WORK, ENERGY & POWER

Work Done

Work done by a constant force is the product of the force, F and the distance moved by the object in the direction of the force.

$$W = F \times d_{\parallel}$$

W : Work done (J)
F : Force (N)
d : Distance moved (m)

- Work done is a scalar quantity. SI unit is Nm or J.
- When the object moves in the direction of the force, the work done is positive, implying that the object is gaining energy. Work is done **BY** the force.
- If the object moves in the direction opposite to the force, the work done is negative, implying that the body is losing energy. Work is done **AGAINST** the force.
- Work done by frictional and viscous forces is always negative since the forces opposes motion.
- Work done is **zero** when the object
  - does not move under the application of force.
  - moves perpendicularly to the direction of force.

Energy

Energy is the capacity to do work. SI unit is in joule (J).

Types of Energy	Description	Examples
Kinetic	Energy due to its motion.	Rolling soccer ball
Chemical potential	Energy stored due to position of the atoms or molecules.	Food, fossil fuels, batteries.
Elastic potential	Energy stored due to elastic deformation.	Stretching a spring
Gravitational potential	Energy stored due to its position relative to the ground.	A book on top of a shelf
Electrical	Energy due to its movement and position of charges.	Lightning
Light	EM wave energy that is visible to the eye.	Sunlight, LED lamps
Thermal	Energy stored due to its temperature. It flows from hotter to colder body.	Radiator
Nuclear	Energy released during a nuclear reaction	Nuclear fusion or fission

Principle of Conservation of Energy

Energy can be converted from one form to another but it cannot be created or destroyed. The total energy of an **isolated system** is constant.

Mechanical energy = Kinetic Energy + Potential Energy

Kinetic Energy (KE)

Kinetic energy is energy possessed by the object by virtue of its motion.

$$KE = \frac{1}{2}mv^2$$

KE : Kinetic energy (J)
m : Mass (kg)
v : Velocity (ms^{-1})

Gravitational Potential Energy (GPE)

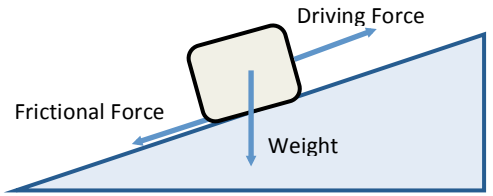
Gravitational PE is energy possessed by body by virtue of its position.

$$GPE = mgh$$

GPE : Gravitational PE (J)
m : Mass (kg)
g : Grav. field strength (Nkg^{-1})
h : Vertical height (m)

The above formula is only for finding GPE *near the surface of the Earth*.

Energy Conservation in a Ramp



Wd by driving force = KE gain + GPE gain + Wd against friction

POWER

Power, P is defined as the rate at which work is done or the rate at which energy is transformed.

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

P : Power (W)
E : Energy converted (J)
W : Work done (J)
t : Time (s)

The SI unit for power is the watt (W). One watt is defined as the rate of work done or energy conversion of one joule per second. 1 W = 1 Js^{-1}

Instantaneous power of a moving object, $P = F \times v$

F : Driving force (N)
v : Velocity (ms^{-1})

Efficiency, η

$$\eta = \frac{P_{output}}{P_{input}} \times 100\ \% = \frac{E_{output}}{E_{input}} \times 100\ \%$$

Energy input = Useful energy output + wasted energy output