بسم الله الرحمن الرحيم

King Saud University
College of Science
Physics & Astronomy Dept.

Phys 145 (General Physics)

Chapter 4: Work, Energy and Power (Part 1)

Week n° 5

This presentation has been prepared by: Pr. Nabil BEN NESSIB

Chapter 4: Work, Energy and Power

- **We will learn in this chapter 4:**
- Work and Energy
- Kinetic energy
- Potential energy
- Dissipative Forces
- Power

Chapter 4: Work, Energy and Power (First part)

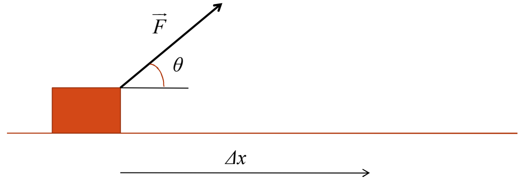
- **We will learn in this first part of chapter 4:**
- Work and Energy
- Kinetic energy
- Potential energy

Work of a force

- The work done by a force is defined as the product of the force component and the displacement.

Work = Force x Displacement

- In the S.I., work is in Joule (J), 1J = 1N x1m.



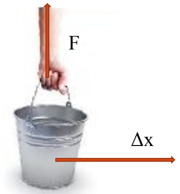
$$W(\vec{F}) = \vec{F}.\vec{\Delta x} = F\Delta x\cos(\theta)$$

if $\vec{F}$ and $\vec{\Delta x}$ are in the same direction: $W(\vec{F}) = F\Delta x$

Work of a force

Example 5.1

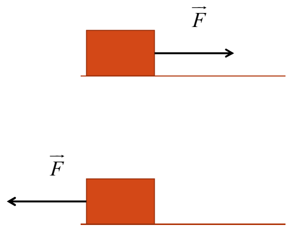
When a man carries a bucket of water (دلو من الماء) horizontally at constant velocity, the force does no work on the bucket:
Displacement is horizontal and Force is vertical.
cos 90° = 0 so W = 0



Work of a force

Example 5.2

Work can be positive or negative:



$\theta = 0,\ W > 0$

$\theta = 180°,\ W < 0$

Work done against gravity

Work (joules) → W = mgh

Mass (kg)

Height object raised (m)

Gravity (m/s²)

Work done by multiple forces

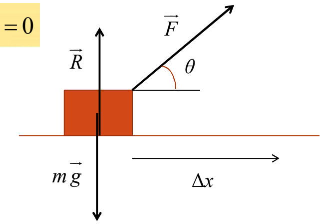
Example 5.3

$$W(m\vec{g}) = m\vec{g}.\vec{\Delta x} = mg\Delta x\cos(90°) = 0$$

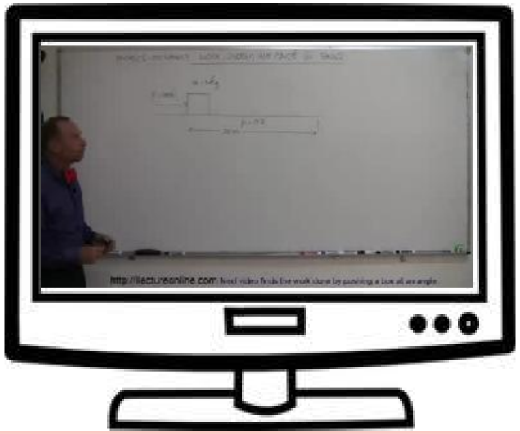
$$W(\vec{R}) = \vec{R}.\vec{\Delta x} = R\Delta x\cos(90°) = 0$$

$$W(\vec{F}) = \vec{F}.\vec{\Delta x} = F\Delta x\cos(\theta)$$

$$W_{net} = W(m\vec{g}) + W(\vec{R}) + W(\vec{F}) = F\Delta x\cos(\theta)$$



Video 01 of Week 05: Work and energy



Kinetic energy

- The total work done on an object by all the forces acting upon it is equal to the variation of its kinetic energy.

$$W_{net} = \Delta(KE) = KE_f - KE_i$$

- We have:

$$2a\Delta x = v_f^2 - v_i^2 \text{ so } a\Delta x = \frac{v_f^2}{2} - \frac{v_i^2}{2} \text{ and } W_{net} = F_{net}\Delta x = ma\Delta x = \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$$

- The kinetic energy of an object having a mass m and a velocity v is:

$$KE = \frac{mv^2}{2}$$

Kinetic energy

- Remember that: $KE = \dfrac{mv^2}{2}$
- So:
- The KE is always positive.
- If the mass is doubled the KE is also doubled, but if the velocity is doubled the KE is quadrupled (KE is proportional to the square of the velocity).

Kinetic energy

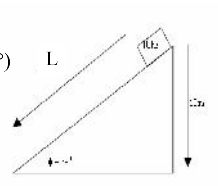
Example 5.4

If the surface is smooth what is the speed of the block at the bottom of the incline?

We have:

$$W_{net} = W(R) + W(mg) = 0 + W(mg) = mgL\sin(38°)$$

$$= KE_f - KE_i = \frac{1}{2}mv^2 - 0$$



So:

$$v = \sqrt{2gL\sin(38°)} = \sqrt{2gh} = \sqrt{2\times 9.8\times 10} = 14\text{m/s}$$

Potential energy

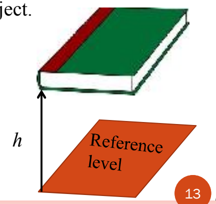
An object can store energy as the result of its position.

Energy is the ability to do work, so one of the energy form is the potential energy. This stored energy of position is referred to as potential energy. Potential energy is the stored energy of position possessed by an object.

Gravitational potential energy is the energy stored in an object as the result of its vertical position or height. The energy is stored as the result of the gravitational attraction of the Earth for the object.

$$PE_{grav} = mgh$$

where h is the height of the object.



Reference level for potential energy

- The reference level is a location where the gravitational potential energy is zero. It must be chosen for each problem.
- The choice is arbitrary since the change in the potential energy is the important quantity.
- Once the position is chosen, it must remain fixed for the entire problem.

Total mechanical energy (*TME*)

The total amount of mechanical energy is merely the sum of the potential energy and the kinetic energy. This sum is simply referred to as the **total mechanical energy** (abbreviated *TME*).

$$TME = KE + PE = \frac{1}{2}mv^2 + mgh$$

Law of conservation of energy

The total amount of mechanical energy is merely the sum of the potential energy and the kinetic energy.

$$TME_i = TME_f$$

Or:

$$KE_i + PE_i = KE_f + PE_f$$

No new energy is created and no existing energy is destroyed.

This is the principle of conservation of energy.

Law of conservation of energy

Example 5.5

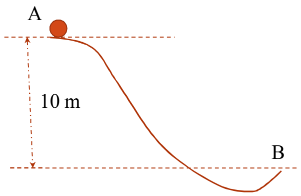
If the surface is smooth what is the velocity at B if the initial velocity at A is zero?

We will treat the problem with the law of conservation of energy:

$$TME_A = TME_B$$

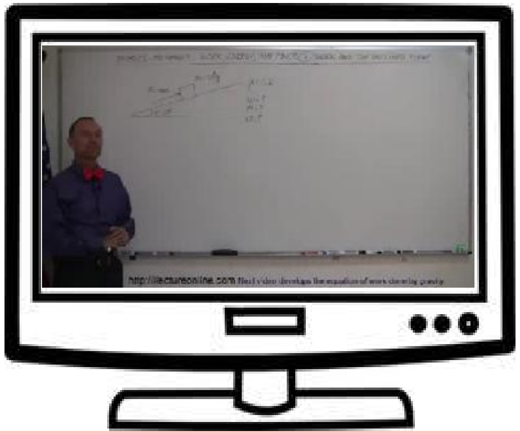
$$mgh_A + 0 = mgh_B + \frac{1}{2}mv^2$$

$$v = \sqrt{2g\left(h_A - h_B\right)} = 14 \text{ m/s}$$



17

Video 02 of Week 05: Work and energy



18

Conservative force

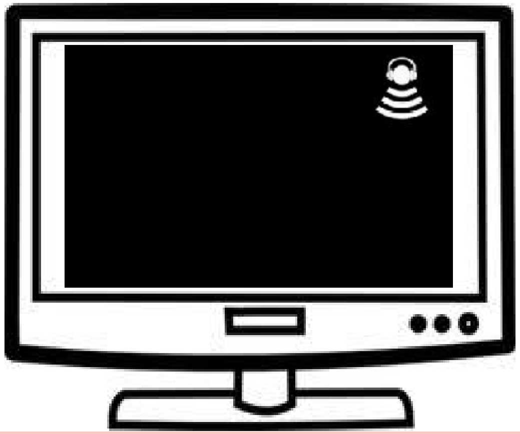
Any force that has the property that the **work it does is the same for all paths between any two given points** is said to be **conservative force**.

Gravitational, electrical and spring forces are examples of conservative forces.

Friction and many other forces are not conservative.

19

Video 03 of Week 05: Kinetic and potential energies



20

Summary of week 05

- **Work of a force is:**

$$W(\vec{F}) = \vec{F}.\vec{\Delta x} = F\Delta x\cos(\theta)$$

- **Kinetic and potential energies are respectively:**

$$KE = \frac{mv^2}{2} \qquad PE_{grav} = mgh$$

- A **force is conservative** when its **work** between two points is **independent of the path** between the two points.
- Gravitational force is conservative but friction is not.

Quiz for week 05