Meligy4Science
Ahmed Meligy

WORK

- The scalar product of the force acting on a body and its displacement.
- Work is a scalar quantity.

$W = F.d = Fd \cos\theta$

- A sign representing the scalar product process, pronounced «dot».
- The magnitude of displacement moved by the body.
- Magnitude of the force acting on the body.
  - If motion is horizontal : $F = ma$
  - If motion is vertical : $F = mg$
- The angle between the direction of the force acting on the body and the direction of the body's displacement.
  - Maximum work at the smallest angle.
  - Minimum work at an angle of 90°.

forget

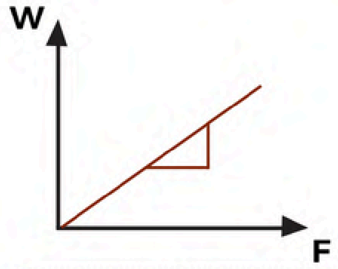
Work → Measuring Unit → $kg.m^2/s^2$ → equivalent → N/m (or) joule (J) → Dimensions → ML^2T^{-2}

W = 0

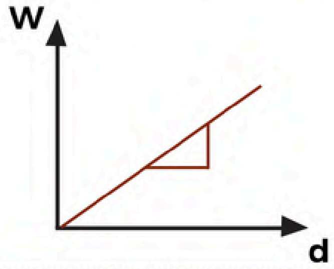
- F = 0
- d = 0 — When acting on a body with force and it remains stationary.
- θ = 90 — The Effect of Weight in Horizontal Motion

- The horizontal applied force = the force of friction between the object and the surface
- If a force is applied to an object and it moves at a constant velocity, this implies that the applied horizontal force equals twice the frictional force

1



$slope = \frac{\Delta W}{\Delta F} = d \cos\theta$



$slope = \frac{\Delta W}{\Delta d} = F \cos\theta$

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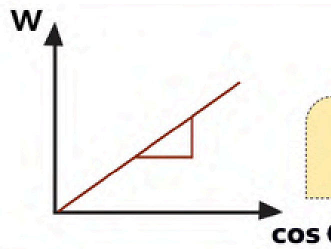

$slope = \frac{\Delta W}{\Delta \cos\theta} = fd$

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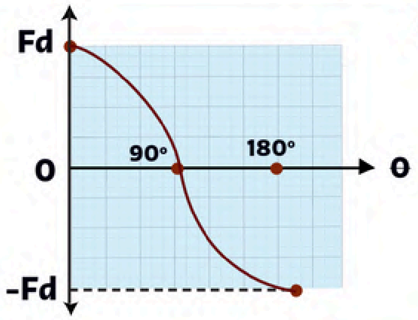

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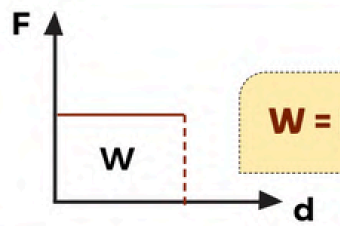
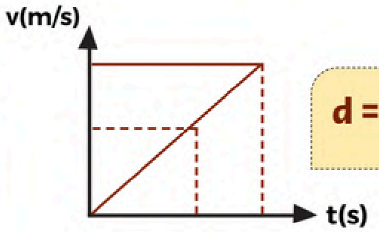


W = Fd = Area under the curve

5



d = Vt = Area under the curve

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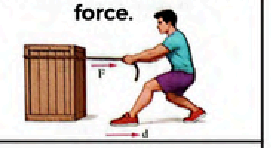
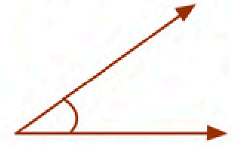
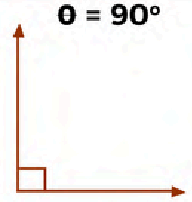
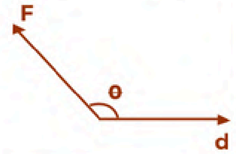
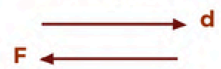
The effect of the angle (θ) between the direction of force and displacement on the work done.

The value of the angle between the directions of force and displacement.	The work done (W)	example
θ = 0 	W = Fd Cos 0 = Fd The work done is at a maximum positive value.	A person pulls a box with a force (F), causing the box to undergo a displacement (d) in the same direction as the force. 
0 < θ < 90° 	W = Fd cos θ The work done is a positive value, as the cosine of the angle is positive.	A person pulling a suitcase 
θ = 90° 	W = Fd cos 90 = 0 The work done is equal to zero (i.e., null).	A girl carrying a bucket and moving through a horizontal distance. 
180° > θ > 90° 	W = Fd cos θ The work done is a negative value, as the cosine of the angle is negative.	A person attempts to slow down a box as it slides down an inclined plane by applying a force (F) upwards. 
θ = 180° 	W = Fd cos 180° = -Fd The work done is at a maximum negative value.	The work done by frictional forces (such as braking forces). 

energy

It is the capacity to do work.

forget

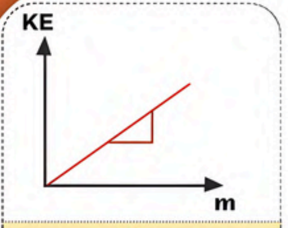
energy → Measuring Unit → joule (J) The same unit of measurement as work. → equivalent → $kg.m^2/s^2$ (or) N.m → Dimensions → ML^2T^{-2}

kinetic energy (K.E)

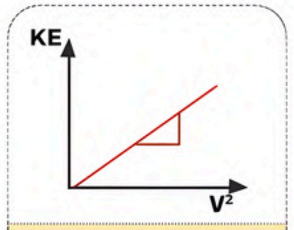
- The energy possessed by an object due to its motion.

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

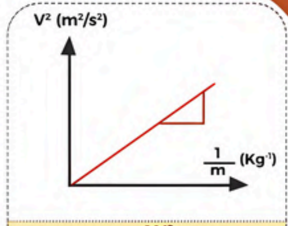
$W = Fd = \Delta(KE) = \frac{1}{2} m(V_f^2 - V_i^2)$



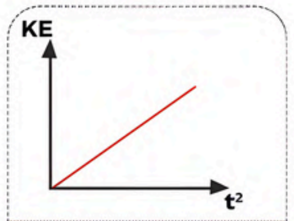
slope = $\frac{\Delta KE}{\Delta m} = \frac{1}{2} V^2$



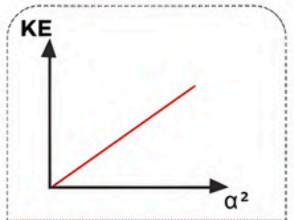
slope = $\frac{\Delta KE}{\Delta V^2} = \frac{1}{2} m$



slope = $\frac{\Delta V^2}{\Delta(\frac{1}{m})} = 2\,KE$



slope = $\frac{1}{2} ma^2$



slope = $\frac{1}{2} mt^2$

When moving at a certain velocity and then applying a force (F) to the brakes, the car stops after a displacement (d); this displacement is directly proportional to the square of the velocity

- If the velocity before braking V ⟶ d
  3V ⟶ 9d

Velocity conversions

Km/h → m/s: $\times \frac{5}{18}$

m/s → Km/h: $\times \frac{18}{5}$

Potential Energy (PE): The energy possessed by an object due to its position.

Examples of Potential Energy

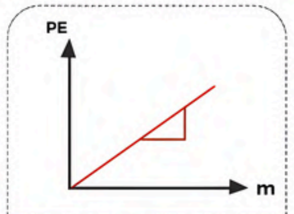
1. Elastic Potential Energy

- The Spring - Rubber band - Elastic string

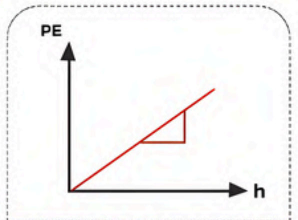
2. Gravitational Potential Energy

- When a person lifts an object from the surface of the Earth.
- The collapse of eroded rocks.

P.E= mgh



slope = $\frac{\Delta PE}{\Delta m} = gh$



slope = $\frac{\Delta PE}{\Delta h} = mg = w$

Aid

Assuming the potential energy at the surface of the Earth is zero, the sign of (h) will be :

Positive (+) : If the object is above the Earth's surface.

Negative (-) : If the object is below the Earth's surface (e.g., in a hole or well).

When lifting a box vertically upwards or along an inclined plane, in both cases, the same amount of work is done.

- Lifting vertically requires a force equal to the weight of the box.
- Lifting along an inclined plane requires a force less than the weight of the box.

The Law of Conservation of Energy.

Energy can neither be created nor destroyed; it can only be transformed from one form to another.

$$\Delta PE = -\Delta KE$$

$$\therefore g\,[h_f - h_i] = -\frac{1}{2}\,[V_f^2 - V_i^2]$$

The sum of potential and kinetic energies at point (2) = The sum of potential and kinetic energies at point (1)

$$\therefore (PE)_f + (KE)_f = (PE)_i + (KE)_i$$

Mechanical Energy

- The sum of potential and kinetic energies of an object

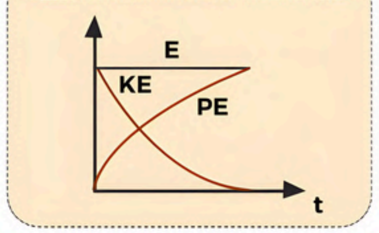
E = K.E + P.E

The Law of Conservation of Mechanical Energy

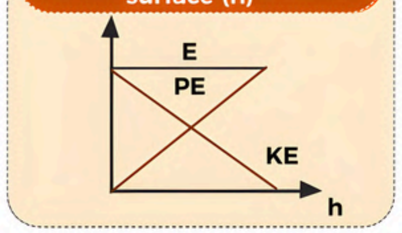
- The sum of an object's potential and kinetic energies at any point in its path, when moving under the influence of a conservative force such as gravitational or elastic force is constant

When an object is projected vertically upwards from the Earth's surface, during its ascent until it reaches maximum height, the relationship between Kinetic Energy (KE), Potential Energy (PE), and Mechanical Energy (E) can be represented as follows:

Time (t)



Height above the Earth's surface (h)



When an object is projected (or thrown) upwards

E	P.E	h	K.E	P	v	a	m
Constant	Increases	Increases	Decreases	Decreases	Decreases	Constant	Constant

When an object falls downwards (or is dropped)

E	P.E	h	K.E	P	v	a	m
Constant	Decreases	Decreases	Increases	Increases	Increases	Constant	Constant

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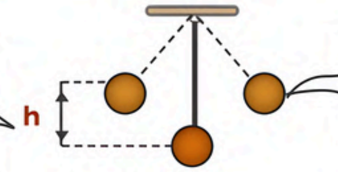
When an object falls freely from rest from a height (h_o):

	Height (h)	Potential Energy (PE)	Velocity (V)	kinetic Energy (EK)	Mechanical Energy E =KE + PE
At maximum height	h_o	mgh_o	0	0	$(PE)_{max} = mgh_o$
At the midpoint between the Earth's surface and the maximum height	$\frac{h_o}{2}$	$\frac{1}{2} mgh_o$	$\sqrt{gh_o}$	$\frac{1}{2} mgh_o$	2 PE= 2 KE= mgh_o
The moment the object reaches the Earth's surface	0	0	$\sqrt{2gh_o}$	mgh_o	$(KE)_{max} = mgh_o$

Therefore

E = PE (At maximum height) = KE (At the Earth's surface)

In the case of a simple pendulum oscillation, as shown in the figure:



In the relation (PE = mgh), the height (h) represents the vertical distance between the equilibrium position and the position of the pendulum bob at any point.

This position represents the equilibrium position, where the ball's velocity is at its maximum, and at this point:

h = 0

∴ PE = 0

∴ E = KE

At this position, the ball (bob) has reached its maximum displacement from the equilibrium position, and at this point:

V = 0

∴ KE = 0

∴ E = PE

علَى قدرِ حُلمك تتسعُ الأرضُ