

Exercise walk-through

7.4

Energy of Simple Harmonic Oscillators

AP Physics C: Mechanics

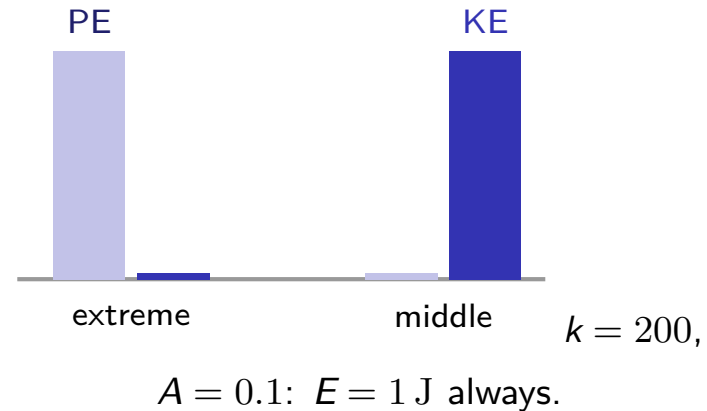
Energy of an oscillator

Energy sloshes between two forms, but the total is constant:

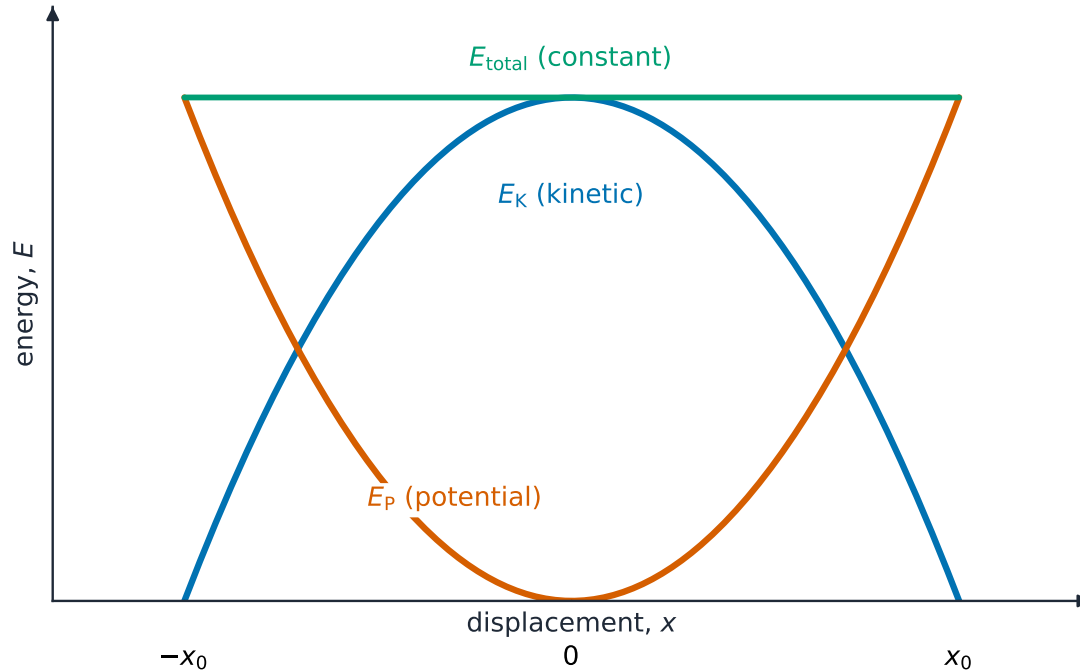
Set by the amplitude

$$E = \frac{1}{2}kA^2 = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$

All **potential** at the extremes; all **kinetic** in the middle
– solve for the speed at any x .



Energy of Simple Harmonic Oscillators



Kinetic and potential energy swap over a cycle while the total energy stays constant

Worked example – where is the energy split evenly?

At what displacement is the potential energy exactly half the total?

- $\frac{1}{2}kx^2 = \frac{1}{2}E = \frac{1}{4}kA^2$
- $x^2 = \frac{1}{2}A^2$
- $x = A/\sqrt{2} \approx 0.71A$

Much closer to the **end** than to the middle – because U grows as x^2 , so the outer part of the swing holds most of the potential energy.

Exercises 2.1-2.3

2.1 A spring with $k = 100 \text{ N m}^{-1}$ oscillates with amplitude 0.2 m . Find the total energy. [2]

2.2 At which point is the energy entirely kinetic? [1]

2.3 If the amplitude doubles, by what factor does the total energy change? [1]

Exercises 2.1·2.3

2.1 A spring with $k = 100 \text{ N m}^{-1}$ oscillates with amplitude 0.2 m . Find the total energy. [2]

2.1

- $E = \frac{1}{2}kA^2 = \frac{1}{2}(100)(0.2)^2 = 2 \text{ J}$

2.2 At which point is the energy entirely kinetic? [1]

2.2

- At the equilibrium position

2.3 If the amplitude doubles, by what factor does the total energy change? [1]

2.3

- Four times

Exercises 2.4·3.1

2.4 A spring with $k = 100 \text{ N m}^{-1}$ is displaced 0.1 m. Find the stored potential energy.[2]

3.1 The total energy of a simple harmonic oscillator is [1]

☐

A $\frac{1}{2}kA^2$

B $\frac{1}{2}kA$

C kA^2

D $\frac{1}{2}mA^2$

Exercises 2.4·3.1

2.4 A spring with $k = 100 \text{ N m}^{-1}$ is displaced 0.1 m. Find the stored potential energy.[2]

2.4

- $U = \frac{1}{2}kx^2 = \frac{1}{2}(100)(0.1)^2 = 0.5 \text{ J}$

3.1 The total energy of a simple harmonic oscillator is [1]

☐

A $\frac{1}{2}kA^2$

B $\frac{1}{2}kA$

C kA^2

D $\frac{1}{2}mA^2$

3.1 A

- $E = \frac{1}{2}kA^2$

Exercise 3.2

3.2 Doubling the amplitude changes the total energy by a factor of

[1]

☐

A 2

B 4

C $1/2$

D 1

Exercise 3.2

3.2 Doubling the amplitude changes the total energy by a factor of

[1]

☐

A 2

B 4

C 1/2

D 1

3.2 B

- $E \propto A^2$, so $2^2 = 4$

Exercise 3.3 (a)

3.3 A spring with $k = 400 \text{ N m}^{-1}$ oscillates with amplitude 0.1 m .

(a) Find the total energy.

[2]

Exercise 3.3 (a)

3.3 A spring with $k = 400 \text{ N m}^{-1}$ oscillates with amplitude 0.1 m .

(a) Find the total energy.

[2]

(a)

- $E = \frac{1}{2}(400)(0.1)^2 = 2 \text{ J}$

Exercise 3.3 (b)

3.3 A spring with $k = 400 \text{ N m}^{-1}$ oscillates with amplitude 0.1 m.

(b) State the kinetic energy at the equilibrium position.

[1]

Exercise 3.3 (b)

3.3 A spring with $k = 400 \text{ N m}^{-1}$ oscillates with amplitude 0.1 m .

(b) State the kinetic energy at the equilibrium position.

[1]

(b)

- 2 J (all kinetic there)

Exercise 3.4 (a)

3.4 A mass oscillates on a spring.

(a) State where the potential energy is greatest.

[1]

Exercise 3.4 (a)

3.4 A mass oscillates on a spring.

(a) State where the potential energy is greatest.

[1]

(a)

- At the extremes (maximum x)

Exercise 3.4 (b)

3.4 A mass oscillates on a spring.

(b) State whether the kinetic and potential energies can both be maximum at the same instant. [1]

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(b) State whether the kinetic and potential energies can both be maximum at the same instant. [1]

(b)

- No – each is greatest where the other is zero