Teacher Notes

Work and Energy

Work is done when a force is exerted on an object and the object moves a distance. Energy is measured in units called joules (J). One joule is the amount of work done to exert a force of one newton (N) to move an object a distance of one meter. The formula for calculating work is: Work (J) = Force (N) x Distance (m).

Energy is defined as the ability to do work or cause change. There are two kinds of energy: potential energy and kinetic energy. Potential energy (PE) is the energy of position, or stored energy. Kinetic energy (KE) is the energy of motion. The more potential an object has to do work, the more potential energy it has. Potential energy is present when an object is lifted off of a surface (called gravitational potential energy) or when an object is controlled by an elastic force (called elastic potential energy). Potential energy is converted into kinetic energy as soon as the object begins to move.

Trebuchets

A trebuchet is a medieval catapult used for hurling large stones or objects through the air. This war machine is basically a type of lever, in that it consists of a rigid bar, or arm, that pivots around a fixed point called a fulcrum. In the case of a trebuchet, the fulcrum is set off-center, making one arm of the lever much longer than the other. At the end of the long arm is a small weight — the object to be thrown — suspended in a sling. At the end of the short arm is a large counterweight that is about 100 times as heavy as the object being thrown. The difference in the lengths and weights of the two arms creates an imbalance, causing the short, heavy end to rotate downward, and the lighter, longer end to fly upward, flinging the object into the air. The potential energy of the trebuchet can be calculated by multiplying the mass and weight of the heavy counterweight. However, not all of the potential energy is successfully converted into kinetic energy because of the way in which the trebuchet works.

To be as efficient as possible, the trebuchet's counterweight should fall as close to vertical as possible. This takes advantage of the full effect of gravity, but it is very difficult to accomplish. The movement of the trebuchet's frame during launch also drains energy. If the trebuchet is on wheels, it moves forward and backward with the dropping of the weight. This prevents the trebuchet from tipping over, but it also detracts from the amount of energy converted. Other limiting factors include the friction of the moving parts involved, air resistance (although this is limited with such a large weight), and the potential energy that is converted to thermal energy as the trebuchet's parts rub together. As a result, the overall efficiency of a trebuchet in terms of the conversion of potential energy to kinetic energy is between 50 and 70 percent.