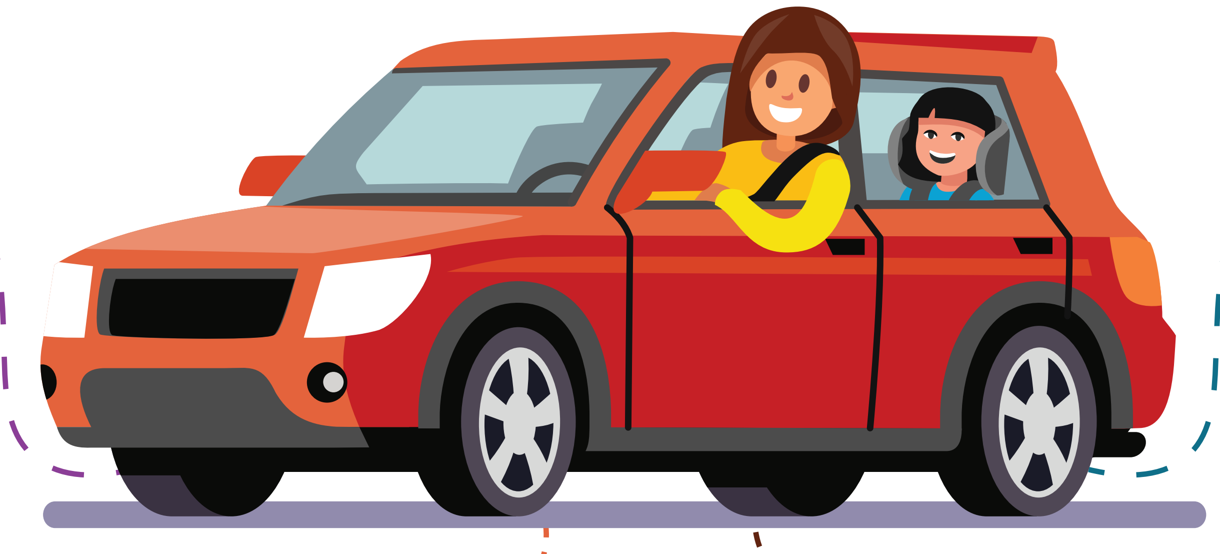
WORK, ENERGY AND POWER



WORK

- Work is said to be done when force produces displacement.

WORK DONE BY ALL FORCES

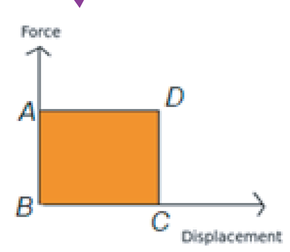
- mg
- Friction
- Tension
- Spring force
- Pseudo
- Normal

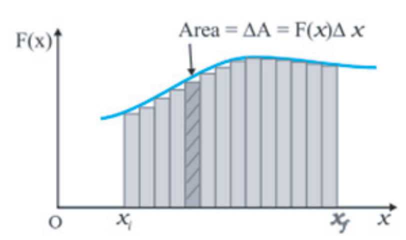
- $W = F\,d\cos\theta$.
- S.I. unit is J (Joule)

SPECIAL UNITS

- 1 hP = 746 W
- 1 KWH = 3.6×10^6 J

WORK DONE FOR CONSTANT FORCE & VARIABLE FORCE





- Area under F.S graph gives work done
- work done = Area under ABCD

- If work is done by variable force, then

$$W = \int_{r_1}^{r_2} \vec{F}\cdot d\vec{r}$$

WORK DONE BY CONSERVATIVE & NON-CONSERVATIVE FORCES

CONSERVATIVE FORCES

(1) Kx, mg and electrostatic forces are conservative forces.
(2) Work for these forces is stored in the form of potential energy.
(3) They are path independent.

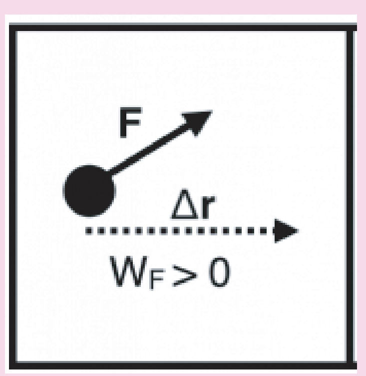
NON – CONSERVATIVE FORCES

(1) Non – conservative forces are path dependent.
(2) Friction is an example of non – conservative forces.

WORK CAN BE POSITIVE, NEGATIVE OR ZERO

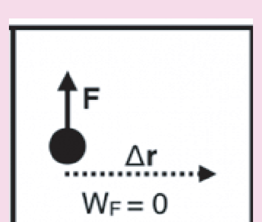
POSITIVE WORK

(1) If force and displacement both are '+' or '-' and θ is acute.
(2) If either of force or displacement is negative and θ is between 90° to 180°.



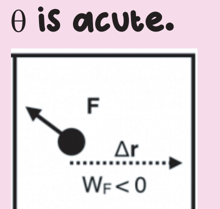
ZERO WORK

(1) $w = 0$, if force is perpendicular or to the displacement.
(2) Either force or displacement is zero.



NEGATIVE WORK

(1) If both force & displacement are '+'or '-' and θ is between 90° to 180°.
(2) If either of force or displacement is positive and θ is acute.



POWER

(1) Time rate at which work is done.
(2) It is a scalar quantity
(3) S.I. Unit is watt.

FORMULAE

(1) $dw = \vec{F}\cdot d\vec{r}$

(2) $P = \dfrac{dw}{dt}$

For small amount of work

AVERAGE POWER

Total work done in time t is average power

$$P_{avg} = \frac{w}{t}$$

INSTANTANEOUS POWER

Scalar product of force and instantaneous velocity (V) is instantaneous Power.

$$\vec{P}_{inst} = \vec{F}\cdot\frac{d\vec{s}}{dt} = \vec{F}\cdot\vec{V}$$

ENERGY

- Capacity to do work is defined as energy
- It is a scalar quantity
- S.I. unit is Joule (J)

VARIOUS FORMS

(1) Heat energy
(2) Chemical energy
(3) Electrical energy
(4) Nuclear energy
(5) Mass – Energy equivalence

WORK-ENERGY THEOREM

(1) Net work done on an object by all forces will change in Kinetic energy of an object
(2) $W_{net} = \Delta K$

$W_{conservative} + W_{non-conservative} + W_{ext} = \Delta K$

(3) $w = \int F(x).dx$, $\int F(x).dx = \Delta K + \Delta V$ if variable force does work .

MECHANICAL ENERGY IS CONSERVED

ENERGY IN SPRING MASS SYSTEM

(1) Total mechanical energy at each point is constant.
(2) $\Delta K + \Delta V = 0$

$(K_{initial} + V_{initial}) = (K_{final} + V_{final})$

(3) maximum velocity

$$V_{max} = x_m\sqrt{\frac{k}{m}}$$

MOTION IN VERTICLE CIRCLE

(1) In absence of dissipative forces, mechanical energy is conserved
(2) $V = \sqrt{5gl}$ at bottom to reach top
(3) V = $V = \sqrt{3gl}$ at bottom to cross quarter Circle
(4) $V = \sqrt{gl}$ to reach quatre circle
(5) Tension at any point on circle.

$$T = \frac{m\mu^2}{r} - mg(2 - 3\cos\theta)$$

(6) Velocity at any point on circle.

$$V^2 = \mu^2 - 2gl(1 - \cos\theta)$$

TYPES OF ENERGY

MECHANICAL ENERGY

Sum of kinetic energy and potential energy

KINETIC ENERGY

- By virtue of velocity $K = \frac{1}{2}mv^2$

POTENTIAL ENERGY

- By virtue of position, height, stresses within its & Electrostatic factors:
- Gravitational Potential Energy = mgh
- Elastic Potential energy = $\frac{1}{2}kx^2$
- Electrostatic Potential energy = $\dfrac{kq_1q_2}{r}$

COLLISIONS

- An instance of one moving body striking with another
- Collision of car with truck, collision of balls in snooker are examples.

CONSERVATION OF MOMENTUM

(1) If netexternal force on system is zero then linear momentum of system is conserved
(2) $\Delta\vec{P} = 0$
(3) $\vec{P}_i = \vec{P}_f$
(4) $m_1\vec{\mu}_1 + \dots\dots\dots + m_1\vec{\mu}_n = m_1\vec{\upsilon}_1 + \dots\dots\dots + m_1\vec{\upsilon}_n$

NATURE OF COLLISIONS

- Value of coefficient of restitution defines nature of collision.

$$e = \frac{V_{seperation}}{V_{approach}}$$

- e = 0, e = 1, 0 < e < 1 Defines nature of collisions

TYPES OF COLLISIONS

- In elastic collision, momentum and K.E of system are conserved
- e = 1
- Bodies do not stick together after collision

- In inelastic collision, momentum is conserved
- 0<e<1
- Bodies do not stick together after collision

- In perfectly inelastic collison momentum is conserved
- e = 0
- Bodies sticks together after collision

1 - D COLLISION

(1) $(\Delta P)_{sys} = 0$

(2) e = $\dfrac{V_2 - V_1}{\mu_1 - \mu_2}$

(3) V_1 = $\left(\dfrac{m_1 - em_2}{m_1 + m_2}\mu_1 + \dfrac{(1+e)m_2}{m_1 + m_2}\mu_2\right)$

velocity of first particle after collision.

(4) V_2 = $\dfrac{m_1 - (1+e)}{m_1 + m_2}\mu_1 + \dfrac{m_2 - em}{m_1 + m_2}\mu_2$

velocity of second particle after collision

(5) Change in kinetic energy, ΔK

$$\Delta K = \frac{1}{2}\frac{m_1m_2}{m_1 + m_2}(\mu_1 - \mu_2)^2(1 - e)$$

2 - D COLLISION

(1) Bodies moving in a plane results in arbitrary collision in different directions is 2 – D.

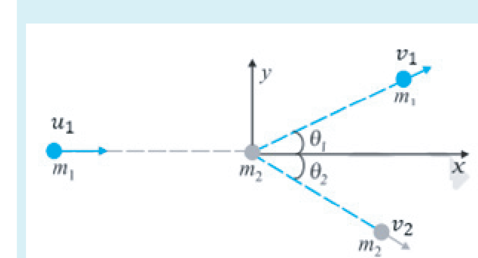
(2) $\Delta\vec{P} = 0$

$\Delta P_x = 0$

$m_1\mu_1x + m_2\mu_2x = m_1v_1x + m_2v_2x$

$\Delta P_y = 0$

$m_1\mu_1y + m_2\mu_2 = m_1v_1y + m_2v_2y$



SPECIAL CASES

(1) $h_n = e^{2n}\,ho$

e = coefficient of restitution.
N = Nth collision.
ho = initial height.
hN = height after Nth collision

(2) VN = eNVo.

N = Nth collision.
Vo = initial velocity.
VN = velocity after Nth collision.

(3) H = ho $\left(\dfrac{1+e^2}{1-e^2}\right)$

H = total distance travelled before it stops

(4) T = $\left(\dfrac{1+e^2}{1-e^2}\right)\sqrt{\dfrac{2h_o}{g}}$

T = time taken by ball to stope bouncing.