Trebuchet Design by G105

The sling pouch is made out of leather.

The counterweight is made out of reinforced concrete. This makes it stronger and less brittle.

Steel and iron gusset plates is used to strengthen the wooden joints along with steel rods for the fulcrum.

Materials - The trebuchet is mostly made out of treated pine wood.

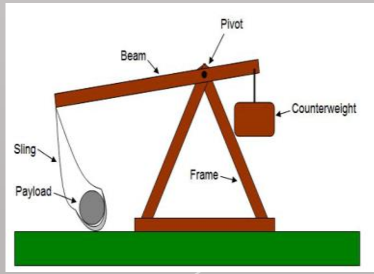
Tar and pitch is used to prevent the trebuchet from weakening.

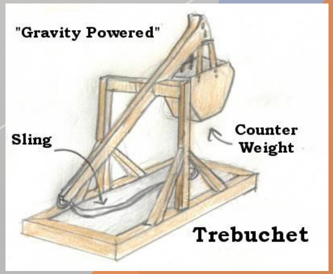
The arm is made out of carbon fibre as it is of low mass and strong enough to sustain the weight of the projectile.

Jutes ropes is used to hold the counterweight and will be used to pull it up to position. This prevents splintering of the wood at key joints.

- ❑ A trebuchet is a machine (a catapult) which has a long arm-like structure to throw a projectile across a range of distance. A trebuchet works by using the energy of a falling counterweight (gravitational potential energy) to launch a projectile using mechanical advantage to achieve a high launch speed (translational kinetic energy).

- ❑ These are the requirements by LFS Demolitionists.
- The full-scale trebuchet must have a pivot height of x = 1.5m.
- Maximum allowable counterweight is 300kg.
- The total mass of the arm must not exceed 25kg uniformly distributed over the entire length.
- No energy sources other than the counterweight are to be used to propel the projectile.





Data collection and testing methods

- The data is collected using the virtual trebuchet simulator which can be found on the internet. Firstly the fixed, dependent and independent variables are identified.
- The dependent variable will be modified and a test will be conducted based an estimated range.
- A graph was then plotted involving the dependent and the independent variables.
- A decision was made regarding the most suitable value after referring to the graph.
- The data was also collected by building a smaller scale version of the trebuchet, collecting the data and scaling up the result.

Fixed variable	Dependent Variable(y)	Independent Variable(x)
Pivot Height	Range (30m)	Counterweight mass
Mass of arm	Wind Speed	The angle launched
Size of projectile		Inertia of the counterweight
Energy sources(Gravity)		
Length of short/long arm		
Length of sling		
Length of weight		

Trebuchet Design Specifications	Value
Length of Short Arm (m)	0.35
Length of Long Arm (m)	1.35
Length of Sling (m)	0.35
Length of Weight (m)	0.20
Height of Pivot (m)	1.50
Mass of Arm (kg)	7.50
Mass of Counterweight (kg)	300
Inertia of Counterweight (kgm^{-2})	2
Wind Speed Consideration (ms^{-1})	+0.833 to -1.67
Optimum Release Angle	38
Target Range (m)	30
Size of Projectiles kg	(3,5,7) kg
Projectile Diameter (m)	0.25

Justification for the values chosen

- The counterweight is to be made up of a rectangular slabs. The inertia of counterweight is calculated using the formula of moment of inertia.
- The value of the long arm is chosen to be 1.35m as to make sure that the arm is long but still allows for the movement of the arm.
- Based on Siano's key fact, the optimal ratio between the length of the long arm to short arm should have a ratio of 3.75:1.
- The length of the weight is chosen to be 0.20m based on the material(reinforced concrete) picked.
- The mass of the arm should be as low as possible as to increase the range of the projectile. The mass of the arm is dependent on the material used.
- The optimum release angle by plotting a graph of range against launch angle.

Theories governing the motion of the trebuchet

The larger the mass of the counterweight the larger the gravitational potential energy. The principle of conservation of energy results in a large amount of kinetic energy converted in the projectile facilitating a further distance travelled.

The counterweight pivots around a much shorter distance as opposed to the projectile end. This enables the projectile end to reach a much higher linear velocity as opposed to the counterweight part of the arm according to the principle of mechanical advantage.

The falling of the counterweight produces a torque on the throwing arm causing it to rotate clockwise. This, causes the projectile to experience acceleration allowing it to move outwards.

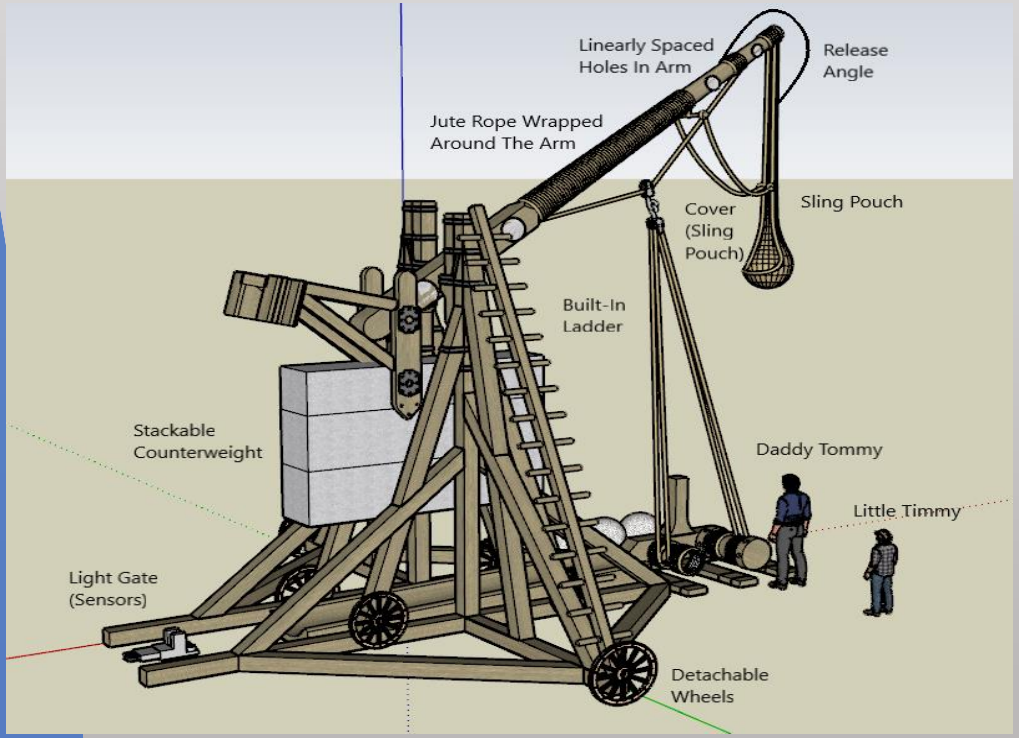


Image of the trebuchet designed labelled with the modifications/ improvements made

Trebuchet Design Highlights

A light gate is used to ensure the trebuchet is released at a proper angle. A sensor is attached to the side.

The sling used has a cover which encloses the sling pouch and will be triggered to open only when a certain angle is reached.

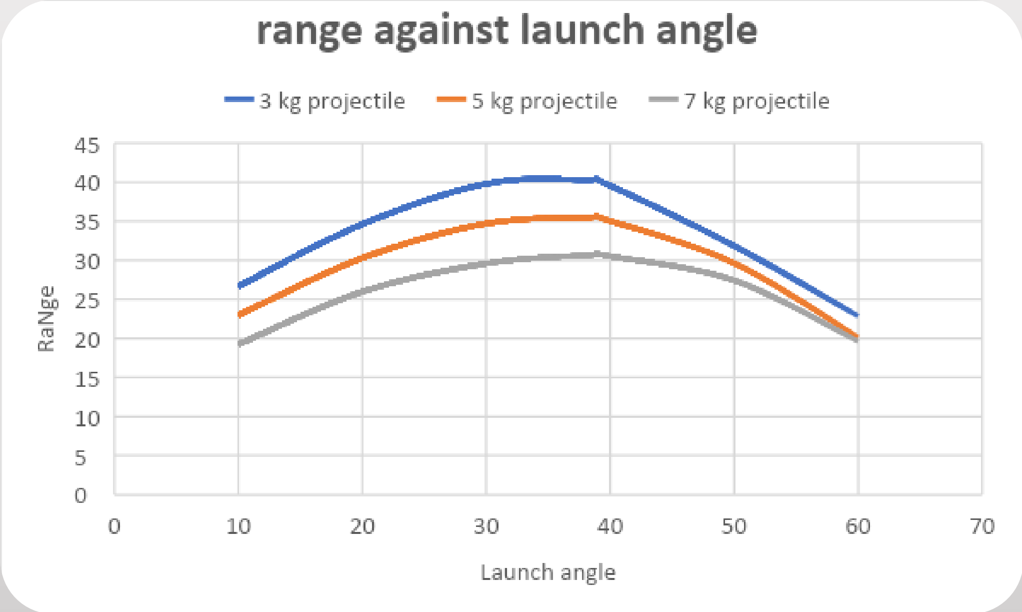
The base of the trebuchet is heavy and detachable wheels are included to facilitate movement.

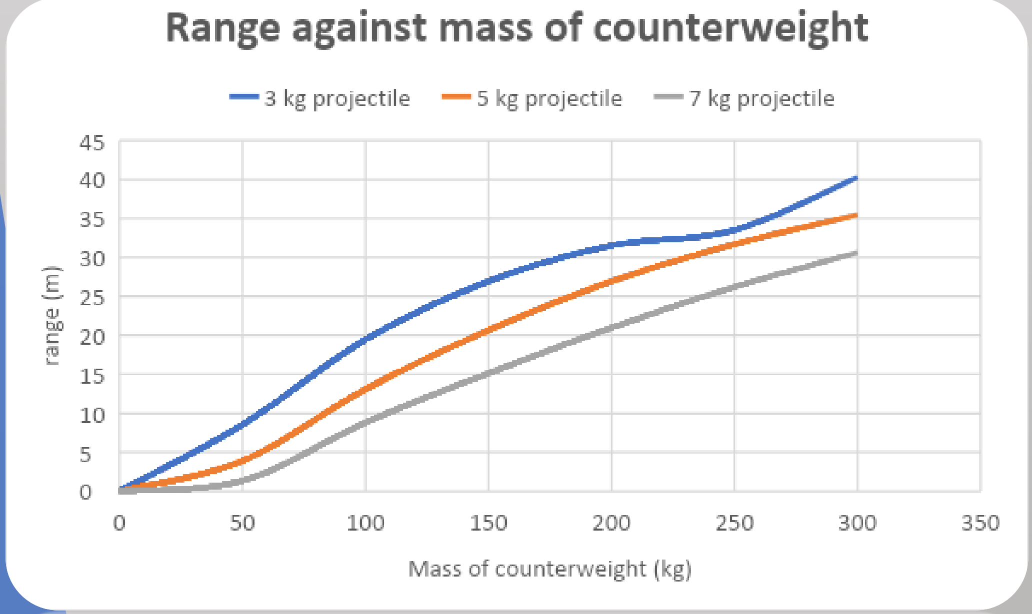
Linearly spaced holes are incorporated in the arm of the trebuchet. This reduces the mass of the arm, achieving a larger range.

The moment of inertia of the counterweight is designed to be small. Hence, its shape is decided to be rectangle.

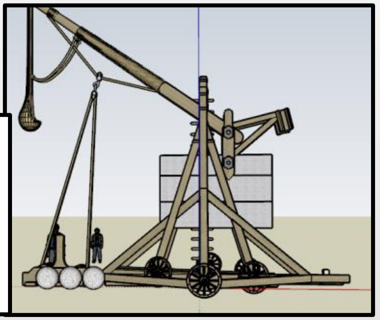
The mass of the counterweight is maximized based on the design requirement.

Graphical summary of trebuchet range and variability for different settings

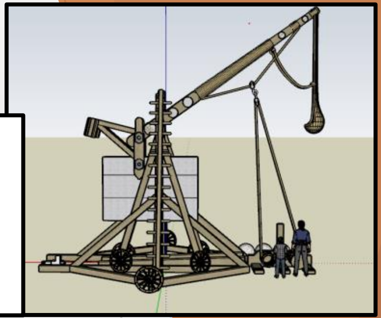




Left side view

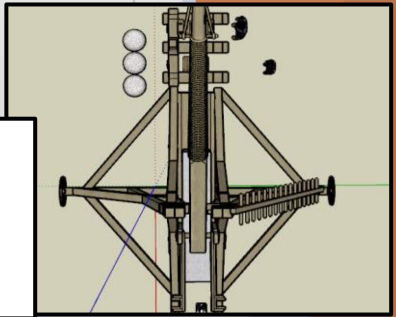


Right side view



Drawings of our trebuchet model from different angles

Top view



CONCLUSION

In conclusion, our design of the trebuchet implements modern technology using archaic technology as a base. Understanding the principle of conservation of energy, principle of mechanical advantage and torque we have modelled our design with the help of the virtual trebuchet simulator. It has an energy efficiency and a range efficiency of approximately 0.6 for both aspects respectively. Furthermore, it is made mostly out of treated pine wood, a material which not only has a high resistance against decay it also has an aesthetic natural design. Our design is also eye catching as it has a unique pentagonal base. LFS Demolitionists can use this to demolish small structures at varying positions in a single direction as shown on the graphs on the left hand side. Thus, not only does our design fit the given requirements it is also bodacious, sturdy and highly efficient making it better than the designs of other teams. Based on the reasoning above it is evident that out design can and should be implemented by LFS Demolitionists.