Chapter 7

Energy and Energy Transfer

CHAPTER OUTLINE

Chapter 8

Potential Energy

CHAPTER OUTLINE

بسم الله الرحمن الرحيم

Chapter (7) - Chapter (8)

Ch (7) : Work
and kinetic energy
the scalar product of two vectors,
work done by a constant force,
and the work-kinetic energy theorem

Ch (8): Potential energy and
conservation of energy
and the work-Potential energy theorem
conservative and non conservative forces,
conservation of mechanical energy,
work done by non-conservative forces.
Power

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Work done by a constant force:

The **work** done by a constant force $\vec{F}$ acting on a particle is defined as

the product of the component of the force in the direction of the particle's displacement and the magnitude of the displacement

If $\vec{F}$ makes an angle θ with the displacement $\vec{s}$, the work (W) done by $\vec{F}$ is

$$W \equiv \vec{F} \,.\, \vec{s} = F\, s \cos\theta$$

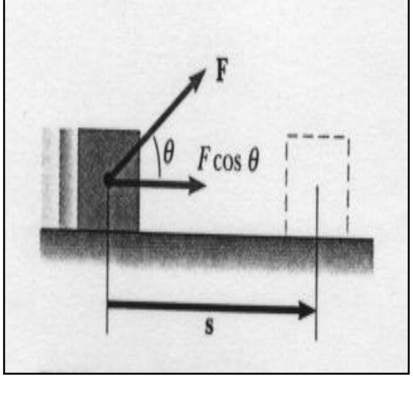


Figure 1. *If a force acting on an object undergoes a displacement* $\vec{s}$, *the work done by the force* $\vec{F}$ *is* $(F\cos\theta)s$

The different work done by a different forces

n: is perpendicular force on displacement s, ($\theta = 90$)

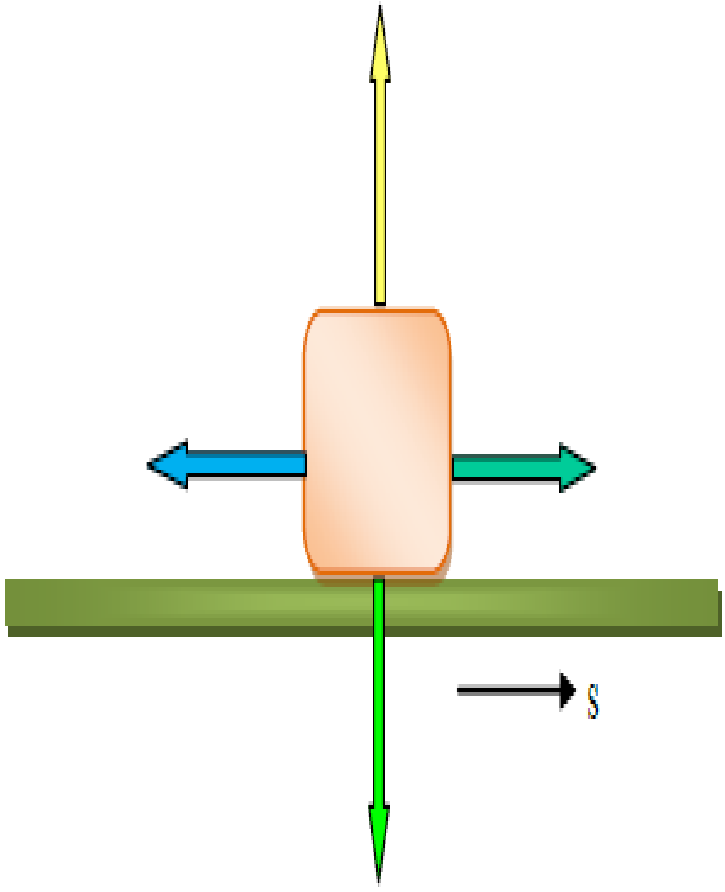
$w_n = Fs\cos90 = ns\cos90 = mgs\cos90 = 0$

F_s: is horizontal force In the oppisit direction of displacement s

($\theta = 180$)

$W_{F_s} = F_s s\cos180$

$W_F = -\mu_s n s$



F: is horizontal force In the same direction of displacement s

($\theta = 0$)

$W_F = Fs\cos0$

$W_F = Fs$

F_g: is perpendicular force on displacement s, ($\theta = 270$)

$W_{F_g} = F_g s\cos270 = mgs\cos270 = 0$

$W = Fr\cos\theta$

θ is the angle between F and s

if $\theta = 0^o$

means

F in the same direction of s

$W = Fs\cos 0$

$W = Fs$

if $\theta = 180^o$

F in the oppisite direction of s ,e.g : friction force

$W = Fr\cos 180$

$W = -Fs$

if $\theta = 90^o$ or 270^o

means

F is perpendicular on s

e.g: normal force

$W = Fs\cos 90$

$W = 0$

e.g: gravitational force

$W = Fs\cos 270$

$W = 0$

if θ = other angle the signe of the work depends on the direction of F relative to s

$W = Fs\cos\theta$

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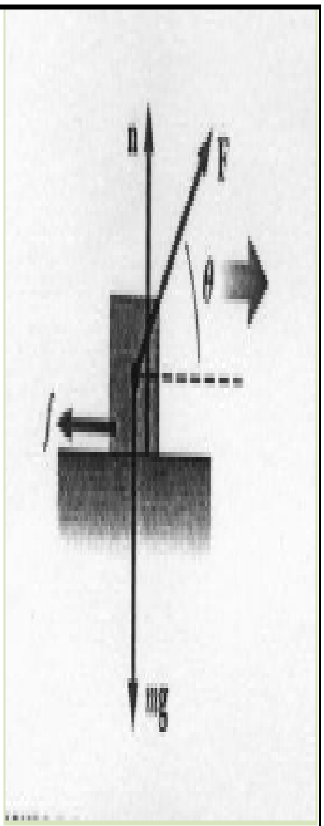
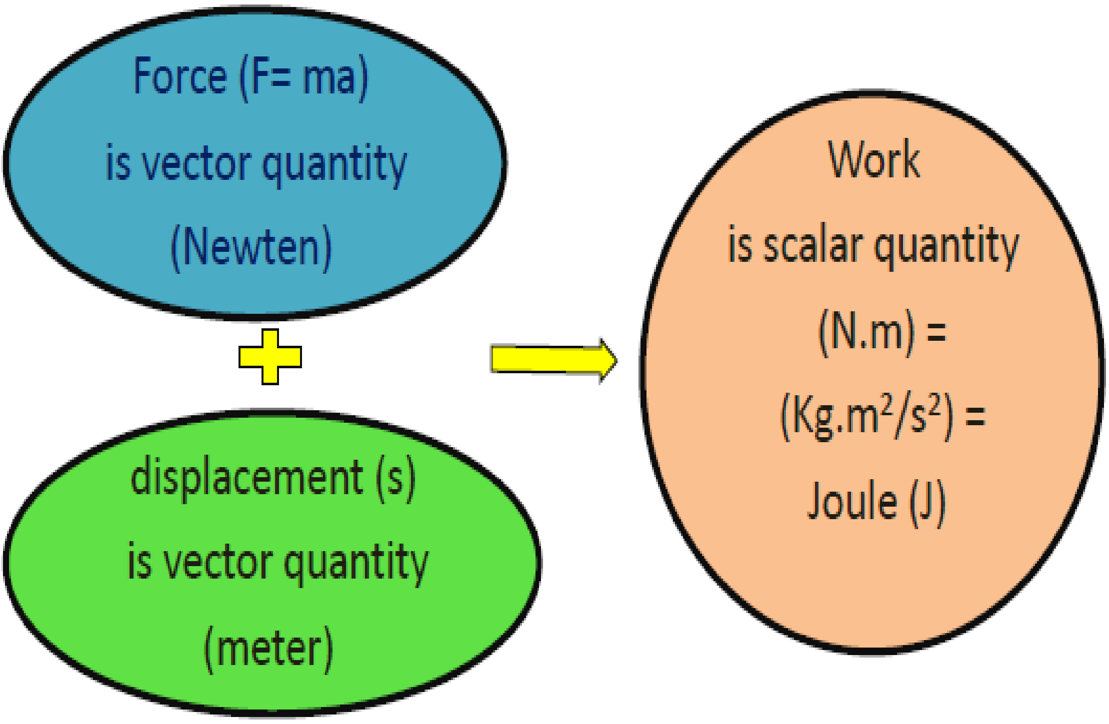
that the work done by the force is zero when the force is perpendicular to the displacement. That is, if θ=90°, then W=0 and cos90°=0. For example, the work done by the normal force, $\vec{n}$, and the work done by the force of gravity $m\vec{g}$, are zero because both forces are perpendicular to the displacement and have zero components in the direction of $\vec{s}$.



We see also that a force does not work on a particle if the particle does not move s=0



In general, a particle may be moving with a constant or varying velocity under the influence of several forces. In that case, since work is a scalar quantity, the total work done as the particle undergoes some displacement is the algebraic sum of the amounts of work done by each of the forces.

$$W = \left(\sum_i \vec{F}_i \right) . \vec{s}$$

Example (1.7)

A man cleaning a floor pulls a vacuum cleaner of 10 kg with a force of magnitude F = 50.0 N at an angle of 30.0° with the horizontal Calculate the work done by the
1-force on the vacuum cleaner
2-normal force
3-gravitational force
4-friction force if μ_k =1
5- total work
as the vacuum cleaner is displaced 3.00 m to the right.

Example (7.3)

A particle moving in the *xy* plane undergoes a displacement r = (2.0ˆi + 3.0ˆj) m as a constant force F = (5.0ˆi + 2.0ˆj) N acts on the particle.

(A) Calculate the magnitudes of the displacement and the force.

(B) Calculate the work done by F.

Kinetic energy: (K)

1- K α mass (m), kg , scalar quantity (+)

If the particle is so massive ⟶ the K= 0

2- K α speed^2 (v^2), m^2/s^2 , scalar quantity (+)

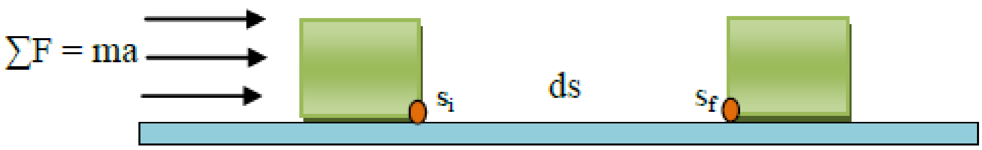
If the particle is at rest ⟶ the K= 0

Kinetic law	Kind of quantity	Unit
From 1 and 2: K α ($m\,v^2$) K = constant ($m\,v^2$) **K = 1/2 ($m\,v^2$)**	Kinetic energy is a scalar quantity	Kg . m^2/s^2 = N . m = Joule (J)

Kinetic energy is a **scalar quantity** (mass is scalar quantity and v ai a scalar quantity) and has the same units as work **Joule**. We can think of kinetic energy as energy associated with the motion of a body.

Kinetic energy and the work-energy theorem

The **kinetic energy** of a particle of mass *m* moving with a speed *v* is



$W_{net} = \int_{s_i}^{s_f} \sum F \, . \, ds$	*Where :* $\sum F = ma$
$W_{net} = \int_{s_i}^{s_f} ma \, . \, ds$	*Where:* $a = \frac{dv}{dt}$
$W_{net} = \int_{s_i}^{s_f} m \frac{dv}{dt} \, . \, ds$	*Where:* $\frac{dv}{dt} = \frac{dv}{ds} \frac{ds}{dt}$
$W_{net} = \int_{s_i}^{s_f} m \frac{dv}{ds} \frac{ds}{dt} . \, ds$	*Where:* $\frac{ds}{dt} = v$
$W_{net} = \int_{v_i}^{v_f} m \frac{ds}{dt} \, . \, dv$	
$W_{net} = \int_{v_i}^{v_f} mv \, . \, dv$	
$W_{net} = m \int_{v_i}^{v_f} v \, . \, dv$	

$$W_{net} = m\left[\frac{v^2}{2}\right]_{v_i}^{v_f}$$

$$W_{net} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W_{net} = K_f - K_i$$

$$W_{net} = \Delta K$$

The work-energy theorem

that the net work done on a

particle

by external forces

equals

the change in kinetic energy of

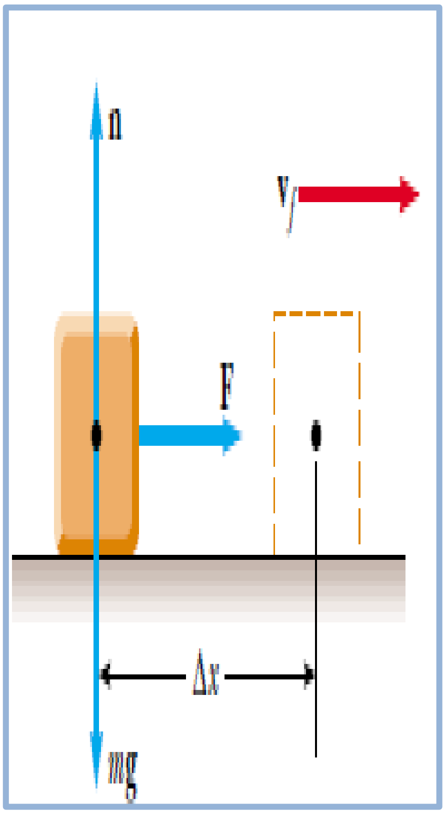
the particle

Example (7.7)

A 6.0-kg block initially at rest is pulled to the right along a horizontal, frictionless surface by a constant horizontal force of 12 N.

A) Find the speed of the block after it has moved 3.0 m.

B) Find the speed of the block after it has moved 3.0 m on a friction surface and μ_k= 0.15



Power:[P]

Power

- It is the time rate of the work
- P= W/ dt

Power unites

- **J/sec** = N.m/s
- = $kg.m^2/s^3$
- = watt (**w**)
- where kw = 10^3 w

Quantity

- work , J, scalar +
- time, s , scalar +
- so: power is scalar

In SI unit

J/s = w

1- w .s = J

2- w . h = w. (3600s) = 3600 w.s = 3600 J

But : Kw = 10^3 w

1- kw .s = (1000 w) . s = 1000 w.s = 1000 J

2- kw .h = (1000 w) . (3600s) = 3.6×10^6 w.s = 3.6×10^6 J

Average power (p_{avg})	Instantaneous power (p_{inst})
It is the time rate of work $P_{inst} = \frac{w}{dt}$	$P_{inst} = \lim_{\Delta t \to 0} (P_{avg})$ $P_{inst} = \lim_{\Delta t \to 0} \left(\frac{w}{dt}\right)$ $P_{inst} = \frac{dw}{dt} = \frac{F.ds}{dt}$

Good luck everyone, T. Merfat Al-Zumia,

Phy 101