Work

Work, in the context of physics, is defined as the product of the force applied to an object and the distance over which that force is applied in the direction of the force. Mathematically, it can be expressed as:

$$W = \vec{F} \cdot \vec{d}$$

$$W = Fd\cos\theta$$

Work (W)=Force (F)×Distance (d)×cos(θ)

Where:

- W (Work): The work done, typically measured in joules (J).
- F (Force): The force applied to the object, measured in newtons (N).
- d (Distance): The distance over which the force is applied, measured in meters (m).
- θ (Theta): The angle between the direction of the force and the direction of motion (if they are not in the same direction). This angle is measured in radians.

- Direction Matters: Work is only done if the force and displacement are in the same direction.
- Calculating Work with Angles: If the force and displacement are not in the same direction, use the dot product of the force and displacement vectors: $W = F \cdot d$

Work Done Against Gravity:

- Key Idea: Work is done when an object is lifted against gravity.
- Formula: Work (W) = Weight (mg) x Height (h)
- **Units:**
  Weight: Newtons (N)
  Height: Meters (m)
  Work: Joules (J)

- **Where:**
  m = mass of the object
  g = acceleration due to gravity (approximately 9.8 m/s^2 on Earth)
  h = vertical distance the object is lifted

- In Simple Words: The work done in lifting an object is equal to its weight multiplied by the height it is lifted.

Dimensions of Work

In the International System of Units (SI), work has dimensions represented as:

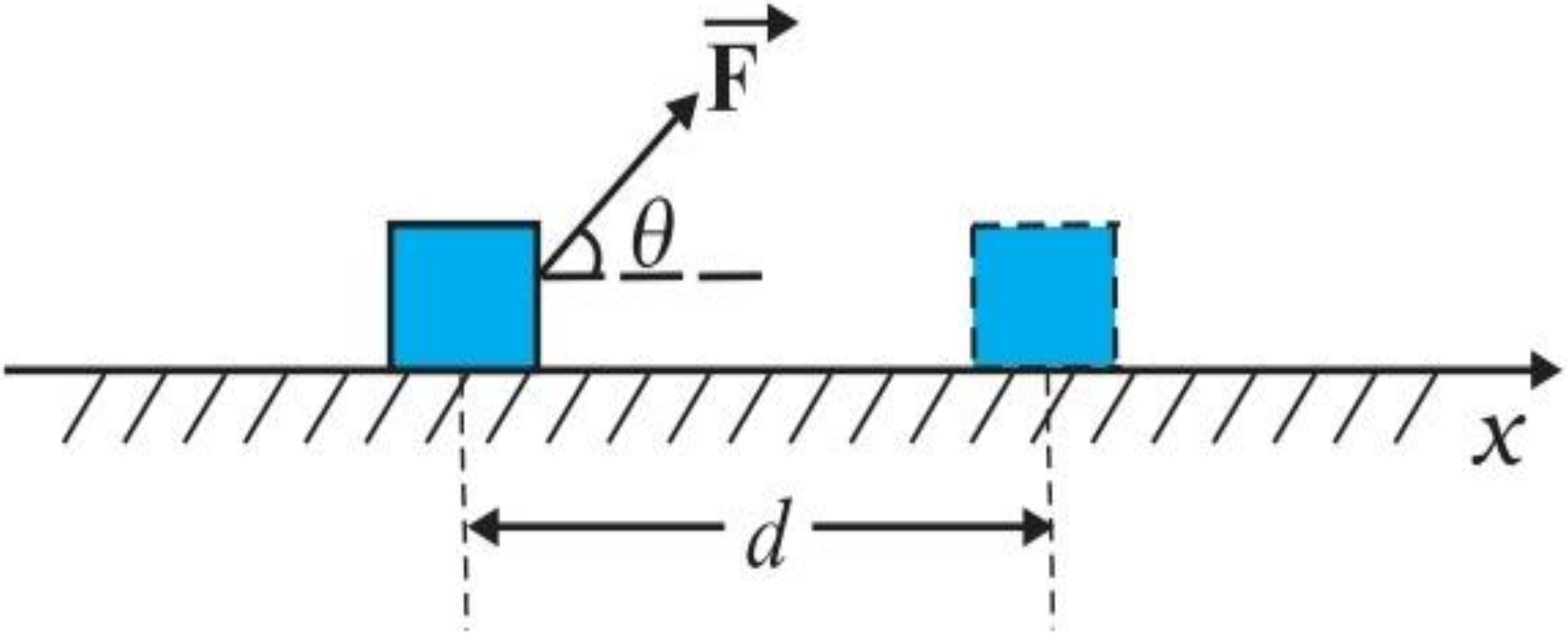
$[W]$=Force (N)×Distance (m)

So, the dimensions of work are force multiplied by distance.

Unit of Work: The standard unit of work in the SI system is the joule (J). One joule is defined as the work done when a force of one newton is applied over a distance of one meter in the direction of the force:

1 joule (J)=1 newton (N)×1 meter (m)

$$1\,\mathrm{J} = 1\,\mathrm{N}\cdot m = 1\,kg\cdot\frac{m^2}{s^2}$$



$\vec{F}$
θ
x
d

One kilowatt hour is equal to

(a) 36×10^3 joule

(b) 36×10^5 joule

(c) 10^3 joule

(d) 10^5 joule

Work Done by a Constant Force

Work done (W) by a constant force (F) is a measure of the energy transferred to or from an object when the object is moved through a distance (d) in the direction of the force. Mathematically, it can be calculated using the following formula:

$$W = F \cdot d \cdot \cos(\theta)$$

Where:

- W is the work done (measured in joules, J).
- F is the magnitude of the constant force (measured in newtons, N).
- d is the distance over which the force is applied (measured in meters, m).
- θ is the angle between the direction of the force and the direction of motion (if they are not in the same direction).

Key points to remember

1. Work is a scalar quantity and can be positive (when the force and displacement are in the same direction), negative (when they are in opposite directions), or zero (when the force and displacement are perpendicular).
2. When the force and displacement are in the same direction, work is positive because energy is being added to the system (e.g., lifting an object against gravity).
3. When the force and displacement are in opposite directions, work is negative because energy is being taken away from the system (e.g., lowering an object with gravity).
4. When the force and displacement are perpendicular, no net work is done (e.g., moving an object horizontally).

Positive Work

Positive work is done when a force applied to an object results in the object moving in the same direction as the force.
In other words, the force and displacement are in the same direction.
When work is positive, it means that energy is being transferred to the object, and the object gains energy.

Example of Positive Work

- Lifting an object against gravity: When you lift an object vertically, the force applied (upward) and the displacement (upward) are in the same direction. As a result, the work done is positive, and you are adding energy to the object.

Negative Work

Negative work occurs when a force applied to an object results in the object moving in the opposite direction of the force. In this case, the force and displacement are in opposite directions. When work is negative, it means that energy is being taken away from the object, and the object loses energy.

Example of Negative Work

- Lowering an object with gravity: When you lower an object vertically, the force of gravity is acting downward, but the displacement is upward. Since the force and displacement are in opposite directions, the work done is negative, indicating that the object loses gravitational potential energy.

Zero Work

Zero work occurs when the force applied to an object does not result in any net change in the object's energy. This happens when the force and displacement are perpendicular to each other. When work is zero, the force may still act on the object, but it does not contribute to a change in energy.

Example of Zero Work:

- Pushing an object horizontally: If you apply a horizontal force to an object, but the object moves vertically or remains stationary, the work done is zero. This is because the force and displacement are perpendicular, and no energy is transferred.

- Energy: Ability of a body to do work.
- Types:
- Potential Energy (PE): Energy due to position or configuration.
- Gravitational PE: Energy due to height above the ground.
- Elastic PE: Energy stored in a stretched or compressed object.
- Kinetic Energy (KE): Energy due to motion. Formula: KE = $(1/2)mv^2$ (where m = mass, v = velocity)

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

$$a = \frac{v_2^{\,2} - v_1^{\,2}}{2d}$$

- Work-Energy Theorem: The work done on an object is equal to the change in its kinetic energy.
- Formula: $W = \Delta KE$

$$\therefore W = m\left(\frac{v_2^{\,2} - v_1^{\,2}}{2d}\right)d$$

$$\therefore W = \frac{1}{2}m(v_2^{\,2} - v_1^{\,2})$$

$$\therefore W = \frac{1}{2}mv_2^{\,2} - \frac{1}{2}mv_1^{\,2}$$

$$W = \frac{1}{2}kx_2^{\,2} - \frac{1}{2}kx_1^{\,2}$$

- Power: The rate at which work is done.
- Formula: Power (P) = Work (W) / Time (t)
- Units: Watt (W) (1 W = 1 J/s)
- Alternative Formula: P = Force (F) x Velocity (v)

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

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

$$\therefore P = \frac{(Fd)}{t}$$

$$\therefore P = F\left(\frac{d}{t}\right)$$

$$\therefore P = Fv$$

. Which one of the following is NOT the unit of energy ?

(a) Joule

(b) Watt-hr

(c) Newton-metre

(d) kg-metre/sec^2