

# How To Make A Wall Go Boom

## The Effect of Counterweight on Trebuchet Launch Distance

By Bryan Z.



# The Question

How will increasing the counterweight of a trebuchet affect its launch distance? Will the increase in counterweight cause the projectile to fly further then it does with a lighter counterweight, or will the opposite result occur?

# Research

Counterweight Trebuchets can be broken into five parts. These parts include the frame, axle, beam, counterweight, and sling/launcher, which all work together to maximize the efficiency of the trebuchet. The frame is used to hold the trebuchet above ground level. This is important because the height of the trebuchet will also determine the air time and distance of the counterweight that falls down (Harvey, "How Did Trebuchets Work?," Par. 4) The axle is attached to both sides of the frame, which will allow the beam to spin when released. The counterweight is hooked to the shorter side of the beam, meaning the launcher is tied to the longer end of the beam. This helps the projectile go higher in the air and achieve more velocity. (Mozias, "Greek Scientists That Invented The Catapult, Par. 6)

Trebuchets are launched by utilizing the energy of a dropping weight to launch a projectile. It also uses a fast falling speed from the counterweight to achieve high velocity. To increase the speed of the launch, the counterweight must be much heavier than the projectile and sling, as the faster the weight falls, the more strength is pushed through the beam and the more velocity achieved (Trebuchet Physics, Par. 3). Because it is the fall time of the trebuchet that affects the launch distance more, by theory, there should be a cutoff point, where an increase in weight will only yield a slightly further distance. Another important mechanic is the placement of the beam. If the counterweight is shifted too far forward, then the drop speed will have less effect on the velocity, and the beam end of the launcher will be shorter, which also lowers its velocity (Trebuchet Physics, Par. 6). However, if the counterweight is shifted too far back, the weight will not have enough space to maximize fall time, causing the trebuchet to fail.

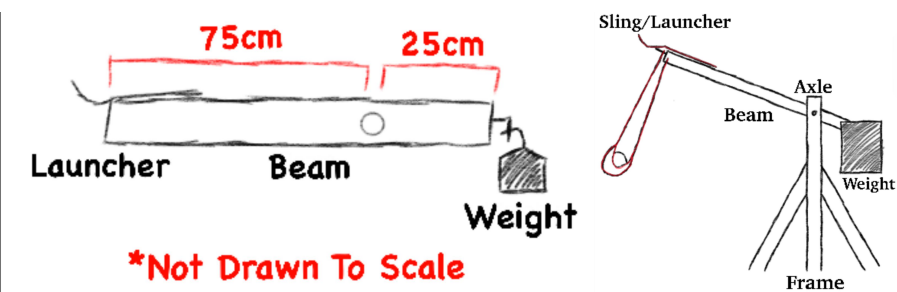


Diagram Of Trebuchet Drawn By Student

# Variables

- Independent variable: The Counterweight Of The Trebuchet
- Dependent variable: Launch Distance Of The Projectile
- Controlled variables (constants): Testing Field, Trebuchet, Projectile, Trebuchet Release Force

# Hypothesis

If the weight of the counterweight in a trebuchet is increased, then the launch distance of the projectile will increase.

# Materials

## Wooden Planks:

- 3x 45cm planks
- 2x 70cm planks
- 2x 75cm planks
- 1x 100cm plank

## Axle:

- 40cm Axle

## Nails:

- 16x 50mm Nails

## Tools:

- Power Drill
- Marker
- Duct Tape
- Hand Saw

## Other Objects:

- Ladle
- Tennis Ball (Projectile)

# Procedure

1. Using 2 70cm planks, and 45cm planks to form a rectangle. The 45cm planks should be under the 2 70cm planks.

2. Under the 2 70cm planks, nail another 45cm plank under it at the central point of the 70cm planks.

3. Nail these planks together using two diagonal nails per side.

4. Attach 2 75cm planks at a 90 degree angle to the rectangular frame in the first step.

5. Use two holders and 4 nails on either side of plank to hold it up.



Images of trebuchet taken by student for procedural plan.



## Procedure (Cont. )

5. 10cm from the top of both upright planks, drill a 2cm by 2cm hole.

6. Fit a 40cm long axle through the previously drilled hole.

7. Take a 100cm long plank, and drill a 2cm by 2cm hole 25cm from the one side.

8. On the shorter side of the hole, hammer in a hook.

9. On the other side, use rubber bands to tie a launcher on. Instead of using a sling, we are using a launcher as it is far more consistent with the lighter weights and smaller design. Any object that has a scoop like shape can be used.

10. Continue wrapping rubber bands around the beam and ladle until it is fit snugly and doesn't wiggle during launch.

11. Attach the beam to the frame of the trebuchet using the axle.



Image of Trebuchet with axle taken by student.

## Procedure (Cont. )

12. Using a smooth piece of rope, attach and tie the rope to a cardboard box.

13. Hang it on the hook hammered in the previous step.

14. Place your weights into the box.

15. Make sure to hold down the beam so it doesn't fly upwards.

16. To launch it, you can tie a piece of string to the bottom of the beam, and cut the string to release the trebuchet.

Here is the final design without the weights.



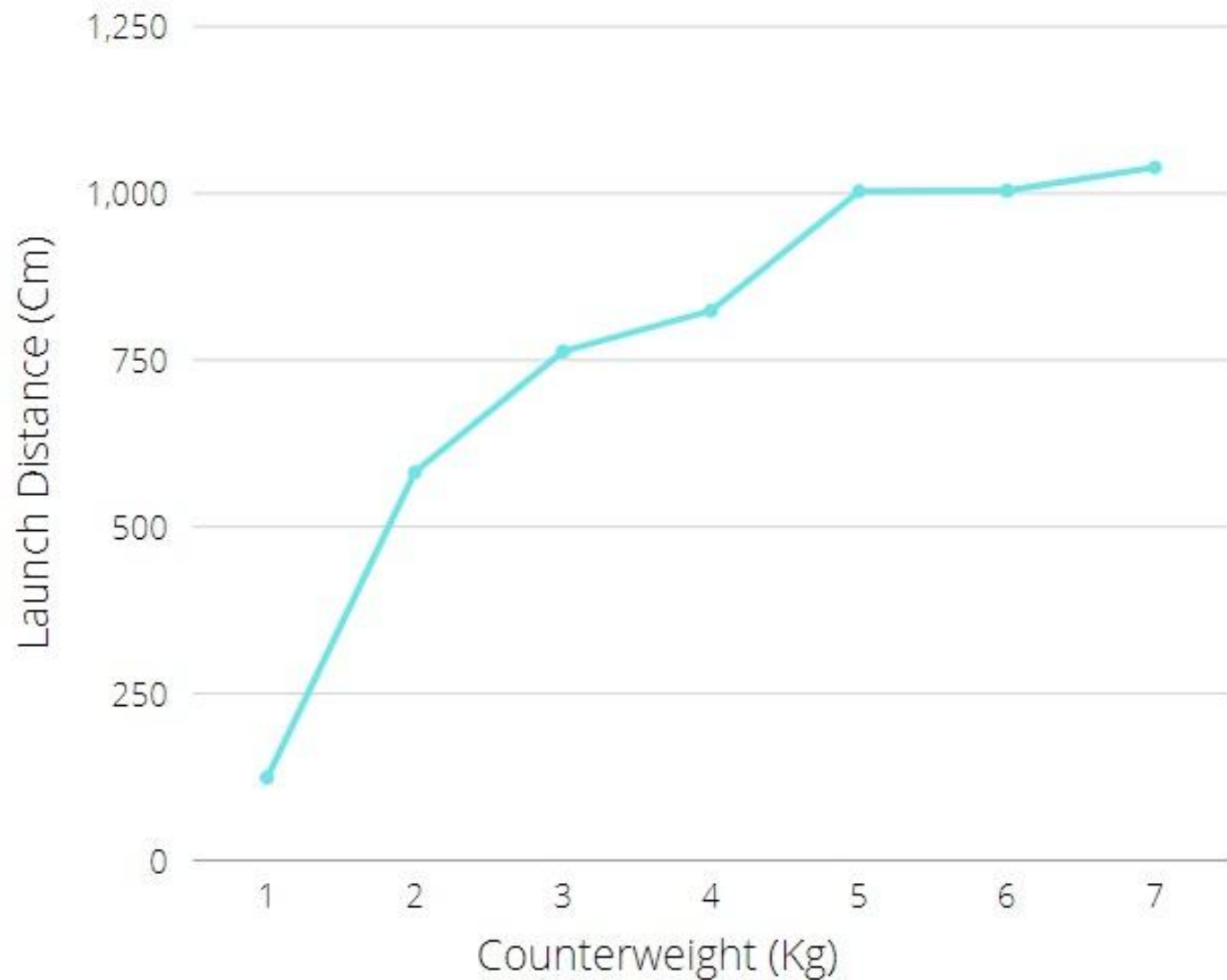
# Data/Observations

## The Effect Of Counterweight On Trebuchet Launch Distance

Counterweight (Kg)	Launch Distance Trial 1 (cm)	Launch Distance Trial 2 (cm)	Launch Distance Trial 3 (cm)	Launch Distance Trial 4 (cm)	Launch Distance Trial 5 (cm)	Launch Distance Mean (cm)
1	370	72	68	45	65	124
2	594	571	566	595	584	582
3	729	751	802	732	800	763
4	820	816	847	830	810	824
5	1049	1001	932	961	1072	1003
6	1036	1004	981	1007	993	1004
7	0 (Rub. Band Snapped)	0 (String Snapped)	861	1217	0 (Rub. Band Snapped)	1039

# Graph

The Effect Of Counterweight On Trebuchet Launch Distance



# Risk Analysis

## Building Procedure Risks

- Splinters
- Injuries from Drill Use
- Heavy Weights

## Launch Procedure Risks

- Broken Glass/Objects (Projectile Launch)
- Heavy Weights
- Sharp Hooks

# Error Analysis

The first systematic error is that the heavier weights put a huge strain on the box and string, and on occasion the string would even snap. This could be prevented if a wooden box was directly nailed to the front of the beam.

The second systematic error is the overswing of the trebuchet beam. This caused the projectile to fly out late, and could be prevented by using a stopping point.

# Conclusion

The hypothesis is accepted. From 1kg to 5kg, the launch distance increased by 709%. This shows that the launch distance of the trebuchet increases drastically as counterweight increases.

However, the launch distance only increased by 3.6% from 5kg to 7kg. This shows that there is indeed a cutoff point. However, this might just be because our trebuchet is smaller.

Further testing can be done with a larger trebuchet and heavier weights to see if the cutoff point still occurs.

# Works Cited

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# Music Credits

"Epic Build Up Music - The Storm," Secession Studios.

<https://www.youtube.com/watch?v=VCLT0HNJLWw>