

Exercise walk-through

3.1

Translational Kinetic Energy

AP Physics C: Mechanics

Kinetic energy and reference frame

$$K = \frac{1}{2}mv^2$$

Kinetic energy is a **scalar**, measured in **joules**. It depends on speed squared, not the sign of velocity.

A passenger at rest in a train moving at 10 m/s has zero translational kinetic energy in the train's **reference frame**, but nonzero energy in the platform frame. Use one frame consistently.

Speed and direction: original attempt

A 2.0 kg particle moves at $+3.0$ m/s, then at $+6.0$ m/s. Calculate its kinetic energy at each speed.

What would change if its velocity were -3.0 m/s instead?

Explain why a force can change direction without changing kinetic energy.

Kinetic energy: worked comparison

$$K = \frac{1}{2}mv^2$$

$$K_1 = \frac{1}{2}(2.0 \text{ kg})(3.0 \text{ m/s})^2 = 9.0 \text{ J}$$

$$K_2 = \frac{1}{2}(2.0 \text{ kg})(6.0 \text{ m/s})^2 = 36 \text{ J}$$

Doubling speed quadruples energy. At -3.0 m/s the squared speed still gives 9.0 J . A perpendicular force can change direction while doing zero work.

Exercises 2.1-2.3

2.1 A 2 kg ball moves at 5 m s^{-1} . Find its kinetic energy. [2]

2.2 If a car's speed doubles, by what factor does its kinetic energy change? [1]

2.3 A 6 kg object has $K = 12 \text{ J}$. Find its speed. [2]

Exercises 2.1·2.3

2.1 A 2 kg ball moves at 5 m s^{-1} . Find its kinetic energy. [2]

2.1

- $K = \frac{1}{2}(2)(5)^2 = 25 \text{ J}$

2.2 If a car's speed doubles, by what factor does its kinetic energy change? [1]

2.2

- Four times (speed is squared)

2.3 A 6 kg object has $K = 12 \text{ J}$. Find its speed. [2]

2.3

- $v = \sqrt{2K/m} = \sqrt{2(12)/6} = \sqrt{4} = 2 \text{ m s}^{-1}$

Exercises 2.4·3.1

2.4 Can kinetic energy be negative? Answer yes or no, with a reason. [1]

3.1 Kinetic energy is given by [1]

☐

A mv

B $\frac{1}{2}mv^2$

C mgh

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

Exercises 2.4·3.1

2.4 Can kinetic energy be negative? Answer yes or no, with a reason. [1]

2.4

- No – mass and v^2 are never negative, so $K \geq 0$

3.1 Kinetic energy is given by [1]

☐

A mv

B $\frac{1}{2}mv^2$

C mgh

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

3.1 B

- $K = \frac{1}{2}mv^2$

Exercise 3.2

3.2 Tripling an object's speed multiplies its kinetic energy by

[1]

☐

A 3

B 6

C 9

D $1/3$

Exercise 3.2

3.2 Tripling an object's speed multiplies its kinetic energy by

[1]

☐

A 3

B 6

C 9

D $1/3$

3.2 C

- $K \propto v^2$, so $3^2 = 9$

Exercise 3.3 (a)

3.3 A 1500 kg car travels at 20 m s^{-1} .

(a) Find its kinetic energy.

[2]

Exercise 3.3 (a)

3.3 A 1500 kg car travels at 20 m s^{-1} .

(a) Find its kinetic energy.

[2]

(a)

- $K = \frac{1}{2}(1500)(20)^2 = 3.0 \times 10^5 \text{ J}$

Exercise 3.3 (b)

3.3 A 1500 kg car travels at 20 m s^{-1} .

(b) State its kinetic energy if the speed rises to 40 m s^{-1} .

[1]

Exercise 3.3 (b)

3.3 A 1500 kg car travels at 20 m s^{-1} .

(b) State its kinetic energy if the speed rises to 40 m s^{-1} .

[1]

(b)

- Four times larger, $1.2 \times 10^6 \text{ J}$

Exercise 3.4 (a)

3.4 A 0.2 kg ball has 10 J of kinetic energy.

(a) Find its speed.

[2]

Exercise 3.4 (a)

3.4 A 0.2 kg ball has 10 J of kinetic energy.

(a) Find its speed.

[2]

(a)

- $v = \sqrt{2(10)/0.2} = \sqrt{100} = 10 \text{ m s}^{-1}$

Exercise 3.4 (b)

3.4 A 0.2 kg ball has 10 J of kinetic energy.

(b) State whether the direction of motion changes the kinetic energy.

[1]

Exercise 3.4 (b)

3.4 A 0.2 kg ball has 10 J of kinetic energy.

(b) State whether the direction of motion changes the kinetic energy.

[1]

(b)

- No – K is a scalar, independent of direction