Lecture-5

Work and Energy

Work

Work is the energy transferred to or from an object by means of force acting on the object. That means work is the act of transferring the energy.

Energy transferred to the object is positive work and energy transferred from the object is negative work.

When a force F is applied to a body, motion takes place in a straight line in the direction of force and work is done.

$W=Fd$

Work

If the applied force does not work in the direction in which the particle moves, the work done by the force is equal to the product of the component of the force along the line of motion and the distance of the body moves along that.

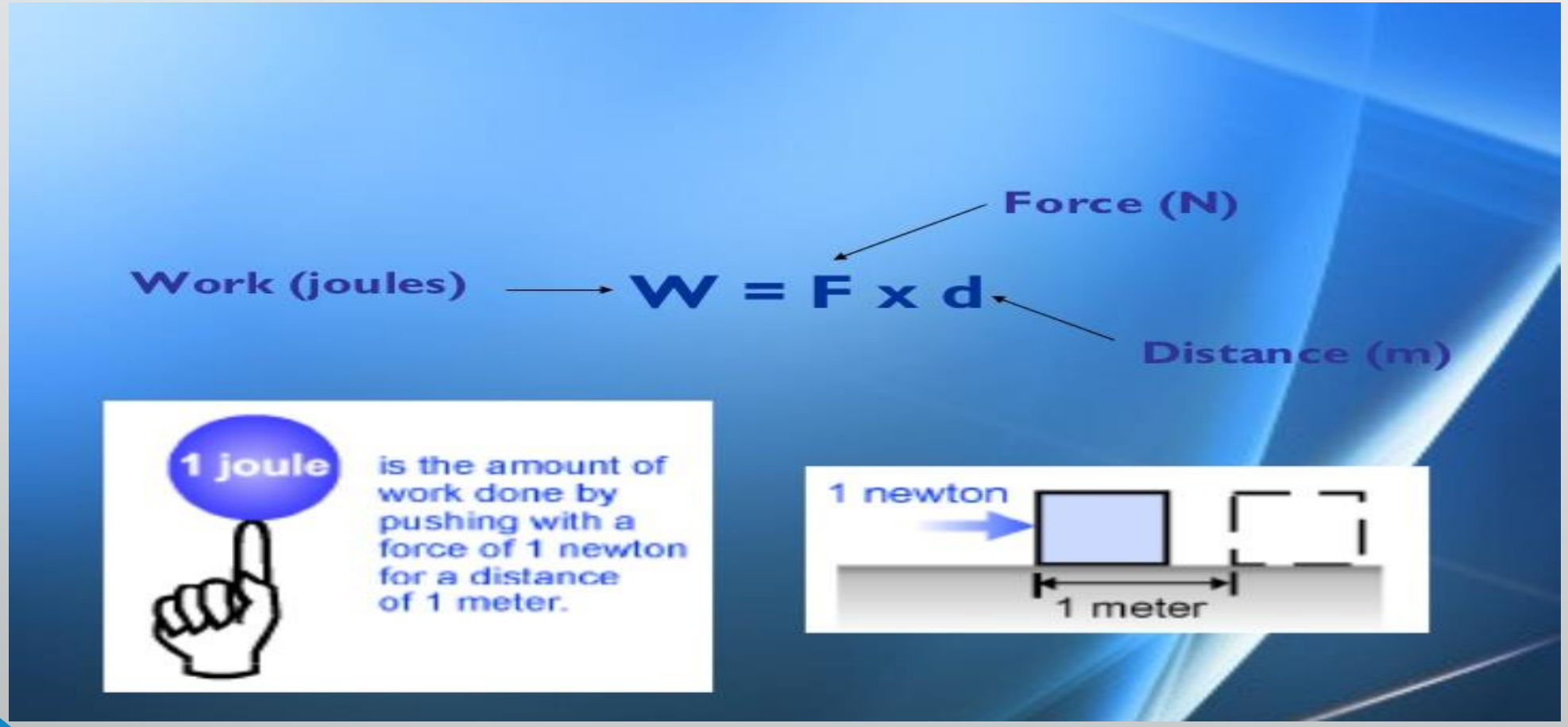
A force **F** acting at an angle θ with **x** axis on a body displaced a distance d along **x** axis

Work done, $W=(F\cos\theta)d$

$=FdCos\theta$

$=F.d$

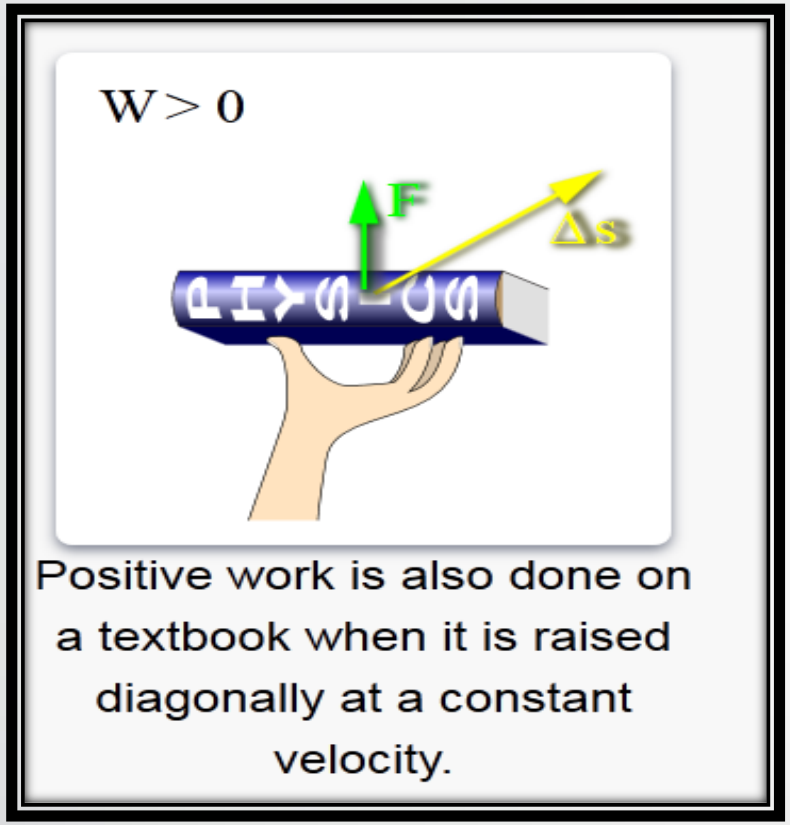
Unit of work: 1 joule is the amount of work done by pushing with a force of 1 newton for a distance of 1 meter.



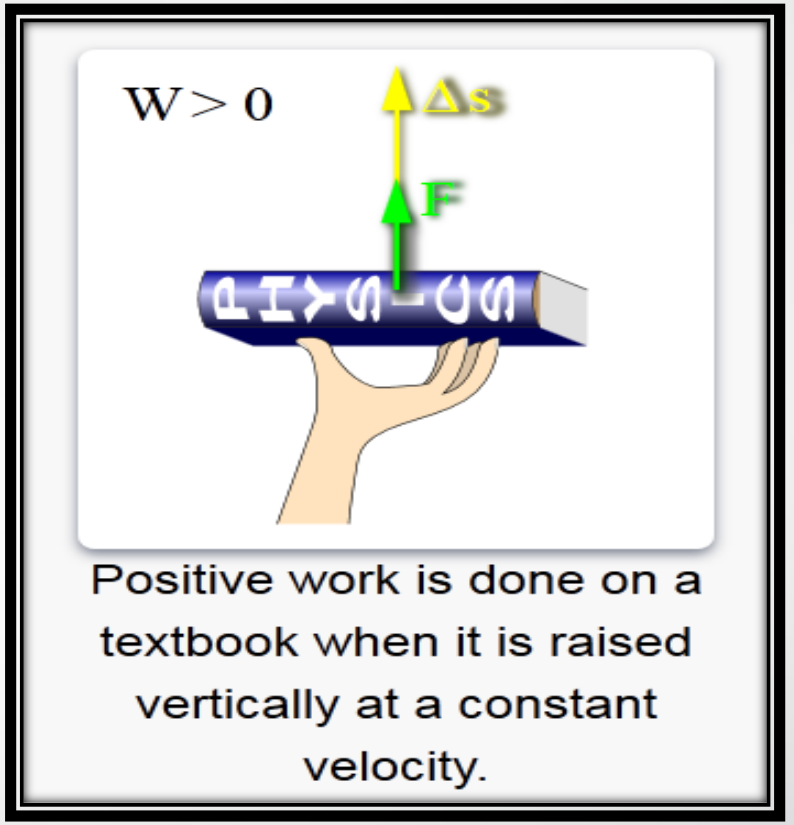
The Person behind this Science

James Prescott Joule

- Born December 24, 1818 and died October 11, 1889
- Joule is best known for his research in electricity and thermodynamics
- "After the knowledge of, and obedience to, the will of God, the next aim must be to know something of His attributes of wisdom, power, and goodness as evidenced by His handiwork."



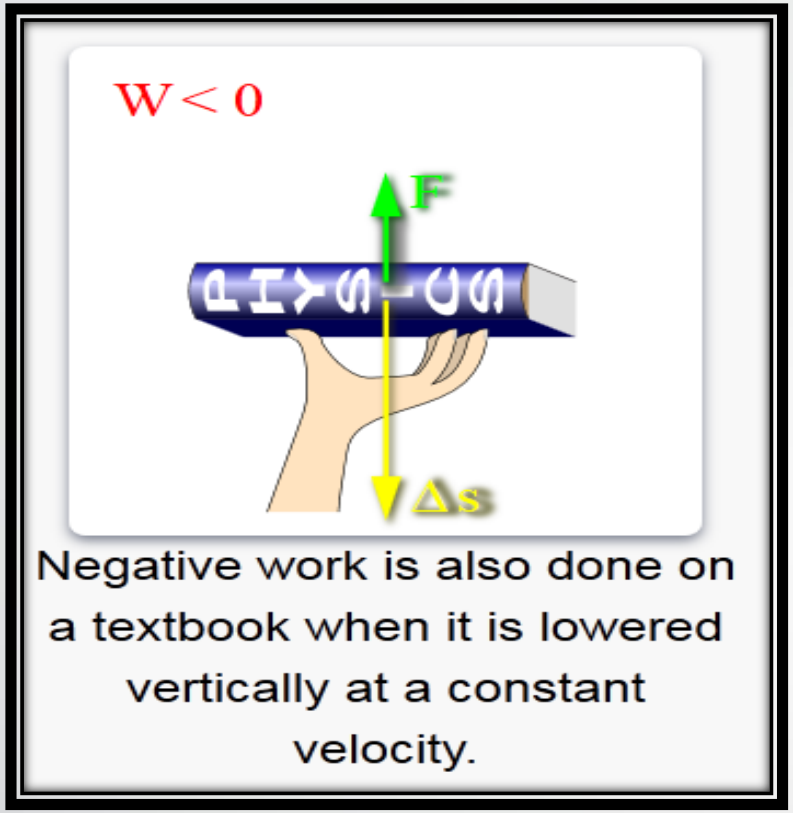
Positive work is also done on a textbook when it is raised diagonally at a constant velocity.



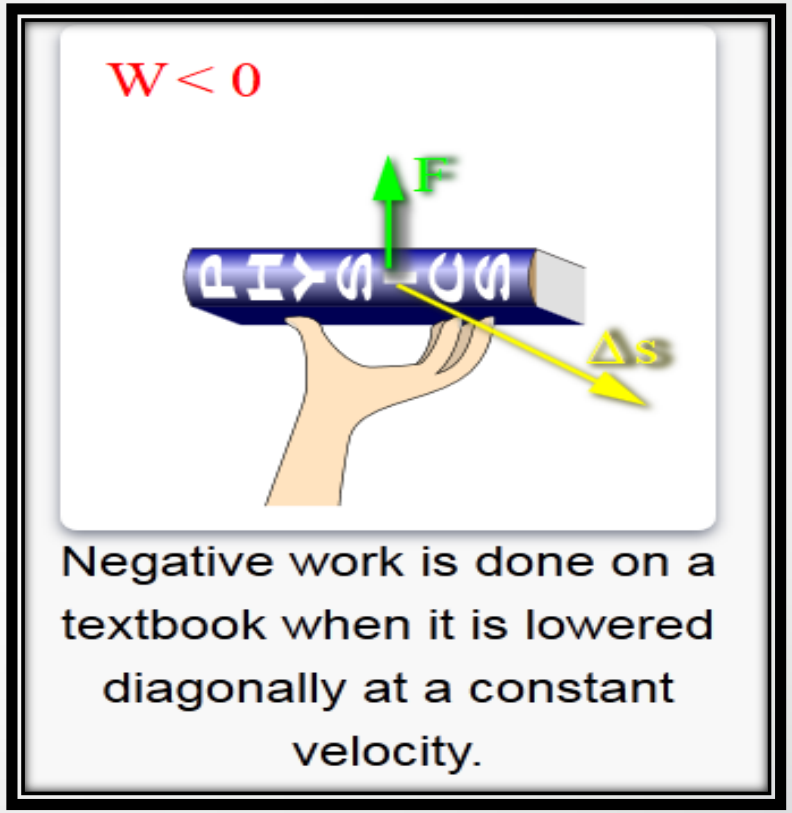
Positive work is done on a textbook when it is raised vertically at a constant velocity.

Positive work: A force does positive work when it has a vector component in the same direction as the displacement

If Φ the angle between the directions of the displacement d and the force F is less than 90^0 then cosΦ is positive that means the work done is positive.



Negative work is also done on a textbook when it is lowered vertically at a constant velocity.



Negative work is done on a textbook when it is lowered diagonally at a constant velocity.

Negative work:

A force does negative work when it has a vector component in the opposite direction as the displacement

If Φ the angle between the directions of the displacement d and the force F is greater than 90^0 then cosΦ is neagtive that means the work done is negative.

Work Energy Theorem

The work-energy theorem states that the work done by the sum of all forces acting on an object is equal to the change in that object's kinetic energy.

Mathematically,

$$\Delta K = \text{Final } K.\text{E.} - \text{Initial } K.\text{E} = W$$

Work Energy Theorem

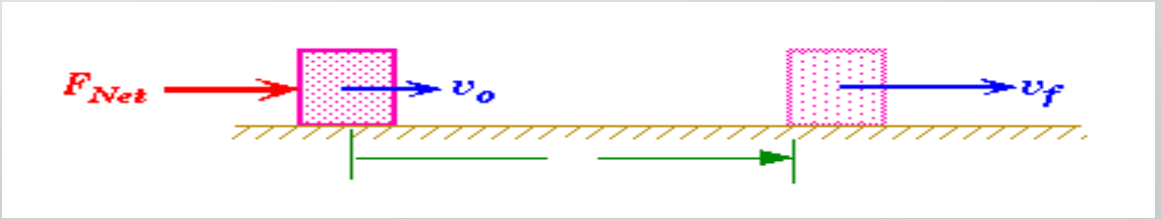
Let us consider **F** is constant resultant force acting on a particle of mass **m**, will produce a constant acceleration **a.**

We have the constant acceleration,

where V and V_0 are initial and final velocity respectively.

If the force causing a displacement X in the direction of force then,

The work done is, W=Fx=max



Work Energy Theorem

Again, if a particle moves with uniform acceleration V_o and V initial and final velocities respectively. Then, the relation can be written as,

$V^2 = V_o^2 + 2ax$
Or, $2as = V^2 - V_o^2$
Or, $as = \frac{1}{2}(V^2 - V_o^2)$

Work Energy Theorem

Using this value, in equation (1), we obtain,

$$W = \frac{1}{2} m (V^2 - V_o^2)$$

$$= \frac{1}{2} m V^2 - \frac{1}{2} m V_o^2$$

$$= K - Ko = \Delta K$$

So, we can write that at constant force the change in kinetic energy is equal to the work done.

Significance of Work Energy Theorem:

- The work energy theorem is useful for solving problems in which the work done by the resultant force is easily computed and in which it is used in finding the particles speed at certain positions. It is the fact that the work energy theorem is the starting point for a sweeping generalization in physics.
- It has been emphasized that the work energy theorem is valid when **w** is interpreted as the work done by the resultant force acting on the particle.
- However, it is helpful in many problems to compute separately the work done by certain types of force. This leads to the concepts of different types of energy and the principle of the conservation of energy

Energy

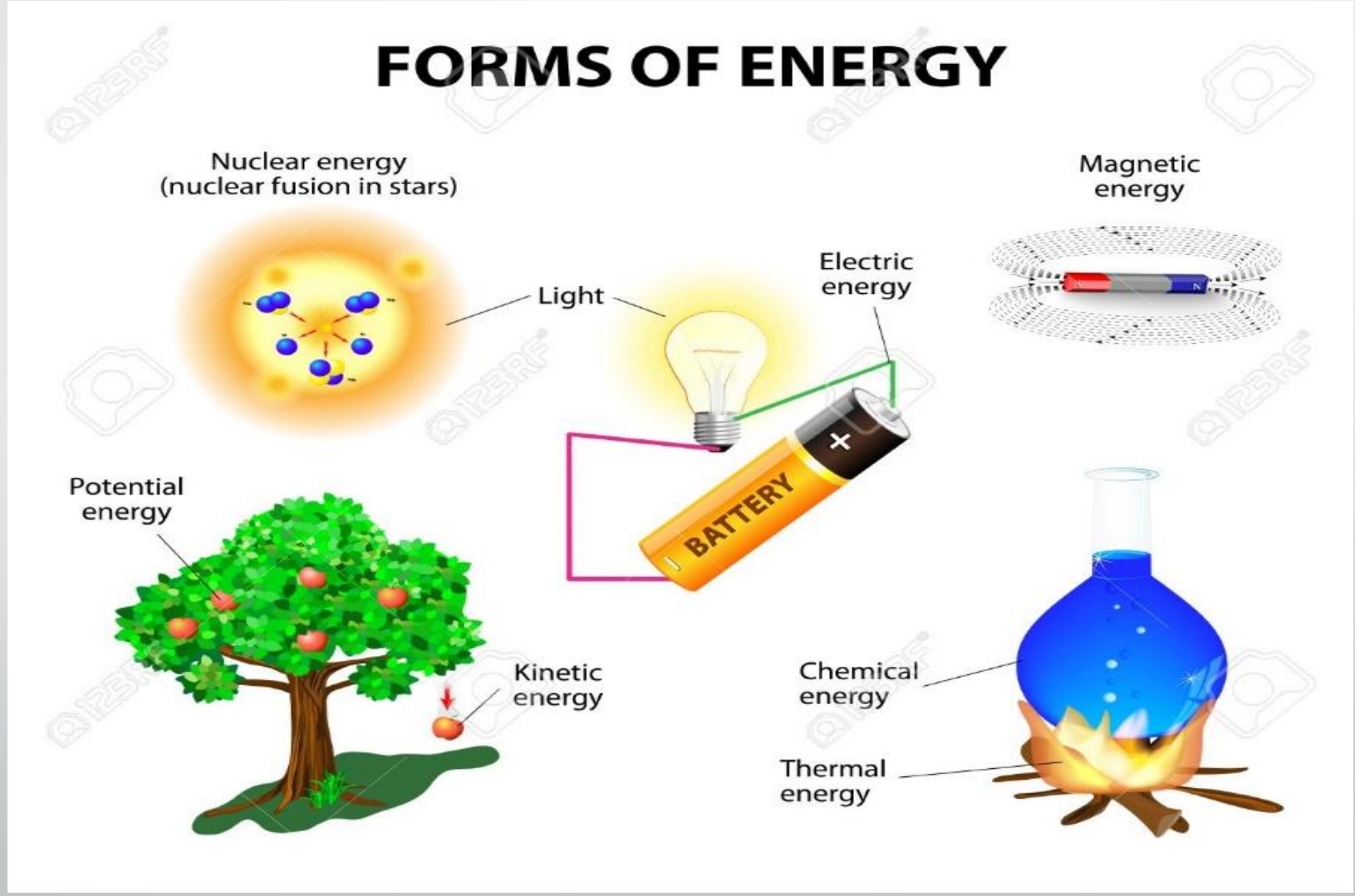
The energy of a system or a body is the property of the system or the body enables it to do work.

The capability of doing work is called energy.

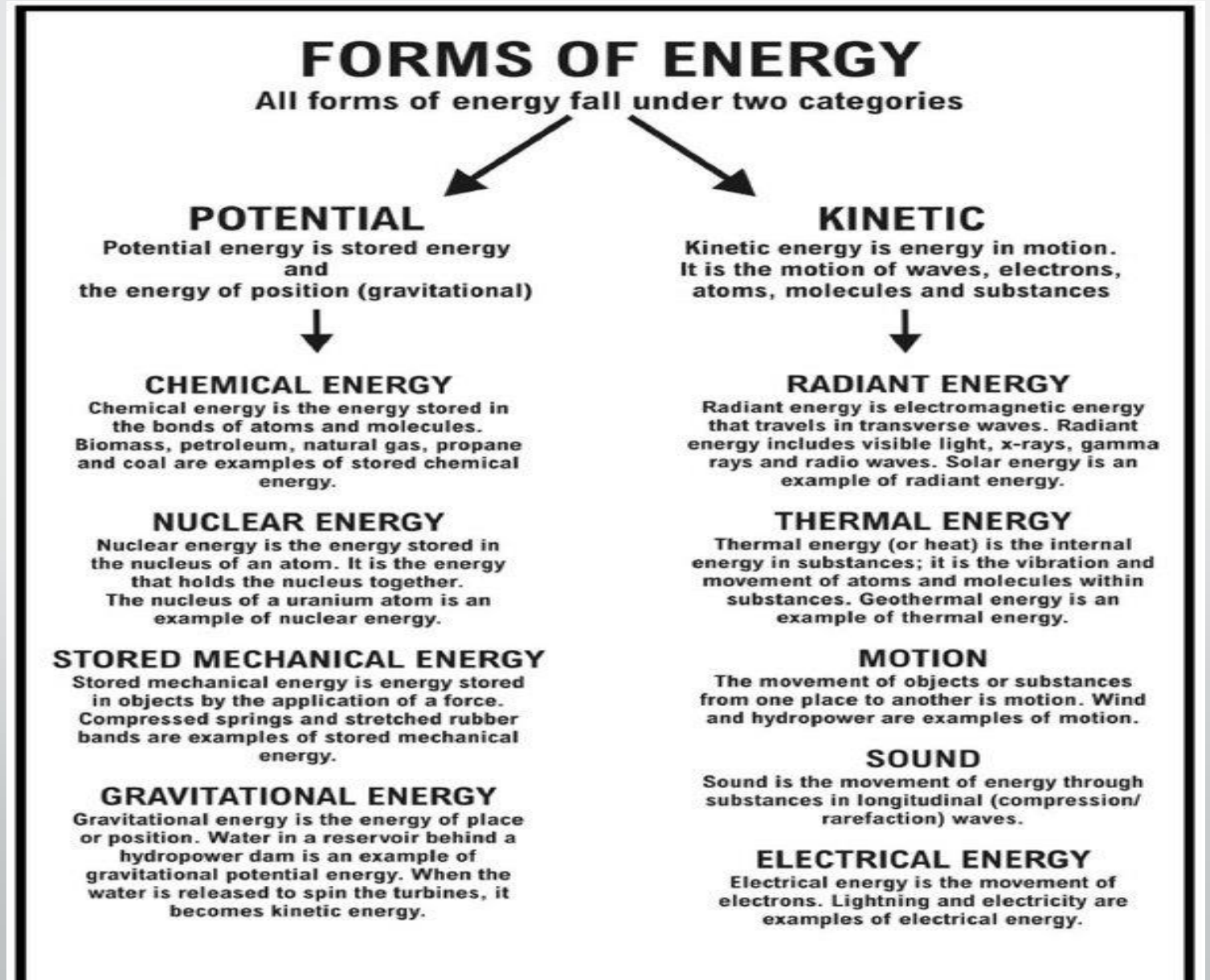
Energy is a scalar quantity.

Unit: Joule.

Different Forms of Energy

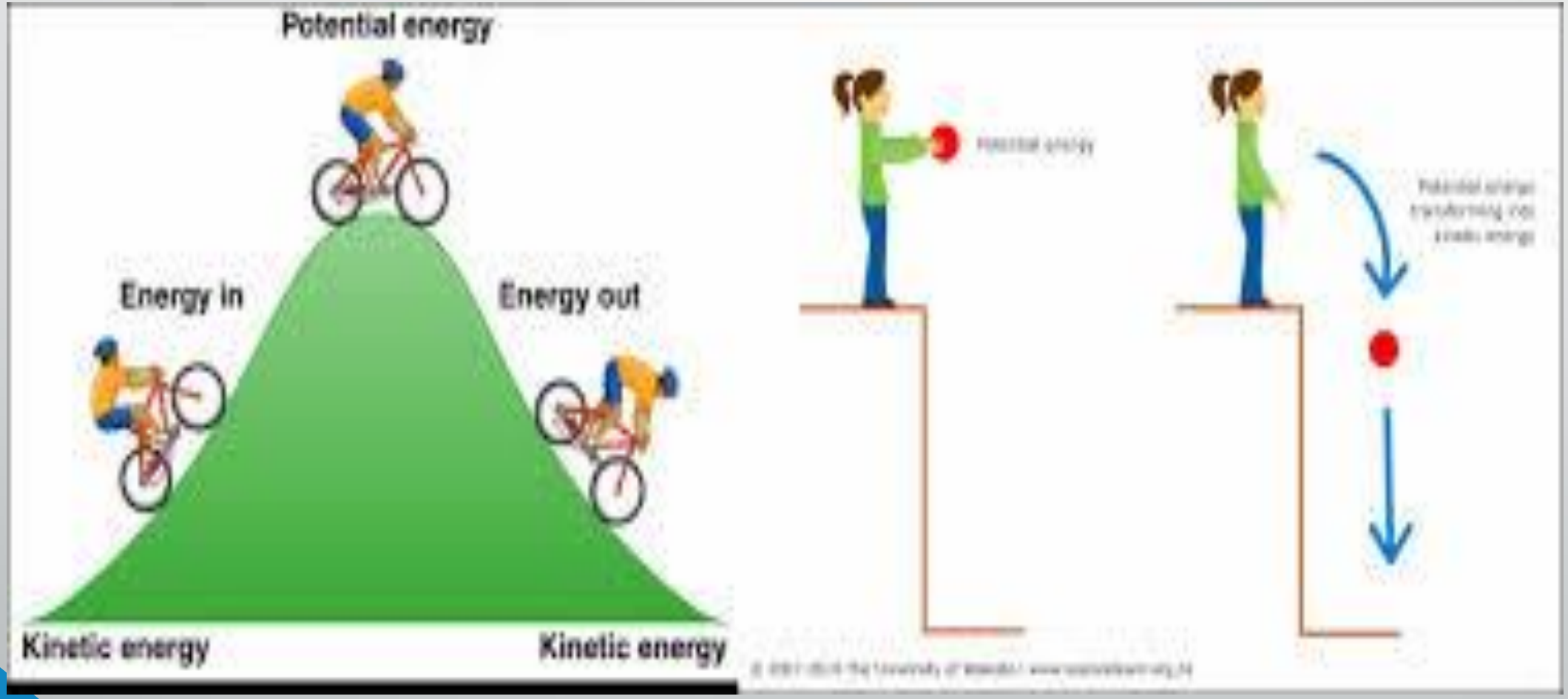


Different Forms of Energy



Kinetic Energy

The kinetic energy of an object is the energy that it possesses due to its motion. It is defined as the work needed to accelerate a body of a given mass from rest to its stated velocity.

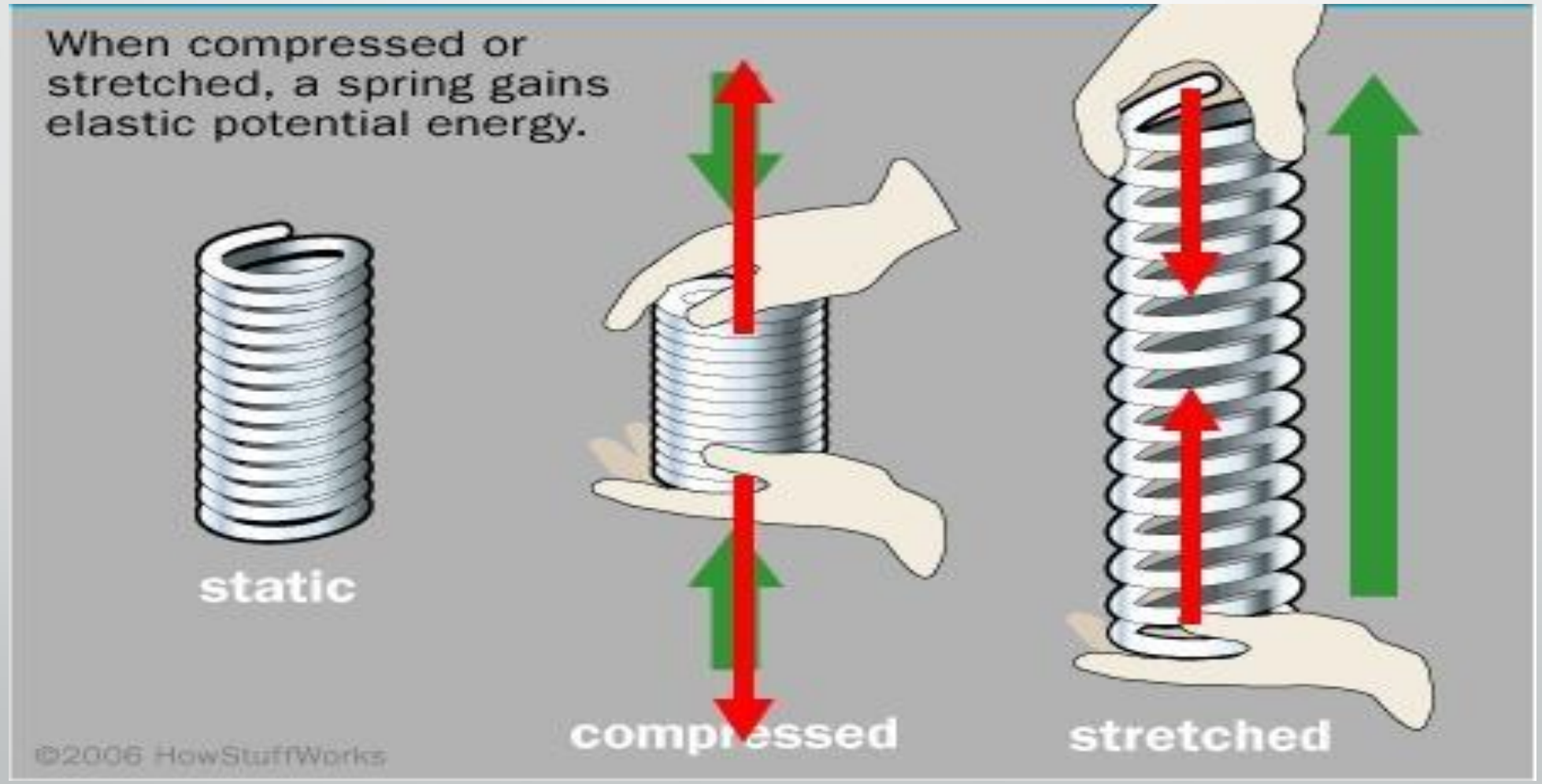

Potential energy
Energy in
Energy out
Kinetic energy
Kinetic energy

Potential Energy

The energy associated with position is called potential energy and it is divided into two categories.

1. Gravitational Potential Energy
2. Elastic Potential Energy

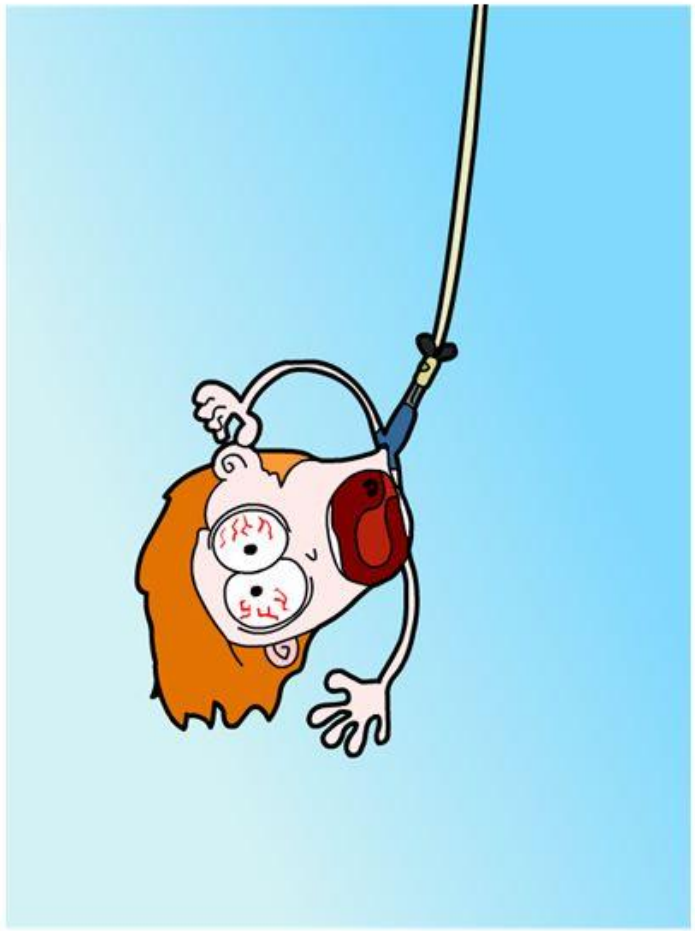
Elastic Potential Energy



What is gravitational potential energy?

The gravitational potential energy (GPE) of an object on Earth depends on its **mass** and its **height** above the Earth's surface.

- When a bungee jumper starts to fall he starts to **lose** GPE.
- As the elastic cord pulls the bungee jumper back up, he **gains** GPE.



Gravitational potential energy

If the *mass* of the container increases, its potential energy will also increase.

If the *height* of the container increases, its potential energy will also increase.