

Exercise walk-through

4.3

Conservation of Linear Momentum

AP Physics C: Mechanics

Conservation of momentum

With **zero net external force**, a system is **isolated** and total momentum is conserved. **Internal forces** cancel in third-law pairs.

Worked example – recoil

Astronaut 60 kg throws a 2 kg wrench at 10 m/s:

$$0 = 2(10) + 60v \Rightarrow v = -0.33 \text{ m/s}$$



Conserved separately along each axis in 2-D.

Exercises 2.1-2.3

2.1 State the condition for total momentum to be conserved.

[1]

2.2 A 4 kg cart at 2 m s^{-1} collides and sticks to a stationary 4 kg cart. Find their common speed.

[2]

2.3 A stationary object explodes into two pieces. State the total momentum afterward.[1]

Exercises 2.1-2.3

2.1 State the condition for total momentum to be conserved.

[1]

2.1

- When no net external force acts on the system

2.2 A 4 kg cart at 2 m s^{-1} collides and sticks to a stationary 4 kg cart. Find their common speed.

[2]

2.2

- $4(2) = 8 = 8v \Rightarrow v = 1 \text{ m s}^{-1}$

2.3 A stationary object explodes into two pieces. State the total momentum afterward.[1]

2.3

- Zero (equal and opposite momenta)

Exercises 2.4·3.1

2.4 Before a collision the total momentum is 30 kg m s^{-1} . State the total momentum after. [1]

3.1 Momentum is conserved in a collision provided [1]

☐

A kinetic energy is conserved

B no net external force acts

C the objects stick together

D the objects are identical

Exercises 2.4·3.1

2.4 Before a collision the total momentum is 30 kg m s^{-1} . State the total momentum after. [1]

2.4

- 30 kg m s^{-1} (conserved)

3.1 Momentum is conserved in a collision provided [1]

- ☐ **A** kinetic energy is conserved
B no net external force acts
C the objects stick together
D the objects are identical

3.1 B

- momentum is conserved when no net external force acts

Exercise 3.2

3.2 A 3 kg ball at 4 m s^{-1} strikes a stationary 1 kg ball and they stick. Their speed after is [1]

☐

A 1 m s^{-1}

B 3 m s^{-1}

C 4 m s^{-1}

D 12 m s^{-1}

Exercise 3.2

3.2 A 3 kg ball at 4 m s^{-1} strikes a stationary 1 kg ball and they stick. Their speed after is [1]

☐

A 1 m s^{-1}

B 3 m s^{-1}

C 4 m s^{-1}

D 12 m s^{-1}

3.2 B

- $3(4) = 12 = 4v \Rightarrow v = 3 \text{ m s}^{-1}$

Exercise 3.3 (a)

3.3 A 60 kg skater at rest throws a 2 kg ball at 10 m s^{-1} .

(a) State the total momentum before the throw.

[1]

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3.3 A 60 kg skater at rest throws a 2 kg ball at 10 m s^{-1} .

(a) State the total momentum before the throw.

[1]

(a)

- Zero (both at rest)

Exercise 3.3 (b)

3.3 A 60 kg skater at rest throws a 2 kg ball at 10 m s^{-1} .

(b) Find the skater's recoil speed.

[2]

Exercise 3.3 (b)

3.3 A 60 kg skater at rest throws a 2 kg ball at 10 m s^{-1} .

(b) Find the skater's recoil speed.

[2]

(b)

- $0 = 60v + 2(10) \Rightarrow v = -0.33 \text{ m s}^{-1}$, i.e. 0.33 m s^{-1} backward

Exercise 3.4 (a)

3.4 A 2 kg trolley at 5 m s^{-1} collides with a 3 kg trolley at rest; they couple together.

(a) Find the total momentum before.

[1]

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(a) Find the total momentum before.

[1]

(a)

- $2(5) = 10 \text{ kg m s}^{-1}$

Exercise 3.4 (b)

3.4 A 2 kg trolley at 5 m s^{-1} collides with a 3 kg trolley at rest; they couple together.

(b) Find the speed of the coupled trolleys.

[2]

Exercise 3.4 (b)

3.4 A 2 kg trolley at 5 m s^{-1} collides with a 3 kg trolley at rest; they couple together.

(b) Find the speed of the coupled trolleys. [2]

(b)

- $10 = 5v \Rightarrow v = 2 \text{ m s}^{-1}$