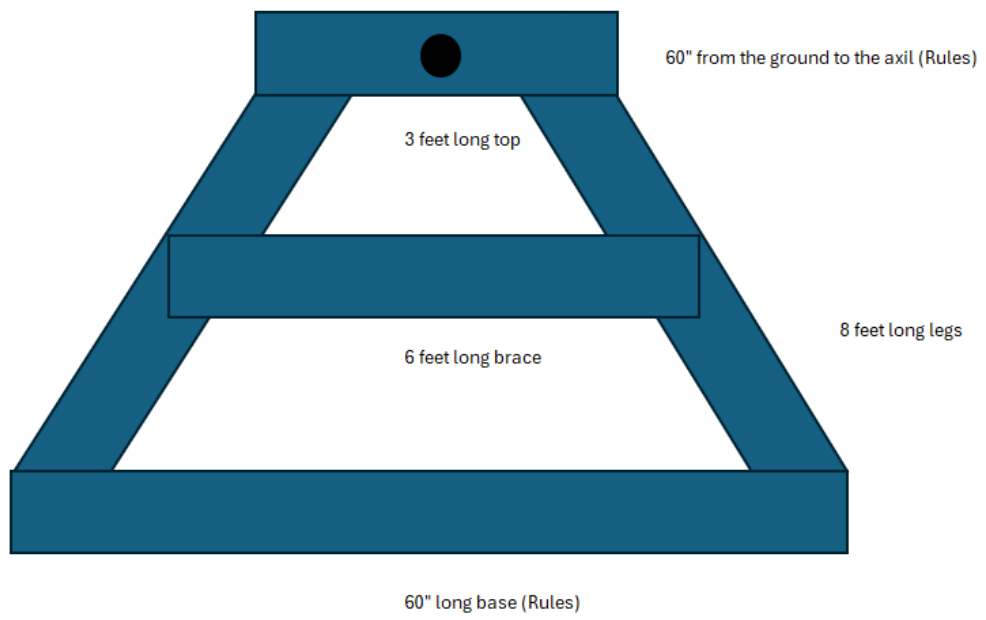


How to Build a Class B Trebuchet for Pumpkin Chuck Dayton

1. Build a Frame
 - a. Build as big as a frame as you can handle
 - i. 1 to 2 feet tall, table top size: launches golf balls and other small objects
 - ii. 3 to 4 feet tall, fits in a truck or SUV: launches tennis balls, base balls, softballs, or other medium sized objects
 - iii. 5 to 6 feet tall, fits on a trailer: launches 2 pound pumpkins, basketballs, soccer balls, and other larger objects
 - iv. 7 to 10 feet tall, stays in one place or as part of a trailer: launches 10 pound pumpkins or other large objects
 - b. Build from 2x4 lumber
 - c. Build an "A Frame"
 - d. Anchor the two "A-Frames" to a base
 - e. Mount the axil on top of the "A-Frame"
 - f. **For Pumpkin Chuck Dayton, the axil needs to be 5 feet from the ground (Rules)**



2. Choose an axil
 - a. Solid steel bar – 1" or larger
 - b. Pipe – 1-1/2" or larger
 - c. 1 to 4 feet long
 - d. Use clamping shaft collars to keep everything in place (link below)
3. Choose bearings
 - a. Pillow block bearings – bolted to the 2x4 frame
 - b. Flange bearings – bolted through the 2x4 arm
 - c. Hole in a piece of wood or metal
 - d. A smaller pipe inside of a larger pipe



4. Build the throwing arm
 - a. Start with an 8 foot 2x4 or 2x6 board
 - b. Drill two holes
 - i. Main Axil
 - ii. Counter weight Axil
 - c. Design Considerations
 - i. The best arm is strong by light. You want all the potential energy to go into accelerating the pumpkin instead of accelerating the arm.
 - ii. Wood: 2x4 or 2x6
 - iii. Metal
 1. Aluminium: 1 x 3 tube
 2. Steel: 1 x 2 tube
 - iv. Tools needed to construct the arm
 1. Wood: Spade bit for the axil (1" or larger)
 2. Metal: Hole saw bits for metal
 - d. For reference
 - i. A 6 foot arm can throw 1,000 feet if perfectly tuned and designed
5. Choose an arm ratio
 - a. Drill a hole at a 4 to 1 ratio between the long side and short side
 - i. For example: an 8 foot board would have 18 inches on the short side
 - b. Make the long arm either as tall as the axil or 12" longer
 - i. Axil height: 60 inches, Long Arm: 60 inches or 72 inches

6"



18"



72"

6. Build two Counter Weight Arms

a. Types:

i. Fixed Counterweight

1. Weight is attached directly to the throwing arm
2. No counterweight arms
3. Easy to build
4. Least efficient
5. Weights take the path as an arch to the ground, this wastes energy because the weight moves horizontal during the drop and not straight down
6. Throws half as far as a hanging counterweight

ii. Hanging Counterweight

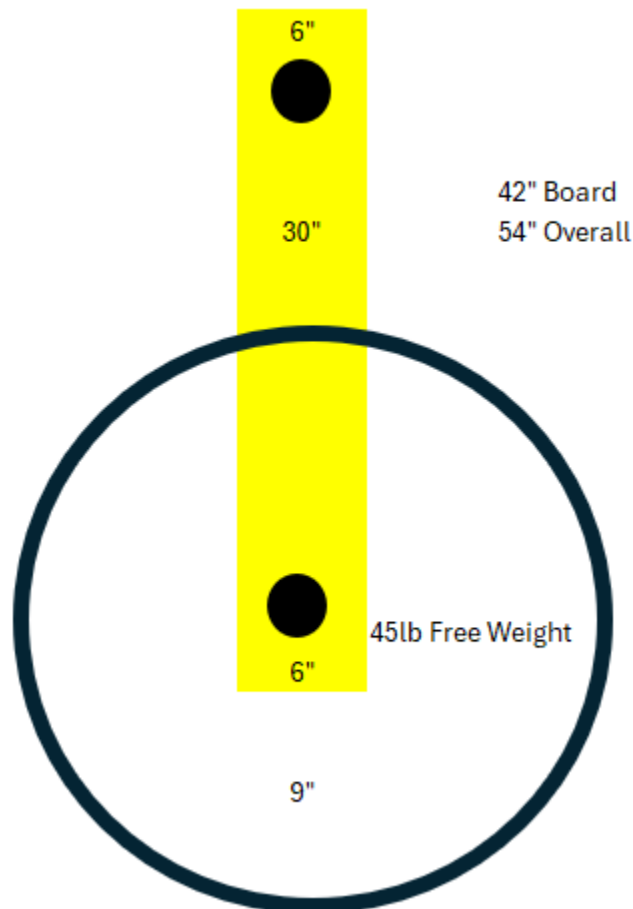
1. Requires counterweight arms to be made, typically two of them
2. Weight is attached to the arm with counterweight arms
3. Weight hangs offset from the arm
4. Weight takes a more direct path to the ground, mostly vertical but only a little arch
5. Throws twice as far as a fixed counterweight
6. Best design for beginners who want to throw far
7. Can be straight or curved, curved makes it even more efficient
8. Only two design points: make it strong, make it long. The weight needs to be 1" off of the ground when hanging free. Any higher means that it's not as efficient as it can be. If you make the offset hangers, make them as long as possible to get the max benefit from them.

iii. Whipping Counterweight

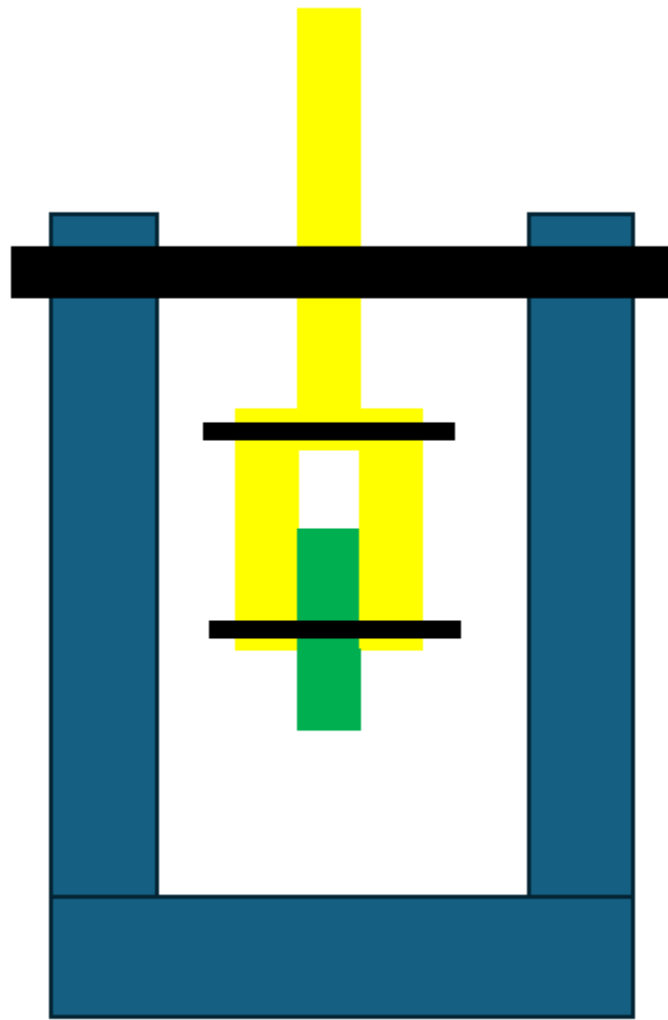
1. Hanging counterweight sits on top of the arm as the arm is pulled back through the frame and 45 degrees from the top vertical position
2. Requires a gap setting feature to tune the counterweight drop point
3. Requires the counterweight to be balanced on the arm or supported by the axle
4. Triples the distance of a hanging counterweight design

iv. Floating Counterweight

1. The design is built around the weight dropping straight down.
Advance design to make the weight drop almost perfectly vertical to the ground
 2. Requires a separate weight loading system
 3. Tough to design and build, most expensive
 4. Throws the projectile twice as far as a hanging counterweight
- b. Use 2x4 or 2x6 wood
 - c. Drill two holes
 - i. Counter Weight Arm Axil
 - ii. Counter Weight Axil
 1. Free weights
 2. Box full of sand
 - d. Secure the arms to the axils
 - e. Make this as long as possible without hitting the ground



7. Assemble the frames and arms



3 or 4 feet wide

8. Make a Sling

- a. The pouch needs to be strong
 - i. Leather
 - ii. Ratchet straps
 - iii. Jeans
 - iv. Towel
- b. Use paracord for the string
 - i. The length of the string needs to be as long as the long arm (72")
- c. Attach one end of the string to the long arm
- d. Attach a ring on the other end of the string

9. Make an adjustable pin
 - a. Bent nail on the end
 - b. Flat to round piece of metal
 - c. 3D printed
 - d. Adjustable pivot with turnbuckle
 - e. Bend it 45 degrees forward as a starting point
10. Attach an "I-Bolt" to the arm and tie one end of the sling to it
11. Make chute or platform for the pumpkin to sit in prior to launch
 - a. Needs to be smooth and clear of obstructions for the pouch to get caught on

12. Make a trigger

a. Types

i. Buy a quick release from Amazon

1. 10-200 lbs

2. <https://a.co/d/08JJC4uW>

ii. Two "I-Bolts" and a pin on a rope

1. 10-600 pounds

iii. Seacatch design

1. 300 pounds and over (pro-level)

b. Attach an "I-Bolt" to the arm for the latch to hold on to

13. Load the weight

a. Rule of Thumb: 100 to 1 ratio, counter weight to projectile

b. For example: 200 pounds of counterweight is needed to launch a 2 pound pumpkin an average distance

c. For max distance, increase to a 300:1 ratio (if your frame can handle it)

d. Types of weight

i. Free weights

1. More available now than in the past with home gyms

2. Easy to use and compact

3. Only requires a 2" pipe to mount to the counterweight arm

ii. Sand and Concrete

1. Requires a basket to be made to hold it

2. Cheapest form of counterweight available

3. A little more tough to take accurate weights

iii. Random metal scrap

1. A good compromise between sand and free weights

2. Sometimes easier to find and easier to mount

14. Prep for Launch

a. Pull the arm back as far as possible

b. Figure out how to set the trigger in this position

c. Load the pumpkin in the sling/ pouch

d. The strings on the pouch need to be as follows:

i. String with the ring over the pin needs to be on the bottom side of the pumpkin

ii. String attached to the arm all the time needs to be on the top side of the pumpkin

- iii. This will make more sense when you see the motion of the throw and see how the pouch goes from the start position to the end position
- iv. Setting this upside down will result in a mis-fire! (because the pouch twists in the air and can't release the ring cleanly)

15. TEST: Testing is the step where you find out if your design is good and your hard work has paid off. Don't worry. If you have a tough time, we are here to help you fix it.

- a. Use slow motion video to analyze every shot
 - i. Look at if the frame is strong enough to withstand all the forces
 - ii. Look at how well the sling is holding the projectile
 - iii. Look at if the arm is swinging freely
 - iv. Look at when the counterweight reaches the bottom
 - v. Look at the sling length
 - vi. Look at the launch angle
- b. Use a projectiles that are exactly the same weight
 - i. Milk jugs
 - ii. Pumpkins
 - iii. Ball on concrete
 - iv. Flour bags
 - v. **For Pumpkin Chuck Dayton: Use 2 pound pumpkins (Rules)**
- c. These can fire backwards. Don't stand behind it

16. Tuning: Tuning the trebuchet is the biggest challenge (and most fun!). Mainly because through tuning, you can triple the distance the projectile flies.

- a. 1st: Determine where the counterweight has reached the bottom. This is where no more potential energy remains and is at the end of its usefulness.
- b. 2nd: Adjust the length of the sling so the projectile releases just after the counterweight has reached the bottom.
- c. 3rd: Adjust the finger angle so the projectile releases at a 30 to 45 degree angle
- d. A rule of thumb is that a trebuchet should throw 100 lengths of its arm length
 - i. For example, if you have an 8 foot arm, it can throw 800 feet if it's perfectly tuned and efficiently designed.

17. Goals

- a. 1st: Survive a dry fire with only a small amount of counter weight.
- b. 2nd: Fire the projectile forward

- c. 3rd: Fire the projectile 100 feet
- d. 4th: Fire the projectile 300 feet (a football field)
- e. 5th: Increase the weight to the max your design can handle
- f. 6th: Tune the throw perfectly

18. Quiz

- a. What is the rule of thumb for the ratio between the long arm and short arm? (4:1)
- b. What is the rule of thumb for the ration between the counterweight and projectile (100:1)
- c. When is there maximum Potential Energy during the throwing process?
(When the counterweight is at its highest point.)
- d. Where is the minimum Potential Energy during the throwing process?
(When the counterweight is at its lowest point.)
- e. What is the ideal launch angle? (30-45 degrees)