Chapter 7

Energy and Energy Transfer

CHAPTER OUTLINE

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7.2 Work Done by a Constant Force

7.3 The Scalar Product of Two Vectors

7.4 Work Done by a Varying Force

7.5 Kinetic Energy and the Work–Kinetic Energy Theorem

7.6 The Nonisolated System—Conservation of Energy

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Chapter 8

Potential Energy

CHAPTER OUTLINE

8.1 Potential Energy of a System

8.2 The Isolated System—Conservation of Mechanical Energy

8.3 Conservative and Nonconservative Forces

8.4 Changes in Mechanical Energy for Nonconservative Forces

8.5 Relationship Between Conservative Forces and Potential Energy

8.6 Energy Diagrams and Equilibrium of a System

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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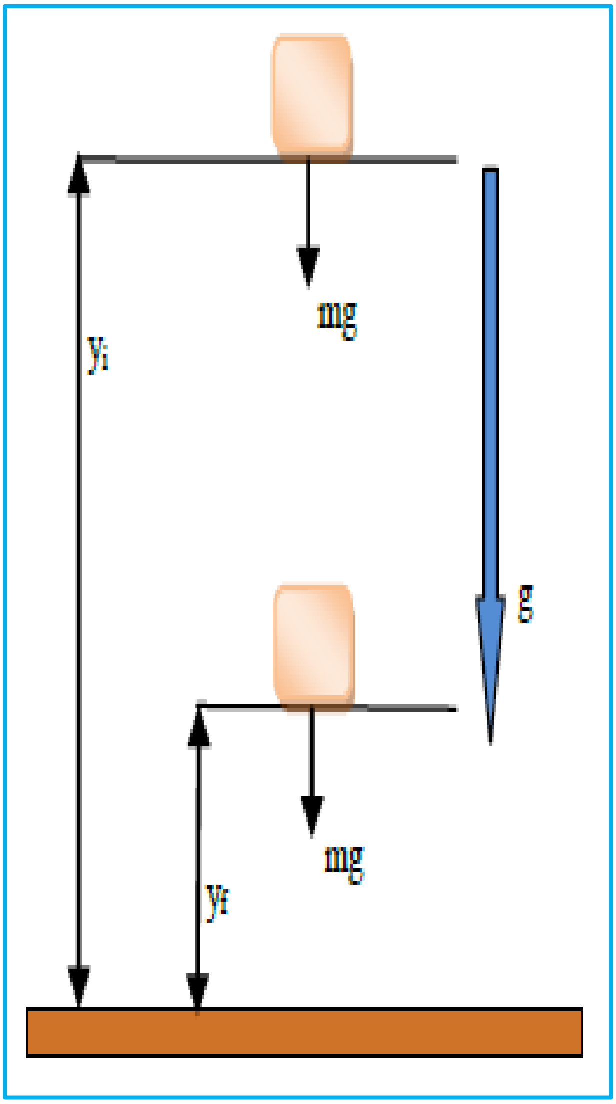
Gravitational potential energy U_g :

Definition	Quantity
The product of the magnitude of the gravitational force *mg* acting on an object and the height y of the object is named the gravitational potential energy $U_g = mgy$	$U_g = mgy$ 1. Mass : m , kg , scalar (+) 2. Acceleration :g , m/s^2 , vector (-) 3. Displacement : y , m vector (-) U_g unit is $kg\,.m^2 / s^2 = N.m = J$ U_g is a scalar quantity

The (potential energy – work energy) theorem:

***The work done by the gravitational force*.**



Let us consider a brick of mass (m) at an initial height (yi) above the ground, as shown in Figure,

then the only force that does work on the brick as it falls is the gravitational force exerted on the brick (mg) .

The work Wg done by the gravitational force as the brick undergoes a downward displacement (d) is

$$W_{net} = \sum W = W_g$$

$$W_{net} = (-\, mg\, j) \cdot (\Delta y\, j)$$

$$W_{net} = -\, mg\, (y_f - y_i)$$

$$W_{net} = -\, mg\, y_f + mg\, y_i$$

$$W_{net} = -\, (mg\, y_f - mg\, y_i)$$

We just learned that the quantity *mgy* is the gravitational potential energy, and so we have

$$W_{net} = -\, (U_{gf} - U_{gi})$$

$$W_{net} = -\, (\Delta U_g)$$

The constant force actes on an Object (system) causes a displacement. That it means there is a work done by F on an Object

1- That it means there is a kinetic energy in an Object

$(W_{net} = + \Delta K)$

2- That it means there is a potential energy in an Object

$(W_{net} = - \Delta U)$

3- The total energy E, of **any isolated system of objects** is defined as the sum of the kinetic and potential energies, is called mechanical energy

$E_{mech} = K + U$ → $\Delta E_{mech} = \Delta K + \Delta U$

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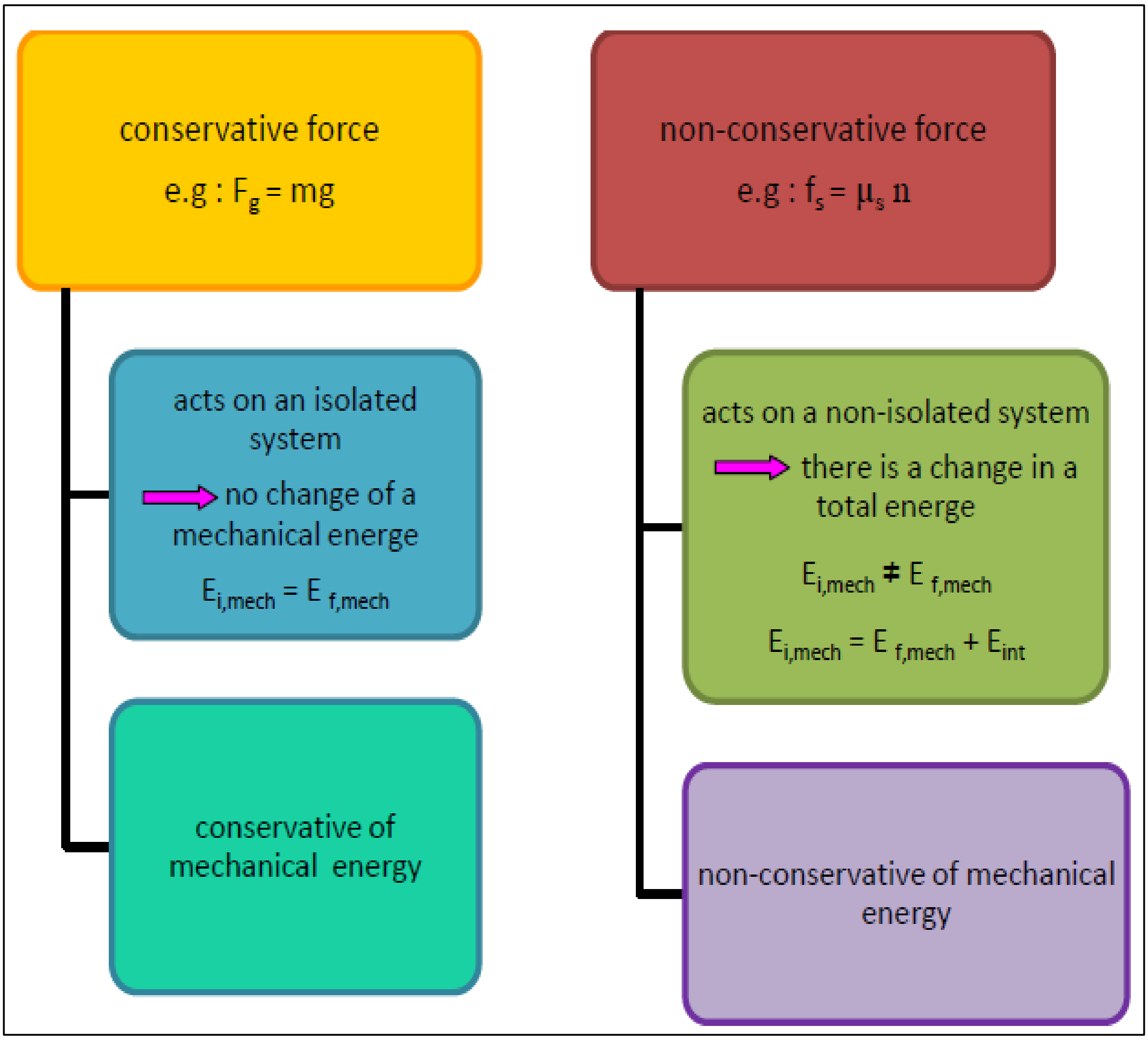
There are two types of this force acts on two types of system:



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A) Conservation of mechanical energy when a conservative force acts on an isolated system: F_g

An object held at some height *y* above the floor has no kinetic energy (*v*=0). However, as we learned earlier, the gravitational potential energy of the object-Earth system is equal to *mgy*.

1- If the object is dropped, it falls to the floor; as it falls, speed and thus its kinetic energy increase, while the potential energy of the system decreases.

2- In other words, the sum of the kinetic and potential energies – [the total mechanical energy, E_{mech}] – remains constant. This is an example of the *principle of conservation of mechanical energy*.

3- We have before two results:

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

2- $W_{net} = - \Delta U$

From 1 and 2:

$\Delta K = - \Delta U$

$K_f - K_i = - (U_f - U_i)$

$K_f - K_i = -U_f + U_i$

$K_f + U_f = U_i + K_i$ ⇒

$E_{f,mech} = E_{i,mech}$

$E_{f,mech} - E_{i,mech} = 0$

$\Delta E_{mech} = 0 =$ constant

In other way:

We can state the principle of conservation of energy as *if* $E_i = E_f$, and so we have

$E_{f,mech} = E_{i,mech}$

$K_f + U_f = U_i + K_i$

$K_f - K_i = -U_f + U_i$

$K_f - K_i = - (U_f - U_i)$

$\Delta K = - \Delta U$ ⇒

$\Delta K = - \Delta U$

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

2- $W_{net} = - \Delta U$

B) Non-Conservation of mechanical energy when a non-conservative force acts on an non-isolated system: f_s

$E_{f,mech} \neq E_{i,mech}$

$E_{f,mech} - E_{i,mech} = E_{int}$

$E_{f,mech} = E_{i,mech} + E_{int}$

$U_f + K_f = (K_i + U_i) + (- f_s . d)$

$(U_f - U_i) + (K_f - K_i) = - f_s . d$

$(U_f + K_f) - (U_i + K_i) = - f_s . d$

$E_{f,mech} - E_{i,mech} = -f_s . d$

$\Delta E_{mech} = - f_s . d$

Where: $(- f_s . d = E_{int})$

As a result there are 2-kinds of force	
conservative force e.g : $F_g = mg$	non-conservative force e.g : $f_s = \mu_s n$
acts on an isolated system	acts on a non-isolated system
Caused no change of a mechanical energy	Caused a change in a mechanical energy
$\Delta E_{mech} = 0$ $E_{f,mech} = E_{i,mech}$ $(K + U)_f = (U + K)_i$ conservative of mechanical energy	$\Delta E_{mech} = E_{int}$ $\Delta E_{mech} = - f_s . d$ $E_{f,mech} \neq E_{i,mech}$ $E_{f,mech} = E_{i,mech} + E_{int}$ $(U + K)_f = (K + U)_i - f_s . d$ non-conservative of mechanical energy

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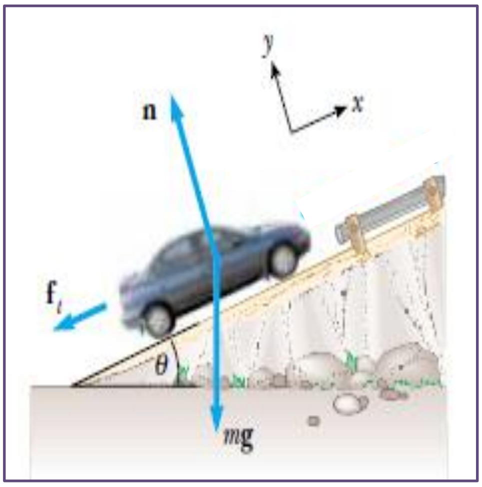
Example (7.12) :

An elevator car has a mass of 1600 kg and is carrying passengers having a combined mass of 200 kg. A constant friction force of 4000 N retards its motion upward, as shown in Figure

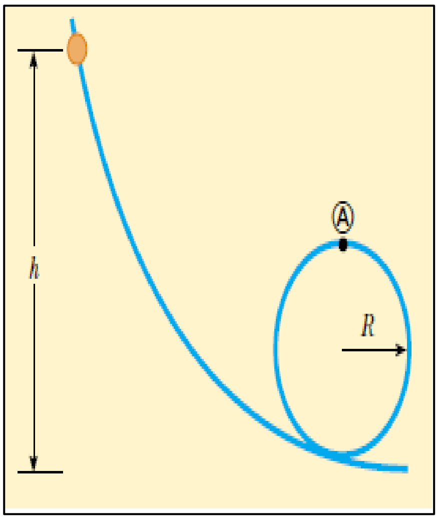
(A) What power delivered by the motor is required to lift the elevator car at a constant speed of 3.00 m/s?

(B) What power must the motor deliver at the instant the speed of the elevator is v if the motor is designed to provide the elevator car with an upward acceleration of 1.00 m/s^2?

Consider a car of mass 30 kg that is slide 5m and it is at angle θ = 20 with respect to the ground , starts from rest at the bottom of the slide. The μ_k =0.2
What is the total work done by the friction force on the car ?



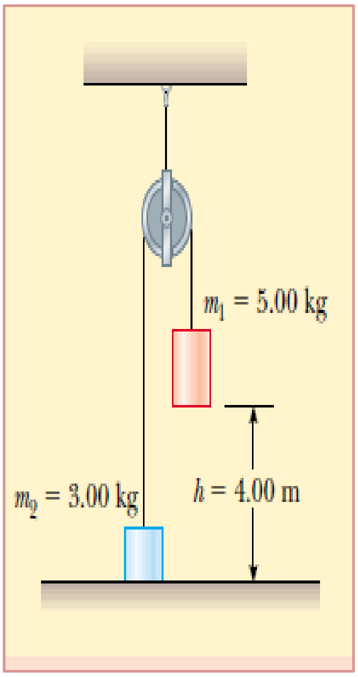
5 - A bead slides without friction around a loop-the-loop
The bead is released from a height $h = 3.50R$.
(a) What is its speed at point (A)
(b) How large is the normal force on it if its mass is 5.00 g?



13 - Two objects are connected by a light string passing over a light frictionless pulley as shown in. The object of mass 5.00 kg is released from rest. Using the principle of conservation of energy,

(a) determine the speed of the 3.00-kg object just as the 5.00-kg object hits the ground.

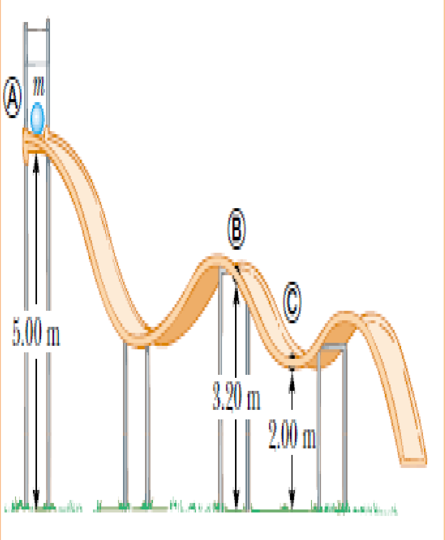
(b) Find the maximum height to which the 3.00-kg object rises.



24 - A particle of mass *m* = 5kg is released from point A and slides on the frictionless track shown in Figure. Determine

(a) the particle's speed at points B and C and

(b) the net work done by the gravitational force in moving the particle from A to C.



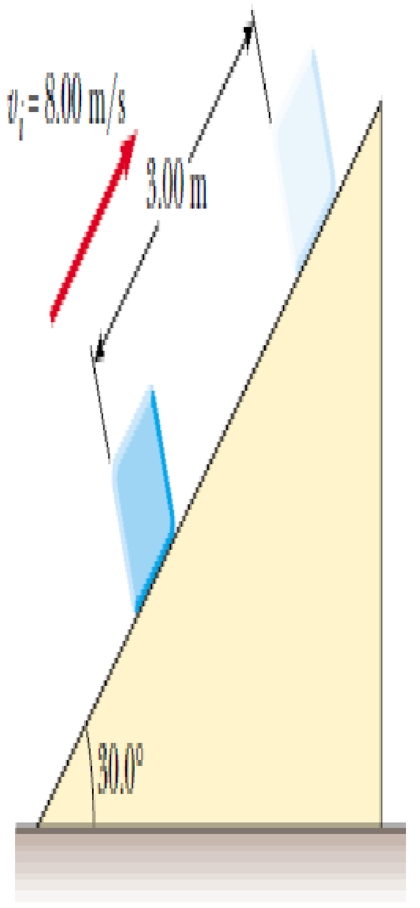
33 - A 5.00-kg block is set into motion up an inclined plane with
an initial speed of 8.00 m/s .The block comes to rest after traveling 3.00 m along the plane, which is inclined at an angle of 30.0° to the horizontal. For this motion determine

(a) the change in the block's kinetic energy,

(b) the change in the potential energy of the block–Earth system

(c) the friction force exerted on the block (assumed to be constant).

(d) What is the coefficient of kinetic friction?



Good luck everyone, T. Merfat Al-Zumia, Phy 101