

Exercise walk-through

3.2

Work

AP Physics C: Mechanics

Work: component and displacement

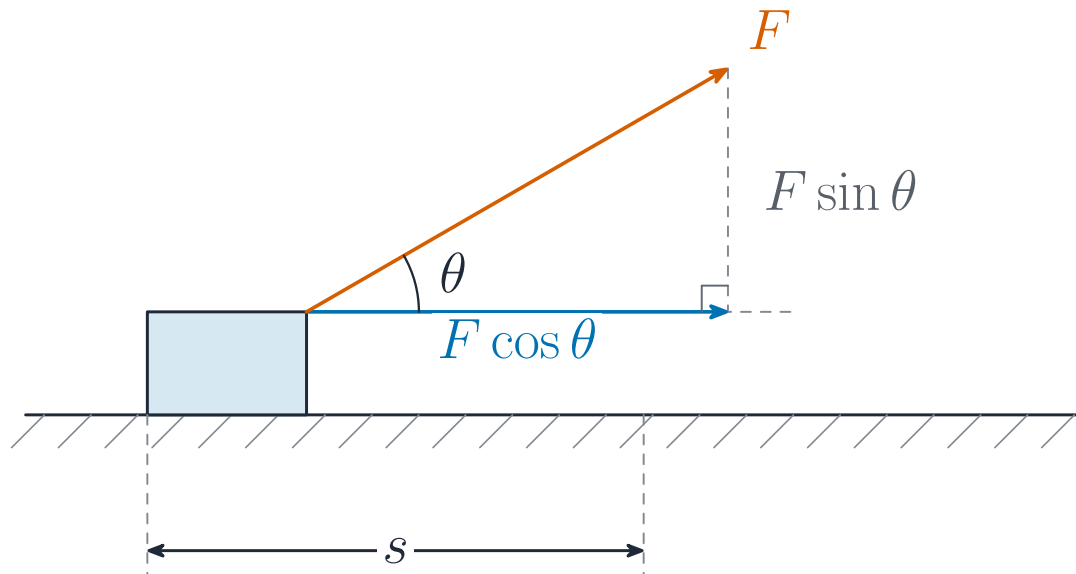
$$W = \int_a^b \vec{F} \cdot d\vec{r}$$

$$W = Fd \cos \theta \quad \text{for a constant force}$$

Work transfers energy by a force through displacement of its point of application. The angle is between force and displacement.

The **integral** follows the actual path. In one dimension, signed area under $F_x(x)$ gives work; area below the axis contributes negatively.

Resolve the force along the displacement



For the pictured horizontal displacement, the parallel component contributes work; the perpendicular component does not.

Work signs: classify the geometry

Force and motion	Work and condition
Along displacement	Positive work by that force; other forces may still give negative net work.
Opposes displacement	Negative work by that force.
Perpendicular	Zero work; a normal force has this result only when the relevant displacement is perpendicular.
Friction	Negative on a block sliding over a fixed rough surface, but can be positive on an object accelerated by a moving belt.
friction	and normal force do not have fixed work signs by name.

Positive pull, falling speed: original attempt

A particle moves 2.0 m rightward. A constant 10 N pull acts rightward, while a constant 12 N resistance acts leftward.

Calculate work by each force and the net work. Does the positive pulling work establish that the particle speeds up?

Assume enough initial kinetic energy to cover the displacement.

Signed work: worked check

$$W = Fd \cos \theta$$

$$W_{\text{pull}} = (10 \text{ N})(2.0 \text{ m}) \cos 0 = 20 \text{ J}$$

$$W_{\text{res}} = (12 \text{ N})(2.0 \text{ m}) \cos 180^\circ = -24 \text{ J}$$

$$W_{\text{net}} = W_{\text{pull}} + W_{\text{res}} = 20 \text{ J} - 24 \text{ J} = -4 \text{ J}$$

The **work–energy theorem** gives $\Delta K = W_{\text{net}}$. The particle loses kinetic energy despite positive work by the pull.

Exercises 2.1-2.3

2.1 A 20 N force pushes a crate 4 m in its own direction. Find the work done. [2]

2.2 State the work done by a force acting perpendicular to the motion. [1]

2.3 A 50 N force acts at 60° to a 2 m displacement. Find the work done. [2]

Exercises 2.1-2.3

2.1 A 20 N force pushes a crate 4 m in its own direction. Find the work done. [2]

2.1

- $W = Fd \cos 0 = 20 \times 4 = 80 \text{ J}$
-

2.2 State the work done by a force acting perpendicular to the motion. [1]

2.2

- Zero
-

2.3 A 50 N force acts at 60° to a 2 m displacement. Find the work done. [2]

2.3

- $W = 50 \times 2 \times \cos 60^\circ = 50 \text{ J}$

Exercises 2.4-3.1

2.4 State what the net work done on an object equals. [1]

3.1 The work done by a force perpendicular to the displacement is [1]

☐

A maximum

B zero

C negative

D equal to Fd

Exercises 2.4-3.1

2.4 State what the net work done on an object equals. [1]

2.4

- The change in its kinetic energy

3.1 The work done by a force perpendicular to the displacement is [1]

☐

A maximum

B zero

C negative

D equal to Fd

3.1 B

- $\cos 90^\circ = 0$, so no work

Exercise 3.2

3.2 The work-energy theorem states that the net work equals the change in [1]

☐

A momentum

B kinetic energy

C mass

D velocity

Exercise 3.2

3.2 The work-energy theorem states that the net work equals the change in [1]

☐

A momentum

B kinetic energy

C mass

D velocity

3.2 B

- net work equals the change in kinetic energy

Exercise 3.3 (a)

3.3 A 30 N force drags a sled 5 m at 37° above the horizontal.

(a) Find the work done by the force.

[2]

Exercise 3.3 (a)

3.3 A 30 N force drags a sled 5 m at 37° above the horizontal.

(a) Find the work done by the force.

[2]

(a)

- $W = 30 \times 5 \times \cos 37^\circ = 120 \text{ J}$

Exercise 3.3 (b)

3.3 A 30 N force drags a sled 5 m at 37° above the horizontal.

(b) State why the vertical component does no work here.

[1]

Exercise 3.3 (b)

3.3 A 30 N force drags a sled 5 m at 37° above the horizontal.

(b) State why the vertical component does no work here.

[1]

(b)

- The vertical component is perpendicular to the horizontal displacement

Exercise 3.4 (a)

3.4 A 2 kg block speeds up from 3 m s^{-1} to 5 m s^{-1} .

(a) Find the change in kinetic energy.

[2]

Exercise 3.4 (a)

3.4 A 2 kg block speeds up from 3 m s^{-1} to 5 m s^{-1} .

(a) Find the change in kinetic energy.

[2]

(a)

- $\Delta K = \frac{1}{2}(2)(5^2 - 3^2) = 16 \text{ J}$

Exercise 3.4 (b)

3.4 A 2 kg block speeds up from 3 m s^{-1} to 5 m s^{-1} .

(b) State the net work done on it.

[1]

Exercise 3.4 (b)

3.4 A 2 kg block speeds up from 3 m s^{-1} to 5 m s^{-1} .

(b) State the net work done on it.

[1]

(b)

- 16 J