DELHI PUBLIC SCHOOL BANGALORE - EAST

PHYSICS

WORK AND ENERGY (NOTES)

CLASS IX

Definition of Work Done: Work is defined as the product of the force applied on an object and displacement caused due to the applied force in the direction of the force. Work is a scalar quantity. It has no direction of its own but a magnitude.

SI unit of Work: N-m or J (Joule)

Work is said to be done only when an object has been displaced from its original position. Therefore,
A person sanding at a place is not doing any work according to science. A student preparing for her exams while sitting on a chair is not doing any work

Two necessary conditions for work to be done:
i) Force should act on the object.
ii) Object must be displaced.
If a constant force 'F' displaces an object by a distance's' in the direction of force; the work done is equals to the product of force and displacement.
That is, W= F x s
W = work done, F = force applied in the direction of displacement, s = displacement or distance covered by the object.
Since, unit of force is Newton (N) and unit of displacement is meter (m), the unit of work is (Nm) or joule (J)
1J of work is the amount of work done when 1N of force displaces an object by 1m.

Positive and negative work
When both the force and the displacement are in the same direction, positive work is done.

$W = F \times s$

when force acts in a direction opposite to the direction of displacement, the work done is negative.

$W = -F \times s$

Angle between force and displacement is 180^o.
If force and displacement are inclined at an angle less than 180^o, then work done is given as:

$W = Fs\cos\theta$

Example:
If a man pulls a moving car from behind but it keeps on moving forward. The work done by the man is said to be negative.
In the above example itself, the work done by the engine will be positive, since the engine is applying the force forward and the car is moving forward.

Zero work:
If force and displacement act at an angle of 90° then work done is zero.
Example: When a person is standing with a heavy load on his head on horizontal road- not doing any work.

Energy

Ability to do work is called energy.
An object that has energy can exert some force on another object.
The energy required to do a particular work is same as the amount of work done.
Units of energy is Joule (J)
I Joule of energy is required to do 1 joule of work.

Types of Energy

1. Kinetic energy
A type of energy possessed by a moving object is called kinetic energy.

Let a body (ball) of mass m is moving with an initial velocity v. If it is brought to rest by applying a retarding (opposing) force F, then it comes to rest by a displacement S. Let, E_k = work done against the force used to stop it.

$$E_k = F . S \text{ -----> (1)}$$

But retarding force F = ma-----> (2)

Let initial velocity u = v, final velocity v = 0
From III equation of motion, $v^2 = u^2 + 2as$ applying,

$$0 = v^2 - 2as \text{ (a is retardation)}$$

$$2as = v^2$$

$$\text{displacement, } s = \frac{v^2}{2a} \text{ ---------------->(3)}$$

substituting (2) and (3) in (1), we get

$$E_k = ma.\frac{v^2}{2a}$$

$$\Rightarrow E_k = \frac{1}{2}mv^2$$

Kinetic Energy of a moving object is defined as half the product of the mass of the object square of the speed of the object.

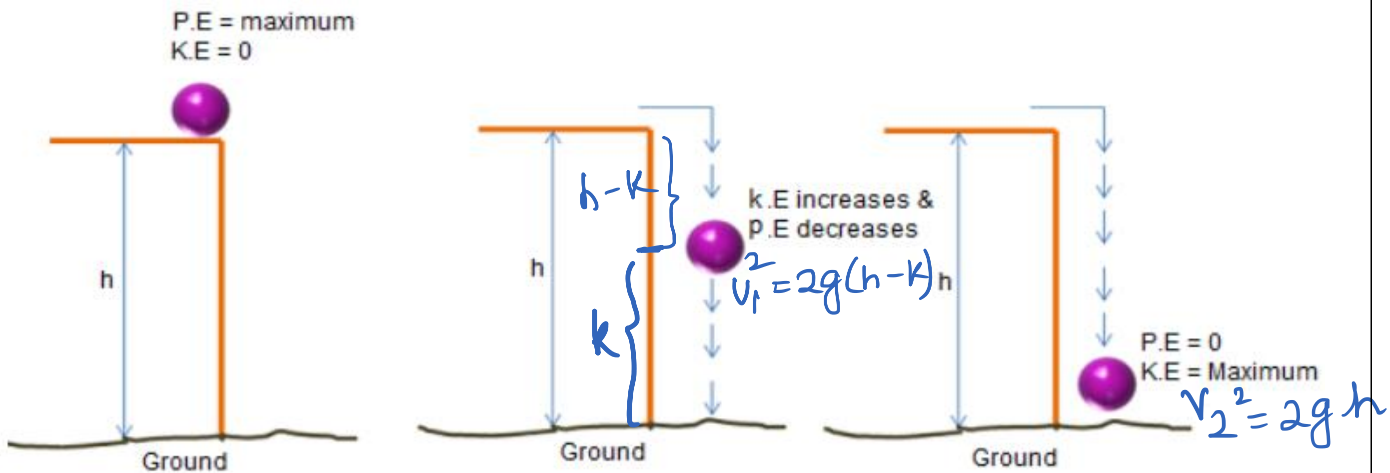
2. **Potential Energy**
A form of stored energy that can change the velocity of an object when released.
For e.g.
A stretched bow with an arrow
A stretched or compressed spring
A ball held at a certain height.
In all the above three examples when the bow, spring or ball is released all of them will increase their speed and start moving.
Hence, the energy that was stored in the above cases was potential energy.

Potential energy of an object kept at a height:

Let an object of mass 'm' be held at a height 'h'
Work can be done by the object = Force * displacement
= m x a x s (F = ma second law of motion)
But here acceleration will be due to gravity so 'a' = 'g' (g = acceleration due to gravity) And 's' is

equal to height of the object or 'h'
So, Potential work or Wp = m x g x h or mgh
Since, same amount of energy is required to do a work
Ep = mgh
Potential energy does not depend on the path followed by the object while moving up or down. It only depends on the perpendicular (straight line) height of the object from the ground.

Law of conservation of Energy of a freely falling object:
According to the law of conservation of energy, the total amount of energy before and after transformation remains the same.
Consider the following example where an object of mass ‘m’ is made to fall freely from a height ‘h’.



Instant	Height at an instant	Kinetic Energy	Potential Energy	Sum of KE + PE = ME
1	Height = h	0 (velocity is 0)	mgh	0 + mgh=mgh
2	Height = k	½ mv_1^2 (velocity = v_1)	mgk	½ mv_1^2 + mgk = ½ m. 2g(h-k) +mgk = mgh- mgk +mgk =mgh
3	Height = 0	½ mv_2^2 (velocity = v_2)	0	½ mv_2^2 + 0 = ½ m .2 gh= mgh

The total energy can neither be created nor destroyed. It can only be converted from one form to another.In other words,
Kinetic energy + potential energy = constant
½ mv2 + mgh = constant

Power
The rate of doing work is called power
Or
The amount of work done per unit time is called power.

$P=W/t$
Where, p = power, W = work done, t = time
SI unit of Joule/sec (J/s) or Watt (W)
Commercial units of power
Since, watt (W) is a very small unit of power the commercial units are expressed in kilowatt hour or kWh
1kilowatt or 1kW = 1000W (Watt)
1W means IJ of energy consumed per second.
1000W or IkW means 1000 J of energy consumed per second.
1 kWh means 1000 J of energy consumed per second for one hour
1hour = 3600 seconds
so 1kWh = 1000 x 3600 J of energy = 3.6×10^6J of energy.
The commercial unit used in household is kWh or kilowatt hour, which is commonly known as units.

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