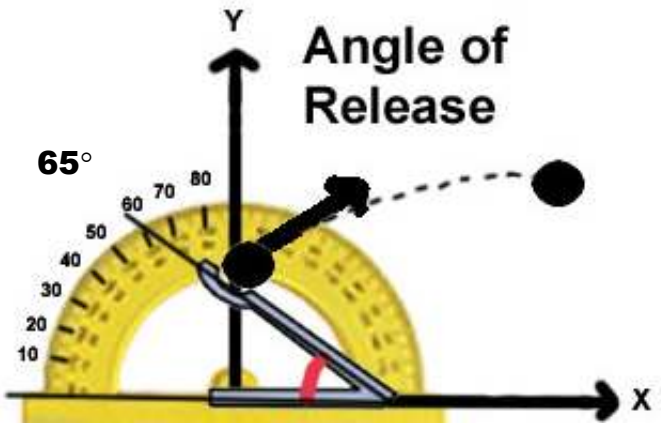
Glossary of Terms

Acceleration:
The rate of change of velocity with respect to time; in other words, the change of velocity. It is measured in meters/second^2 (meters per second squared *or* meters per second per second).
For example, when an object falls, it travels faster and faster as it falls, gaining speed at a rate of 9.8 m/s every second

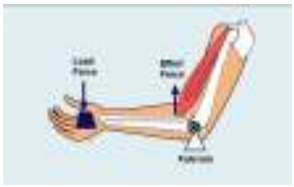
Angle of Release: The amount of turn between two straight lines that have a common end point (the vertex).



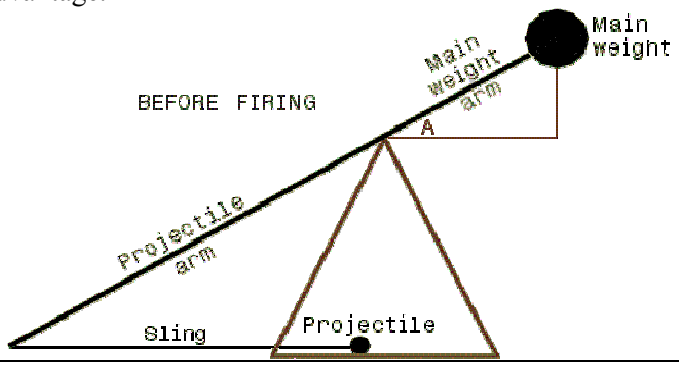
The angle of release can be measured with a **protractor**.

Argument: The process of forming reasons, justifying beliefs, and drawing **conclusions** with the aim of influencing the thoughts and/or actions of others.

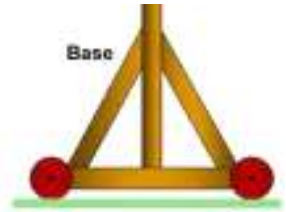
Arm: An upper limb of the human body, or a similar long thin part extending from a central support in a machine. An arm is one of the three basic components of a catapult or trebuchet.



The human arm and an arm in a trebuchet or catapult both act as simple machine levers that can provide a mechanical advantage.



Base: The lowest part of something that supports the rest. A base is one of the three basic components of a catapult or trebuchet.



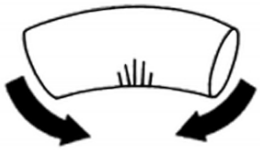
For a catapult or trebuchet to work efficiently it is important for the base to be stable so that when the stored potential energy is released, only the arm and the projectile move, not the base.

Bastion: A tower or turret projecting from a fortification.
The purpose of these small towers which projected out from the castle wall was to cover the blind spots when the castle was under siege.

Battlements: The slot-shaped architecture at the top of a castle wall. Archers inside the castle could stand on a surface at the top of the castle wall and shoot through the gaps and still be somewhat protected.

Bell tower: A tower that supports or shelters a bell. Bell towers were usually located in the village, not the castle, but the Tower of London, a very large and well-fortified castle, had a bell tower.

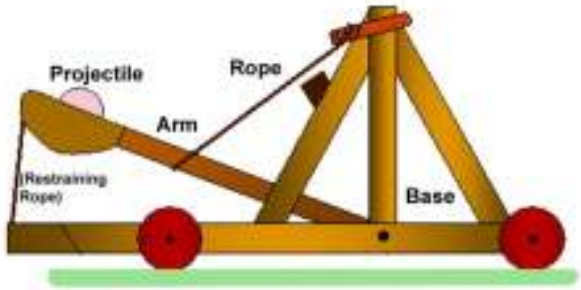
Bend: One of the ways that a force can be applied to elastic material in a catapult in order to store potential energy. In ancient catapults, a bend could be obtained using wood (especially yew) or layers of wood and horn in a bow or arm. In the inventor center you may want to use wood.



Blueprint: A detailed plan or drawing serving as a model for how to build something. The name comes from the fact that in the past these drawings were printed in white on a blue background.

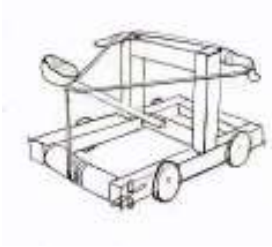
Architects create blueprints that are used to construct a building. Leonardo daVinci's detailed drawings of inventions such as trebuchets could loosely be referred to as blueprints.

Catapult: An ancient weapon, too big to be held by one person that was used for throwing objects such as rocks.



Composed of 1. a base, 2. a throwing arm, and 3. some sort of an elastic spring-type structure that stores potential energy until it is released and converted into the kinetic energy of motion of the projectile.

In a catapult, the potential energy is stored as elastic energy in the form of
1. a stretch (tension)
2 a bend, or
3. a twist (torsion). The material stretched, bent, or twisted must be elastic in nature, such as rope, rubber, wood, or steel.



The earliest catapult, such as the one shown, first appeared in China in 400 BC and were made by adding a pivoting arm to a crossbow.

Note: Some sources refer to a trebuchet loosely as a "catapult" but the accurate definitions will be used in the Inventor Center.

Communication: Using words, pictures, charts, graphs, and diagrams to share information.

Conclusion: A decision reached after thinking about facts and details.

Counterweight: A weight that provides a balance against another weight.

Trebuchets store potential energy in a massive counterweight placed at one end of the arm. A projectile is placed in a sling hanging from the other end of the arm. When the counterweight is allowed to fall, the potential energy is converted to the kinetic energy of motion as the projectile is hurled through the air.

Courtyard: An open area inside the castle walls, sometimes called a bailey.

Crusades: Military expeditions that the Christian powers of Europe undertook in the 11th through 13th centuries to travel to the Middle East and attempt to take the Holy Land from the Muslims.

Data: Observations and measurements that are recorded and gathered into graphs, tables or charts.

Drawbridge: A wooden bridge that spanned a moat in front of the main entrance to a castle. If a castle was under attack, the drawbridge could be moved either sideways or raised up so that the attackers could not reach the castle gate.

Elastic Materials: A springy material (such as rubber, certain types of wood such as yew, tendon, horn, and steel) that is good at storing and releasing energy.

Catapults use elastic materials for the storage and release of energy. We store the energy slowly and release it quickly to get a lot of speed with the release.

Stretch a rubber band. It gets long and skinny. Now let it go. It goes flying! Where did this kinetic energy of motion come from?

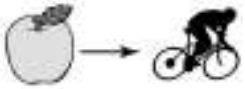
When we apply stretch (provide tension to), bend, compress, or twist (provide torsion to) an elastic material it changes shape. The force from our muscles that we applied as a push or pull to make it change shape is stored as potential energy.
When the stretching, bending, compressing or twisting force is released, the stored potential energy is released as kinetic energy.

This is in contrast to non-elastic, brittle materials such as glass or stone. If we apply enough force to glass it doesn't change shape, it shatters. (Don't try this.) Glass is not elastic.

Energy: The ability to do work or cause a change.

Every time that we observe a change (an apple growing, a low note going to a high note) there must have been an input of energy (solar energy in the sun converted to chemical energy in the apple, increased energy and frequency of vibration of a guitar string).

Energy transformation: Energy can be changed from one form to another. The chemical energy stored in an apple can be converted into kinetic energy by the bicyclist.



For siege engines, the chemical energy stored in food is stored as chemical energy in the attacker's muscles which is converted to the kinetic to cock the siege machine. For a catapult this is the work of stretching, bending, or twisting an elastic material. For a trebuchet this is the work of raising a heavy counterweight up on the lever. The energy in the cocked position has now been transformed into Potential Energy.

When the trigger is released, this potential energy is released as the kinetic energy of motion of the projectile. When the projectile hits the castle wall, the kinetic energy is used to do the work of crumbling the wall. Eventually all of this energy is converted to heat energy.

Engineering: The application of science to the design and creation of large structures (such as roads and bridges) or new products or systems.

The pyramids of Egypt are one of the greatest civil engineering accomplishments of the world.

Error: The most common meaning of error is a mistake. However, in science and engineering it can also mean the difference between a measured observation and the true value.
There is always a certain amount of uncertainty, or error, in any measurement – how much depends on the measurement device and how the measurement is done.

For example, if you measure the length of a fly's wing while it is in flight with a yard stick you will get a lot of error. You would get less error if you used a very small ruler with lots of lines in it and got the fly to hold still.

Experiment: Using scientific methods to test a hypothesis.

Force: A push or a pull. A quantitative description of the interaction between two objects.

Force can be measured in newtons (N). One newton of force is equal to 1 kg * m/s^2.

It takes a form of energy called "***work"*** to apply a force over a distance (work = force x distance, w= f x d).

One type of force, called ***contact force***, occurs when objects come in direct contact with each other. For example, when a huge rock hurtled by a siege engine hits a castle wall, it applies a large force to the wall that can do the "work" of breaking down the wall. The more massive the rock and the faster it is moving, the more damage, or "work" is done on the wall.

Catapults take advantage of another kind of force: the stretching, compressing, bending, or twisting of an elastic material. To prepare a catapult to launch a rock, it takes ***work*** to twist a rope (provide ***torsion***), to stretch a rubber band (provide tension), or bend wood.

Gravitational force can be exerted even across empty space. Trebuchets take advantage of this kind of force. To prepare a trebuchet to launch a rock, it takes ***work*** to raise the arm with the massive counterweight against the ***acceleration*** of ***gravity*** (force = mass x acceleration, f = m x a).

In either case, when the catapult or trebuchet is released, the ***potential energy*** is released as ***kinetic energy*** in the form of the motion of the rock. In this case the ***work*** that is performed is the crumbling of the castle wall.

Gravity: the **force** of attraction that moves or tends to move physical bodies together, the force that causes things to fall towards the Earth.

The force that an object on Earth is attracted downward towards the center of the Earth, is called its **weight** and is equal to the mass of the body times the local **acceleration** of gravity, which is about 9.8 m/s^2.
Weight = mass x acceleration of gravity (weight = m x g).

Inertia: the resistance an object has to a change in its state of motion.

Newton's first law of motion states that "An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force." Inertia is the property of matter that makes it act in this way.

Invention: The idea of a new and useful device, material, or process.

Inventor: Someone who uses technology in a new way to solve a problem. For example, Madame C J Walker, 1867 – 1919, invented hair lotion for black women.

The individual inventors of siege machines have mainly been lost in history. This is because accurate records were often not kept, and also because catapults evolved slowly from cross bows by trial and error over many centuries in many countries.

One inventor of catapults and trebuchets that kept very detailed and beautiful records was Leonardo DaVinci.

Keep: In early castles this was a single square-walled structure where those defending the castle could retreat. When castles became larger and more complex, it was the tallest and strongest part of the castle and the last point of retreat when under attack.

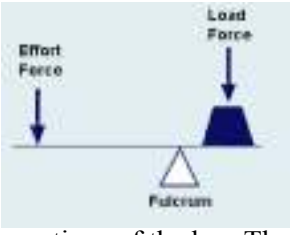
Kinetic energy: Energy due to motion.

A bicyclist speeding down a hill has high kinetic energy because he is moving quickly.

The Law of Conservation of Energy: Energy can neither be created nor destroyed, only change forms.

Leonardo daVinci: (1452-1519) An Italian Renaissance painter, sculptor, draftsman, architect, engineer, and scientist. DaVinci, although against war, designed intricate trebuchets, as well as many other ingenious devices.

Lever: One of the few types of simple machines. It consists of an arm pivoting on a fulcrum. Effort exerted on one position of the lever is used to lift a load. The amount of effort required is related to the position of the pivot and the relative lengths of the sections of the bar. The fulcrum is the point around which the lever pivots.
A type 1 lever is shown here.



A Trebuchet is an inverse type 1 lever.

Machine: A device that changes the direction or the amount of effort needed to do work.

For example, the human arm is limited in how much force it can provide. It would be hard for one human holding a rock to knock down a castle wall. However, by inventing machines such as a catapult or trebuchet, the force in a human's muscles can be used to slowly do enough work to store enough potential energy in a machine so that when that energy is released all at once, a large amount of kinetic energy is released…large enough to hurl a huge rock very quickly at the castle wall with a lot of force.

Mass: The quantity of matter in something. It is not dependent on the volume that it occupies. Mass is measured in grams (g) or kilograms (kg).

Mass is what causes a body to have weight in a gravitational field (weight = mass x acceleration) but it is different from weight. ***Weight*** is the measure of the force of gravity acting on a body.

There is a trade-off between mass (m) and velocity (v) when a projectile is thrown by a catapult or trebuchet with a certain amount of kinetic energy. The higher the mass of the projectile, the lower the velocity it will be thrown with because Kinetic energy = ½ x mass x velocity^2
(KE = ½ m v^2).

Material: The material that the base and other components of a catpult or trebuchet are made of is another crucial **variable**. The word material is related to **matter** which is a physical substance, as opposed to energy.

There exists a whole field of study called **material science**, the scientific study of the properties and applications of materials of construction or manufacture. For example, it would make a lot of difference to how practical and how much fun a bicycle is if it is constructed of paper, aluminum, or steel.

In the Inventor Center you will have lots of materials in the Junk Pile to choose from when building your catapult or trebuchet, such as rubber bands, tongue depressors, Choose materials or ways of putting the materials together that make the base rigid and stable. For your catapult choose elastic components.

Measurement: The assignment of numbers to objects or events.

It is a cornerstone of science, technology, engineering, economics, and quantitative research in other social sciences. One reason for this is that the communication of measurements is essential for reproducibility by others, which is essential.

Scientist learn which type of measuring device to use for different measurements. For example, a meter stick could be used to measure how far a projectile traveled in meters (m) or centimeters (cm). A protractor could be used to measure the angle of release of the projectile (measured in degrees) from the siege machine.

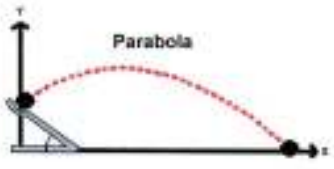
Mechanical Advantage: The ratio of the force that performs the useful work of a machine to the force that is applied to the machine. In other words, it is how helpful or "advantageous" it is to use a machine such as a catapult or a trebuchet to launch a rock, rather than just throwing it by hand.

Mechanical Energy: The energy of motion used to perform work.
When a bicyclist pushes on the pedals, the wheel and axel turns, which performs the work of moving the bicycle. This can be a lot of work if it is uphill.

Middle Ages: The period of European history from the fall of the Roman Empire at about 500AD to the dawn of the Renaissance at about 1500AD. This was a period of great turmoil in Europe. To defend themselves, nobles built castles. To attack the castles, other nobles built siege machines such as catapults and trebuchets.

Moat: A body of water that was built around the outer wall of a castle to keep attackers from tunneling under the castle walls. ***Drawbridges*** were constructed so that people living in the castle could cross over the moat. Drawbridges could be raised when the enemy attacked.

Parabola: The shape of the path through the air that an object follows when the object is thrown forward and up in the air and falls back to the ground.

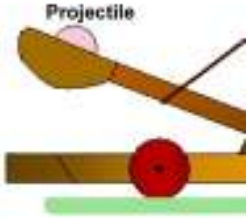


There is a mathematical equation for this shape that you will learn in High School.

Potential energy: Energy that is stored in an object due to its position or arrangement. It is related to an object's position relative to a force (like gravity).
A bicyclist poised at the top of a hill has low kinetic energy (because he is barely moving) but high potential energy because he will be able (or has the "potential to" move very quickly soon.

Projectile: In a battle field**:** an object (such as rock in the battle field or a small ball in the Inventor Center) that is thrown as a weapon.

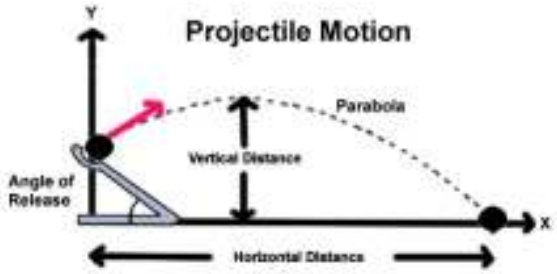
In physics: an object that, once it is propelled with some initial **velocity**, continues in motion by its own **inertia** and is influenced only by the downward force of **gravity**.



Projectile Motion: – The motion of an object (**projectile**) that has been propelled with some initial velocity. This motion follows some simple laws of physics. After the initial **velocity** has been applied, the object continues in motion by its own **inertia** and it is assumed that no force other than **gravity** is acting on the projectile. Birds in flight do not follow the laws of projectile motion because birds are continually self-propelling themselves after take-off.

The shape of the path of the object is called a **parabola** and can be predicted using a mathematical equation. Soccer players can become very good, with practice, at predicting projectile motion so as to know just where to be to head a ball.

The motion of a rock hurled in the air by a catapult or trebuchet follows the rules of projectile motion as long as we ignore the effect of wind or air on the projectile.



Prototype: A first model of something, especially a machine, from which other forms are developed.

This 1915 prototype shape for the coke bottle never went into mass production because its shape would have made it unstable on conveyor belts.

It is often best not to spend too long making a prototype. Make it quickly and test it. Modify it slightly and test it again.

When you visit the Inventor Center you will be making a prototype catapult or trebuchet as quickly as you can so that you have time to make some quick experiments and modify your invention.

The Renaissance: The period of European history from about 1400AD to 1600AD. Renaissance means "rebirth" in French. During this time there was a rebirth of interest in science, art, and literature, especially in Italy.

Siege: A military blockade of a castle or fortified place to make the inhabitants surrender. Sieges were costly to both sides. The people inside the castle might run out of food and water. Soldiers on the outside had to be fed and provided with shelter. To shorten the length of time that sieges lasted, inventors came up with more and more sophisticated siege machines: catapults and trebuchets.

Simple Machine: One of a few devices that only require the application of a single force to work. These include: the lever, the wheel and axle, the pulley, and the inclined plane. (Sometimes people consider the wedge and the screw as other simple machines but these can both be considered special kinds of inclined planes.)

Machines that use two or more simple machines are called Complex Machines. Most of the catapults and trebuchets over history were complex machines. They became more and more complex as they were improved.

Sling: An instrument for throwing stones that usually consists of a short strap with strings that is whirled around to release the projectile. Trebuchets usually used slings to increase the force and velocity that a stone could be hurled at.

Speed: How fast an object is moving, expressed as distance divided by time (for example meters per second, m/s).

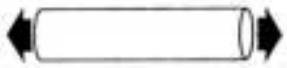
Speed is the same as velocity except that velocity includes the direction that an object is traveling whereas speed is irrespective of direction.

Spring: A specific type of elastic body or device consisting of a twisted or coiled piece of metal. When the spring is pressed together (compressed) or pulled apart (stretched), the spring temporarily changes shape and stores potential energy. When the pressing or pulling force is stopped, the spring returns to its original shape, releasing kinetic energy that can be used to do work.

Some kinds of clothespins contain a spring that is holding two levers together at the fulcrum. It takes force to squeeze the two long ends of the lever together because this is changing the shape of the spring. If a clothespin was built into a catapult that potential energy could be released as kinetic energy of motion of a projectile when the pressure is released.

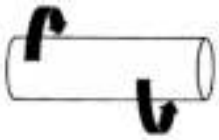
Stirling Castle: Located in Stirling, Scotland, the castle was the scene of one of the most important battles of the Wars of Scottish Independence. In order to break the siege, King Edward I of England had a trebuchet named the Warwolf built.

Tension: The condition or amount that an elastic substance has been stretched, or pulled apart. The stress (potential energy) that results from stretching an elastic body.



One of the ways that a force can be applied to elastic material in a catapult in order to store potential energy. In ancient catapults tension was obtained using tendon, wood (especially yew), or horn. Rope also is somewhat elastic. In the inventor center you may want to use rubber bands or wood.

Torsion: The condition or amount that an elastic substance has been twisted. The stress (potential energy) that results from twisting an elastic body.

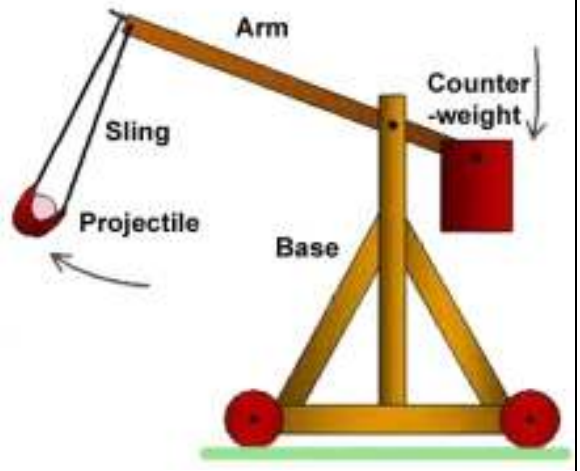


One of the ways that a force can be applied to elastic material in a catapult in order to store potential energy. In ancient catapults torsion was obtained by twisting rope. In the inventor center you may want to twist a rubber band.

Trebuchet: A medieval weapon used for throwing objects such as huge rocks, usually at a castle under siege.

Like a catapult, a trebuchet is composed of
1. a base,
2. a throwing arm (in this case it must be able to pivot), and
3 a structural way of storing potential energy until it is released and converted into the kinetic energy of motion of the projectile.

Unlike a catapult, gravity is the force used to produce the potential energy of a trebuchet. A trebuchet makes use of mechanical advantage by placing a massive counterweight at the end of the short arm and the projectile (usually in a sling) at the end of the longer arm. The force of muscles is used to raise the counterweight. When the counterweight is allowed to fall, the potential energy stored is released as the kinetic energy of motion of the projectile.



The trebuchet was invented in France and was first reported to be used in 1124AD in the siege of Tyre during the Crusades. As it was much more powerful than a catapult, a trebuchet became the siege weapon of choice until about 1600AD when it was largely replaced by the use of canon and gunpowder.

Note: Some sources refer to a trebuchet loosely as a "catapult" but the accurate definitions will be used in the Inventor Center.

Variable: Something that changes.

In an experiment, an **independent** variable is the one which can be varied and controlled by the experimenter. The **dependent** variable depends on the independent variable.

For example, changing the materials that a catapult is made from will change how fast a projectile will be hurled through the air. The type of material is the **independent variable** and how fast the projectile moves is the **dependent variable**.

As another example, changing the mass of the projectile thrown by a trebuchet will change how far the projectile will be thrown before it falls to the ground. The mass of the projectile is the **independent** variable and how far the projectile travels is the **dependen**t variable.

Velocity: How fast an object is moving, expressed as distance divided by time (for example meters per second, m/s).  Velocity is the same as speed except that velocity includes the direction that an object is traveling whereas speed is irrespective of direction. (Mathematically, velocity is a vector.) The velocity of release of a projectile from a catapult or trebuchet depends on many variables. One variable is the mass of the projectile. According to the equation, Energy = ½ x mass x velocity^2 ($E=1/2\ mv^2$), for a given amount of stored potential energy, the heavier the projectile, the slower its velocity will be.	**Wars of Scottish Independence:** A Series of military campaigns fought, between 1286 and 1329, between the Kingdoms of England and Scotland over whether Scotland should remain an independent nation. One of the most important battles was the siege of Stirling Castle in 1304.
Warwolf (trebuchet): A trebuchet built in 1304 under the orders of Edward I of England in order to break the siege of Stirling Castle during the Wars of Scottish Independence. Some consider the Warwolf the most powerful and famous of the trebuchets in history. 	**Weight:** The force that an object on Earth is attracted downward towards the center of the Earth, equal to the mass of the body times the local **acceleration** of gravity, which is about 9.8 m/s^2. Weight = mass x acceleration of gravity (weight = m x g).
Work: Force multiplied by distance. The amount of energy related to the amount of force applied to an object and how far the object moves as a result of the forces. work = force x distance (w = f x d).	