's range. If you do not have that much space available, you may need to start with the catapult closer.
7. Set up your kicking tee.
  - a. Use something like a medicine cup or a small bottle cap as a kicking tee (see Figure 6).
  - b. Using a stack of cardboard boxes or books, as necessary, set up your kicking tee so the ball is at just the right height to be "kicked" by the end of your catapult arm when it swings (see Figure 7). The exact height of boxes/books that you need will depend on the height of the furniture you clamped your catapult to.



**Figure 6.** A medicine cup or small bottle cap will work as a kicking tee.



**Figure 7.** This picture shows a textbook and two cardboard boxes used to adjust the kicking tee to the appropriate height for the catapult.

### Kick Some Field Goals!

1. Make a data table like Table 1.
  - a. *Note:* Depending on the amount of space you have to work with, you may have to adjust the distances in the first column. Try to make sure you test at least four different distances.
    - i. For example, if you only have 4 m of total space, you could test distances of 1, 2, 3, and 4 m.
    - ii. If you have more space available, you could test 1, 2, 3, 4, 5, and 6 m.

Distance (m)	Field Goals Made	Field Goal Attempts	Field Goal Percentage
1			
2			
3			
4			
5			

**Table 1.** A data table to keep track of your field goal kicking. Remember that in NFL games, distances are measured in yards, but for your science project, you should use metric units and measure in meters (m).

2. Double check to make sure your goalpost is set up at the *farthest* distance from your data table. For example, if you are using an exact replica of Table 1, you should put your goalpost 5 m away from your catapult.
3. Take some practice kicks to get used to using the catapult setup.
  - a. Use one hand to pull the arm of the catapult back, while you carefully place the football in the kicking tee with your other hand.
  - b. Move your free hand out of the way once you have placed the ball, so you do not hit your fingers!
  - c. Let go of the catapult arm; it will immediately swing forward and hit the football. Did it go through the goalposts? If so, you scored a field goal!
  - d. If the ball did not go through the goalposts, you may need to make some adjustments to your catapult setup. This part will take some trial and error, depending on how far off your first kick was. There are several different things you can try to help aim your kicks:
    - i. If the ball did not go far enough (the kick was too weak), you can add more rubber bands to your catapult. Your catapult kit came with three rubber bands. Try adding one or two more rubber bands the same way you attached the first one. This will make each "kick" stronger.
    - ii. You can also adjust how far back you pull the catapult arm before releasing it. The farther back you pull the arm, the more it stretches the rubber band, so the harder it will kick the ball.
    - iii. If the ball is going too high or too low, try adjusting the height *or* the forward-backward position of your kicking tee slightly. This will change where, during the swing, the catapult comes into contact with the ball, which will affect how high or low it is kicked.
    - iv. If you are missing field goals wide left or wide right, try adjusting the left/right position of the tee slightly. This can affect whether the ball goes straight or hooks to the side.
  - e. Once you have found a good setup to kick field goals, you need to record the settings you are using to make sure you can do repeated trials.
    - i. Pay attention to how far back you pull the catapult arm. You can do this by reading the angle markings printed on the metal disc on the catapult. For all future trials, make sure you pull the catapult arm back to the same spot. This will ensure the ball always goes far enough.
    - ii. Pay very close attention to *exactly* where you place the kicking tee, as this can have a big impact on where the ball goes. It may help to tape down a piece of paper and draw a box around the kicking tee, to make sure you can put it back in the exact same place each time.
    - iii. If necessary, use duct tape to secure the pile that is holding up your kicking tee (for example, if you are using three cardboard boxes, tape them together so they do not shift around after each kick).
4. When you have completed your practice kicks, take 25 official kicks to calculate your field goal percentage at this distance.



- a. Use your data table to record your total number of successful field goals and your total number of attempts.
  - b. If you have time, you can collect more data and try more attempts (for example, 50 attempts at each distance).
5. When you have completed all of your kick attempts at this distance, calculate your field goal percentage using Equation 1 and enter it in the third column of your data table:

**Equation 1:**

$$\text{Field Goal Percentage} = \frac{\text{Number of successful field goals}}{\text{Number of field goal attempts}} \times 100$$

- a. For example, if you attempted 25 field goals but only made 17 of them, your field goal percentage is:

**Equation 2:**

$$\text{Field Goal Percentage} = \frac{17}{25} \times 100 = 68\%$$

6. Move your goalposts to the next closest distance from your data table (for example, move them from 5 m to 4 m), then repeat steps 4–5 for this new distance.
  - a. Do *not* change how hard you kick the ball. Keep the number of rubber bands and how far back you pull the catapult constant. Technically, this is different from real football (a kicker would not need to kick a 10-yard field goal as hard as they would need to kick a 60-yard field goal). But, since you are doing a controlled experiment, you want to make sure you do not introduce any extra variables.
  - b. You can still take a couple practice kicks before you start taking data at the new distance.
  - c. Remember to record the results in your data table.
7. Make a graph of your data with field goal percentage on the vertical axis (y-axis) and kick distance on the horizontal axis (x-axis).
  - a. If you need help creating a graph, you can use the [Create a Graph](http://nces.ed.gov/nceskids/CreateAGraph/default.aspx) (<http://nces.ed.gov/nceskids/CreateAGraph/default.aspx>) **Website**.
8. Analyze your results. How does field goal percentage vary with kick distance? Did it get harder or easier to kick field goals as the goalposts got farther away? How do your results compare to your hypothesis?

## Frequently Asked Questions (FAQ)

FAQ for this Project Idea available online at [https://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports\\_p059/sports-science/science-behind-a-perfect-football-kick#help](https://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports_p059/sports-science/science-behind-a-perfect-football-kick#help) ([http://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports\\_p059/sports-science/science-behind-a-perfect-football-kick#help](http://www.sciencebuddies.org/science-fair-projects/project-ideas/Sports_p059/sports-science/science-behind-a-perfect-football-kick#help)).