Introduction to Energy and Momentum

Duke Talented Identification Program

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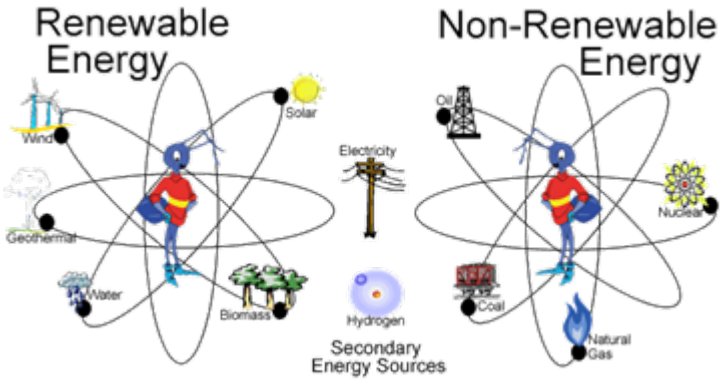
What is Energy?

- Simply, **energy** is the ability to do work measured in the unit joules (J).

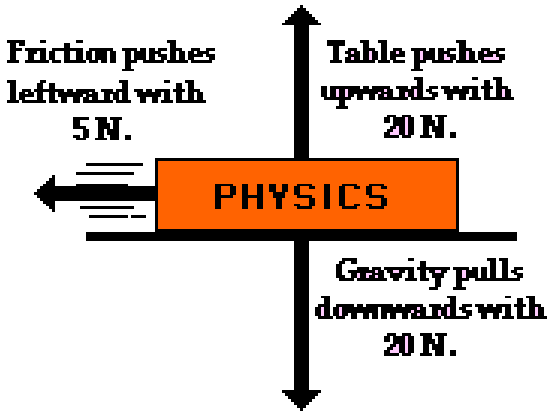
- More technically, **energy** is the scalar physical quantity that describes the amount of work that can be performed by a force.

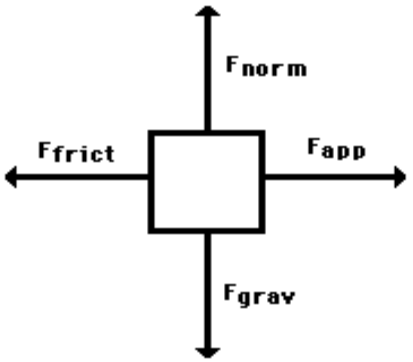


Force

- A **force** is a push or pull that can cause an object with mass to change its velocity.

- Force is a *vector* quantity, i.e. described by magnitude and direction.





Force (2)

- Force is a quantity which is measured using the standard metric unit known as the **Newton**.

- One Newton is the amount of force required to give a 1-kg mass an *acceleration* of 1 m/s/s.

$$1\ \text{Newton} = 1\ \text{kg}^* \frac{\text{m}}{\text{s}^2}$$

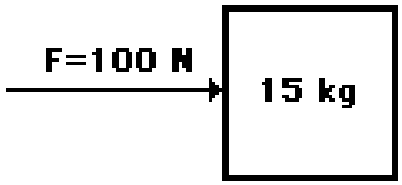
- The force exerted by gravity on 1 kg = 9.8 N.

Work

- Work is related to the distance a force moves an object.

Work done (J) = Force (N) • Displacement (m)

- Work is the measure of a quantity that is capable of accomplishing macroscopic motion of a system due to the action of a force over a distance.



Displacement = 5.5 m

Work done = 100 N x 5.5m = 550 J

Work (2)

$\vec{F}$ = Force vector applied to the object/system.

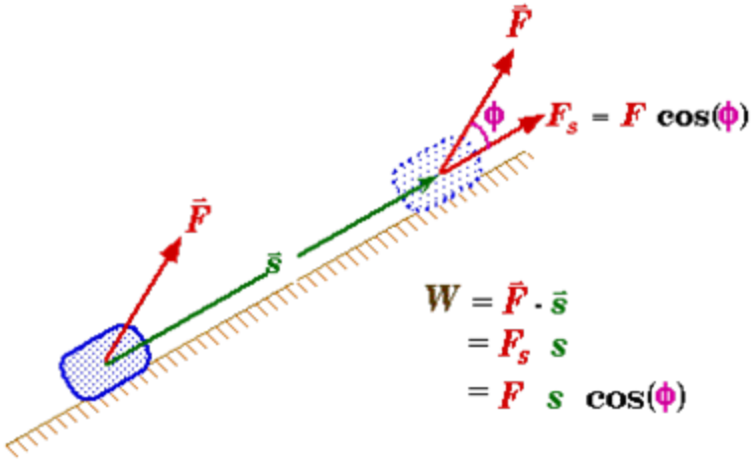
F_s = Component of Force along the direction of movement.

$\vec{s}$ = Displacement vector.

s = Distance the system is displaced.

ϕ = Angle between the displacement and the force.

$\vec{F} \cdot \vec{s}$ = Scalar or Dot product of the force vector and the distance vector



$$W = \vec{F} \cdot \vec{s} = F_s \, s = F \, s \cos(\phi)$$

Forms of Energy

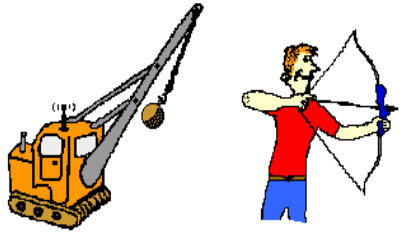
- There are many different forms of energy. Some of which include:
  - **Kinetic Energy**
  - **Potential Energy**
  - Chemical Energy
  - Thermal Energy
  - Light Energy

Potential Energy

- **Potential energy** is the stored energy of position possessed by an object.
- The equation to calculate potential energy is,

$$PE_{grav} = m * g * h$$

- **m** represents the mass of the object,
- **h** represents the height, and
- **g** represents the acceleration of gravity (9.8 m/s^2 on Earth).



The massive ball of a demolition machine and the stretched bow possesses stored energy of position - potential energy.

Kinetic Energy

- **Kinetic energy** is the energy of motion. An object which has motion - whether it be vertical or horizontal motion - has kinetic energy.

- The following equation is used to represent the kinetic energy (KE) of an object.

$$KE = \frac{1}{2} * m * v^2$$

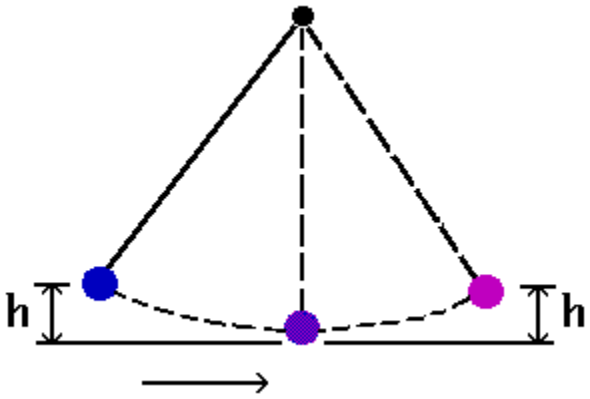
Where, **m** = mass of object

v = speed of object

Law of Conservation of Energy

- Energy in a system may take on various forms (e.g. kinetic, potential, heat, light).

- The law of conservation of energy states that energy may neither be created nor destroyed.



The **mass** of the ball = 10kg
The **height**, h = 0.2m
The **acceleration due to gravity**, g = 9.8 m/s^2

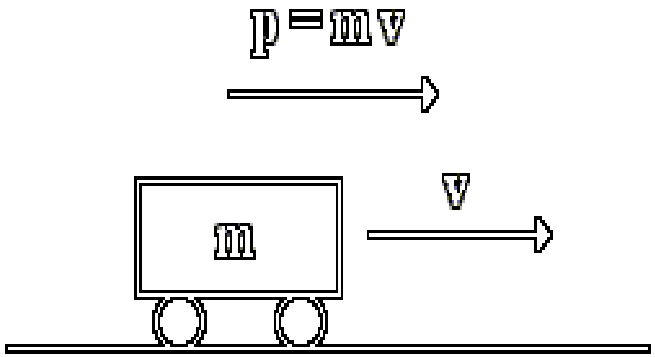
PE = 19.6J , KE = 0

PE = 0, KE = 19.6J

PE at maximum, KE = 0

Momentum

- Objects in motion are said to have a **momentum**.
- It is a product of the mass of an object and its velocity. Momentum is a *vector* quantity.

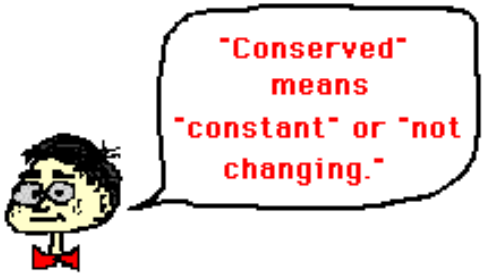


m = 2.0 kg
v *= 4.0 m/s*

p *= m**v***
p *= (2.0 kg)(4.0 m/s)*
p *= 8.0 kg-m/s*

- The direction of the momentum is the same as the direction of the object's velocity.

Law of Conservation of Momentum



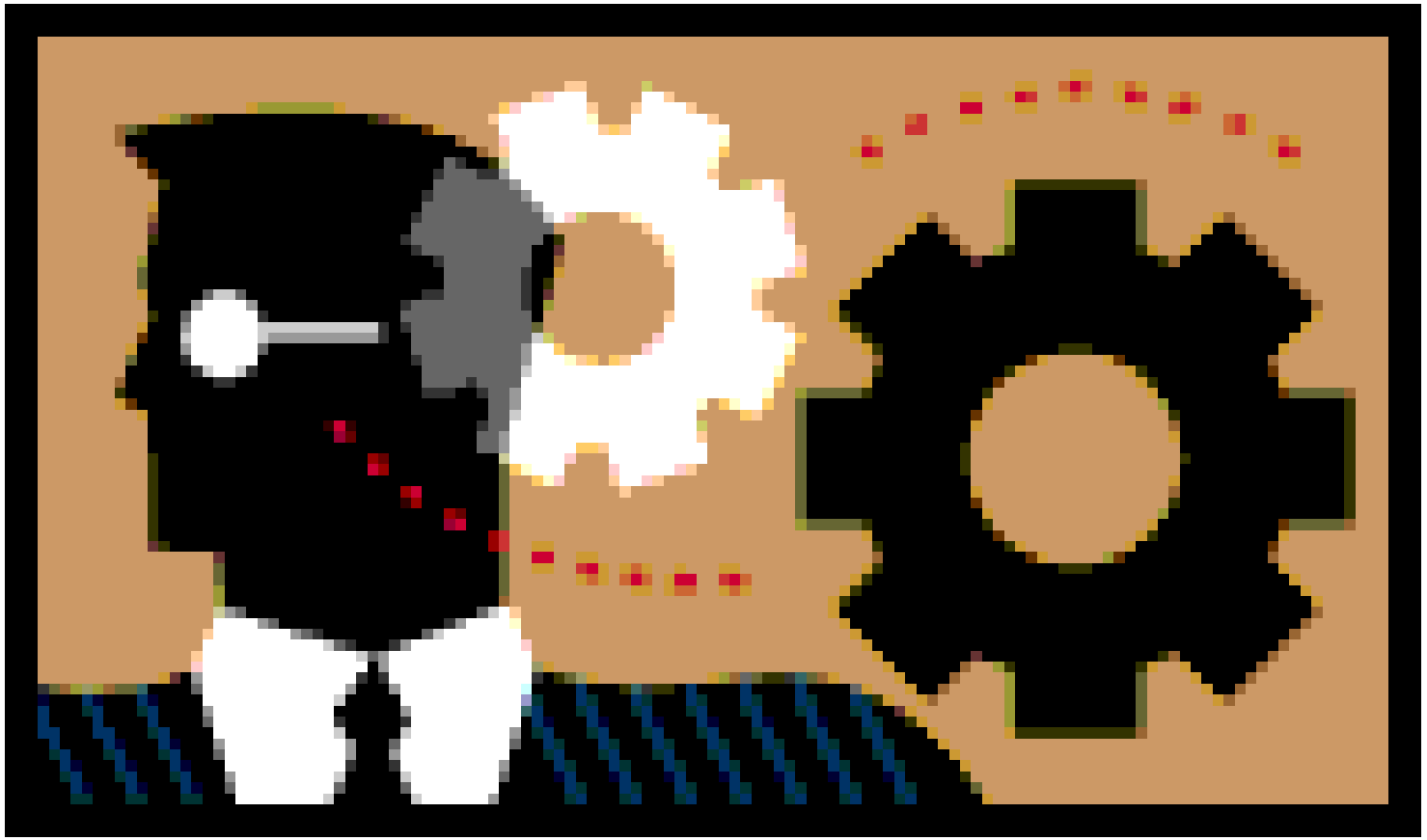
- Momentum is a conserved quantity in phys
- The conservation of momentum states that, within some problem domain, the amount of momentum remains constant; momentum is neither created nor destroyed, but only changed through the action of forces as described by Newton's laws of motion.

$$M_1V_1 = M_2V_2$$

$$m_1 * \Delta v_1 = -m_2 * \Delta v_2$$

The momentum changes are equal in magnitude and opposite in direction.

Questions???



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