

Exercise walk-through

3.4

Conservation of Energy

AP Physics C: Mechanics

Choose the system before the energy balance

Mechanical energy is $K + U$. In the course's particle model, one object has kinetic energy; include Earth or the spring for interaction potential. Real bodies can also have internal energy.

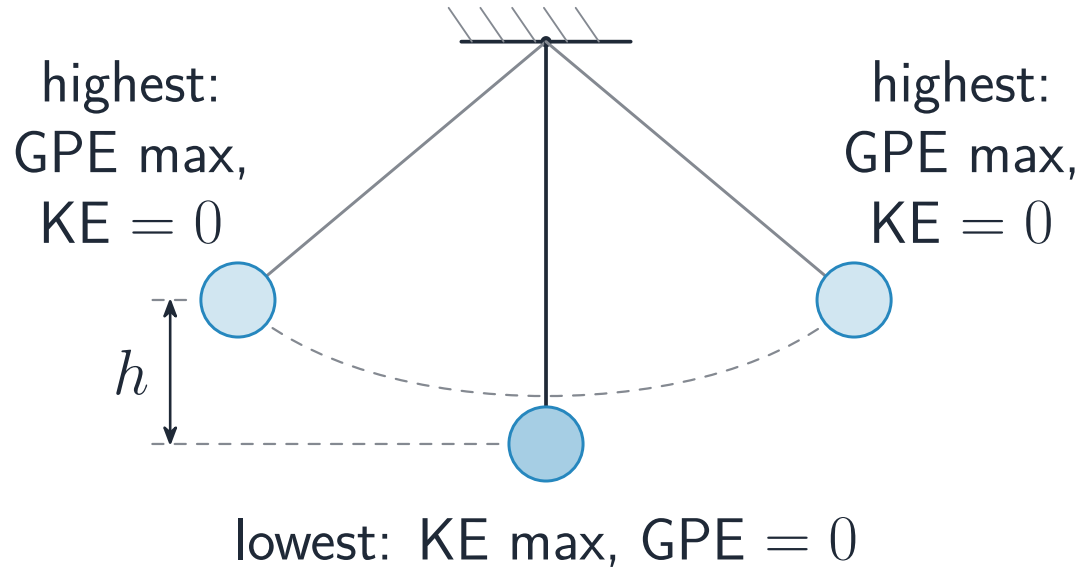
For an ideal isolated mechanical system without dissipation, $K_i + U_i = K_f + U_f$.

Nonconservative interactions can transfer or dissipate mechanical energy; they do not invariably remove it.

One fall, two consistent accounts

Chosen system	Energy account
Particle alone	Gravity is external: $W_g = \Delta K$ if it is the only force doing work.
Particle + Earth	Gravity is internal: $\Delta K + \Delta U_g = 0$ with negligible external transfer.
Avoid double counting	Do not include both gravitational work and the same gravitational potential change as separate transfers.
Boundary	External work equals system energy change only when work is the sole transfer mechanism.

Ideal pendulum energy exchange



For release from rest with negligible dissipation, extreme positions have zero speed and the lowest position has greatest kinetic energy.

Friction and thermal accounting

For a block sliding over a fixed rough track, constant kinetic friction dissipates mechanical energy:

$$\Delta E_{\text{mech}} = -f_k s$$

With block, Earth and track inside an isolated system, and only these changes relevant:

$$0 = \Delta K + \Delta U + \Delta E_{\text{thermal}}$$

Nonconservative forces can produce **thermal energy** . Variable friction needs an integral; other transfers need additional terms.

Rough ramp: original attempt

A 2.0 kg block starts from rest at height 1.5 m and reaches the bottom at 4.0 m/s. Take $g = 9.8 \text{ m/s}^2$.

Choose block, Earth and track as the system. Assume no energy transfer to the surroundings and no other changing energy store.

Calculate the thermal-energy increase. State which assumption allows that interpretation.

Exercises 2.1-2.3

2.1 State the condition under which mechanical energy is conserved. [1]

2.2 A ball is dropped from 2 m ($g = 10 \text{ m s}^{-2}$). Find its speed just before landing. [2]

2.3 At the top of a swing, a pendulum has 6 J of PE and no KE. State its KE at the bottom (no friction). [1]

Exercises 2.1-2.3

2.1 State the condition under which mechanical energy is conserved. [1]

2.1

- When no friction (or other non-conservative force) acts
-

2.2 A ball is dropped from 2 m ($g = 10 \text{ m s}^{-2}$). Find its speed just before landing. [2]

2.2

- $v = \sqrt{2gh} = \sqrt{2(10)(2)} = 6.3 \text{ m s}^{-1}$
-

2.3 At the top of a swing, a pendulum has 6 J of PE and no KE. State its KE at the bottom (no friction). [1]

2.3

- 6 J (all PE becomes KE)

Exercises 2.4·3.1

2.4 Where does mechanical energy go when friction acts?

[1]

3.1 In the absence of friction, as an object falls its

[1]

☐

A total mechanical energy increases

B total mechanical energy stays constant

C kinetic energy decreases

D potential energy increases

Exercises 2.4·3.1

2.4 Where does mechanical energy go when friction acts?

[1]

2.4

- It becomes thermal energy (heat)

3.1 In the absence of friction, as an object falls its

[1]

☐

A total mechanical energy increases

B total mechanical energy stays constant

C kinetic energy decreases

D potential energy increases

3.1 B

- with no friction, total mechanical energy is constant

Exercise 3.2

3.2 A cart at the top of a frictionless track has $PE = 40 \text{ J}$ and $KE = 0$. At the bottom its KE is [1]

☐

A 0

B 20 J

C 40 J

D 80 J

Exercise 3.2

3.2 A cart at the top of a frictionless track has $PE = 40 \text{ J}$ and $KE = 0$. At the bottom its KE is [1]

☐

A 0

B 20 J

C 40 J

D 80 J

3.2 C

- all 40 J of PE becomes KE

Exercise 3.3 (a)

3.3 A 0.5 kg ball is released from rest at height 1.8 m on a frictionless ramp ($g = 10 \text{ m s}^{-2}$).

(a) Find its speed at the bottom.

[2]

Exercise 3.3 (a)

3.3 A 0.5 kg ball is released from rest at height 1.8 m on a frictionless ramp ($g = 10 \text{ m s}^{-2}$).

(a) Find its speed at the bottom. [2]

(a)

- $v = \sqrt{2gh} = \sqrt{2(10)(1.8)} = 6 \text{ m s}^{-1}$

Exercise 3.3 (b)

3.3 A 0.5 kg ball is released from rest at height 1.8 m on a frictionless ramp ($g = 10 \text{ m s}^{-2}$).

(b) State the assumption you made. [1]

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3.3 A 0.5 kg ball is released from rest at height 1.8 m on a frictionless ramp ($g = 10 \text{ m s}^{-2}$).

(b) State the assumption you made. [1]

(b)

- No friction / energy is conserved

Exercise 3.4 (a)

3.4 A 1 kg block slides down a ramp, starting with 20 J of PE, and reaches the bottom with 14 J of KE.

(a) State how much energy was lost to friction.

[1]

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3.4 A 1 kg block slides down a ramp, starting with 20 J of PE, and reaches the bottom with 14 J of KE.

(a) State how much energy was lost to friction.

[1]

(a)

- $20 - 14 = 6 \text{ J}$

Exercise 3.4 (b)

3.4 A 1 kg block slides down a ramp, starting with 20 J of PE, and reaches the bottom with 14 J of KE.

(b) Explain where that energy went.

[1]

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3.4 A 1 kg block slides down a ramp, starting with 20 J of PE, and reaches the bottom with 14 J of KE.

(b) Explain where that energy went.

[1]

(b)

- It was converted to thermal energy by friction