Energy Conservation

If all forces are conservative (no friction, engine etc), Total Mechanical Energy (Kinetic + Potential) is conserved:

$$E = K + U = const$$

Here K is Kinetic energy:

$$K = \frac{mv^2}{2}$$

U is Potential energy, which is the work done against the conservative force, when object is moved from point A to point B. Two important cases are gravity and spring force:

Type of force	F	U
Gravity (on Earth surface)	mg	mgh
Hooke's Law (spring force)	kx	$\frac{kx^2}{2}$

Here x is extension of the spring, h is height.

Forms of Energy & Power

Two types of mechanical energy (Kinetic and Potential) can be converted to each other.
In addition, mechanical energy can be converted into other forms, and back

- Heat (example: friction or inelastic collision, steam engine)
- Electric energy (power plants)
- Chemical and Biochemical Energy (nutrition, burning)

SI unit of Energy is Joule (J):

$$1J = 1N \cdot m = 1\frac{kg \cdot m^2}{s^2}$$

Also commonly used units are calories. One small calorie (cal) is the heat energy needed to change temperature of 1 g of water by 1°C (degree Celsius). Big Calorie (Cal) is the same but for 1 kg of water, so 1Cal is actually 1kilocalorie (1Cal-=1kcal). Those big Calories are used to describe energy content in food. 1000 Calorie diet is actually 1 mln cal. The relationship between calorie and Joule is,

$$1cal = 4.184J$$

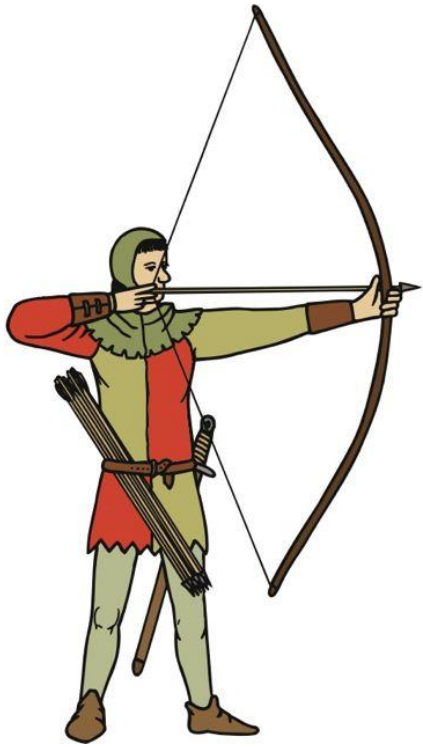
Power is the rate with which energy is transformed from one form to another. For instance, it can be the work by an engine done per unit time. SI unit of power is Watt (1W=1J/s):

$$P = \frac{\Delta W}{\Delta t}$$

Homework

Problem 1

English Longbow was an extremely powerful weapon that gave England big advantage in the Middle Ages. Consider it to be just a simple spring with spring constant *k=1000N/m (Newtons per meter)*. When shooting, an archer had to pull the string back by approximately x=0.7 m.



a) What was the force that an archer had to apply?

b) How much energy was carried by a single shut?

c) If the arrow were shut vertically upward, what would be the maximum height it could reach?

Problem 2

Electricity pioneers Nicola Tesla and George Westinghouse have built the first hydroelectric plant in 1895, on Niagara Falls. Its power was 37 megawatt (could light about a million light bulbs) . How much power they could get, if all energy of Niagara Falls could be converted to electricity? In average on Niagara, 2,000 cubic meters (i.e. 2,000,000 kg) of water fall from the height of 50 m every second.