Work, Energy and Power

Course2 – After Newroz

24-3-2024 (A&B)

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WORK

• Introduction

You have always done work in our daily routine. But can you measure the amount of work you do on a given day?

In physics, work is said to be done when a force is applied on something and moves it through a distance that follows its direction..

When an object moves while a force is being exerted on it, then work is being done on the object by the force.

Work done When a **force acts on an object and the object actually moves in the direction of force, then the work is said to be done by the force**.

Work done by the force is equal to the product of the force and the displacement of the object in the direction of force.

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Note

- If you **accelerate** an object to a greater speed by applying a force on the object, you **increase** its **kinetic energy K**; you performed work on the object.
- Similarly, if you **decelerate** an object, you **decrease** its **kinetic energy**; in this situation, the object actually did work on you (equivalent to you doing negative work).

If an object moves in response to your application of a force, you have performed work.

•The further it moves under the influence of your force, the more work you perform.

•There are only two relevant variables in one dimension: the force, Fx, and the displacement, Δx.

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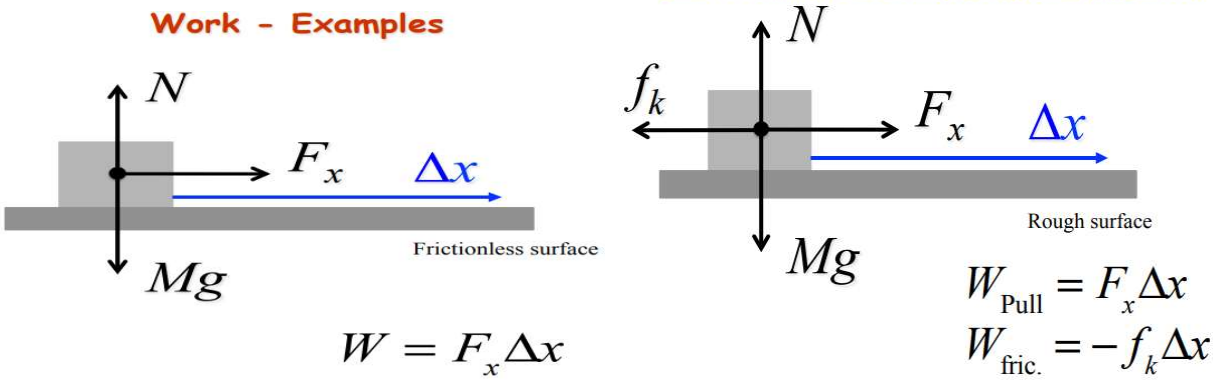
Work

- There are only two relevant variables in one dimension: the force, Fx, and the displacement, Δx. **Work done = force × displacement** (W= f * d)

Definition: $W = F_x \Delta x$ [Units: N.m or Joule (J)]

Fx is the component of the force in the direction of the object's motion, and Δx is its displacement.



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WORK

- If under a constant force F the object displaced through a distance d, then work done by the force

W = F*d = Fdcos θ, where θ is the smaller angle between F and d

A joule is the work done when a force of one newton moves a body through a distance of one meter in the direction of the force.

$$1\,\text{joule} = 1\,\text{J} = 1\,\frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}$$

Other units of work include:
1 kilo joule= 1000 joules = 10^3 J
1megajoule =1000000 joules = 10^6 J

1 joule = 10^7 erg

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Note

- Work done by a force is zero, if

(a) body is not displaced actually, i.e., s = 0

(b) body is displaced perpendicular to the direction of force, i.e. θ = 90°

- Work done by a force is positive if angle between F and d is acute angle.
- Work done by a force is negative if angle between F and s is obtuse angle.

If several different (constant) forces act on a mass while it moves though a displacement d, then we can talk about the net work done by the forces,

$$\begin{aligned} W_{\text{net}} &= \mathbf{F}_1 \cdot \mathbf{d} + \mathbf{F}_1 \cdot \mathbf{d} + \mathbf{F}_1 \cdot \mathbf{d} + \ldots \\ &= \left(\sum \mathbf{F}\right) \cdot \mathbf{d} \\ &= \mathbf{F}_{\text{net}} \cdot \mathbf{d} \end{aligned}$$

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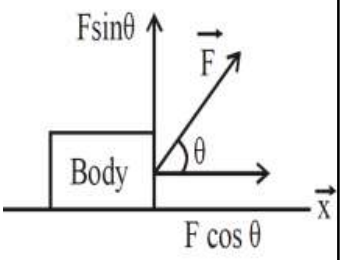
Work Done By a Constant Force

Work done (W) by a force in displacing a body through a displacement x is given by
W =F.x= Fx cos θ

Where θ is the angle between the applied force and body

$$w = \int dw = \int_{s_2}^{s_1} F\cos\theta|ds| = F\cos\theta\int_{s_2}^{s_1} ds = F\cos\theta(s_2 - s_1)$$



When θ = 0° then W = Fx

- When θ is between 0 and π/2 then
  W = Fx cos θ = **positive**
- When θ = π/2 then W = Fx cos 90° = 0 **(zero)**
- Work done by centripetal force is zero as in this case angle θ = 90°
  ∴ When θ is between π/2 and π then
  W = Fx cos θ = **negative**

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Examples of work done

• **Positive work**: when force and displacement are in the same direction, the work performed on an object is said to be positive work. **Example**: When a body moves on the horizontal surface, force and displacement act in the forward path. The work is done in this case known as Positive work.

• **Negative work**: Negative work is performed if the displacement is opposite to the direction of the Force applied. **Example**: Work was done the gravity on a rocket going perpendicular upwards.

• **Zero work**: When force and displacement are perpendicular to each other, or when force or displacement is zero. **Example**: When we hold an object and walk, the force acts in a downward direction whereas displacement acts in the forward direction.

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Examples1

A constant force of 10N acts on a body and moves it through 200cm. find the work done.

Examples2

Calculate the work done when a force of 30N moves through a distance of 9cm.

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Note:

If an object is raised vertically to a height, h or falls freely from a height, h, then the force causing work to be done is its weight.

In such cases, we get the force from the formular below.

Force = Weight = mass × acceleration due to gravity,

Force = Weight = m × g

Force = m g

Thus, the work done against gravity is given by;

Work done = Weight × height

Work done = mgh

The value of acceleration due to gravity, g = 10 N/kg

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Examples3

A body of mass 5 kg is lifted through a distance of 6m. Calculate the work done.

Examples4

Sandra climbs a hill 300m high. If her weight is 50kg.

Examples5

Mr. Okello of mass 80 kg runs up a staircase of 10 stairs, each of vertical height 25cm. Find the work done against gravity.