Exercise walk-through

Change in Momentum and Impulse ▪ 4.2

eXercise

You must be able to

- define **impulse** 冲量 as $\vec{J} = \vec{F}_{net}\,\Delta t$
- state the **impulse-momentum theorem** 冲量-动量定理, $\vec{J} = \Delta\vec{p}$
- find the impulse from the **area** under a force-versus-time graph
- explain how a longer **contact time** 接触时间 reduces the average force

Method — Impulse changes momentum

$\vec{J} = \vec{F}_{net}\,\Delta t = \Delta\vec{p}$, measured in N s (the same as kg m s^{-1}).

Method — Longer time means smaller force

For a fixed change in momentum, a **longer** contact time gives a **smaller** average force. This is why airbags, crumple zones, and bending your knees on landing reduce injury.

Method — Example

A 0.50 kg ball changes velocity from $+4.0$ to -2.0 m s^{-1}:
$\Delta p = 0.50(-2.0 - 4.0) = -3.0$ N s.

Practice 2.1 ▪ 1 mark

A 2.0 kg object's velocity increases by $+3.0$ m s^{-1}. Find the impulse on it.

Solution 2.1

Worked steps

$J = \Delta p = m\,\Delta v = 2.0 \times 3.0 = 6.0$ N s (B1).

Practice 2.2 ▪ 1 mark

A 6.0 N force acts for 0.50 s. Find the impulse.

Solution 2.2

Method: Impulse changes momentum

Worked steps

$J = F\Delta t = 6.0 \times 0.50 = 3.0$ N s B1.

Practice 2.3 ▪ 2 marks

Explain why a longer stopping time reduces the force on a passenger in a car crash.

Solution 2.3

Method: Longer time means smaller force

Worked steps

A longer time for the same momentum change means a smaller average force, since $F = \Delta p / \Delta t$ B1; a smaller force means less injury B1.

Practice 2.4 ▪ 2 marks

A 0.10 kg ball hits a wall at 8.0 m s^{-1} and rebounds at 6.0 m s^{-1}. Taking "toward the wall" as positive, find the impulse on the ball.

Solution 2.4

Worked steps

$\Delta p = 0.10(-6.0) - 0.10(+8.0) = -1.4$ N s **M1** **A1**.

Exam-style 3.1 ▪ 1 mark

Impulse is equal to

A $F\Delta t$

B ma

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

D mgh

Solution 3.1

A $F\Delta t$ ✓

B ma

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

D mgh

Worked steps

A.

Exam-style 3.2 ▪ 1 mark

An airbag protects a passenger by increasing the

A momentum change

B total impulse

C contact time of the collision

D kinetic energy

Solution 3.2

A momentum change

B total impulse

C contact time of the collision ✓

D kinetic energy

Worked steps

C.

Exam-style 3.3 ▪ 2 marks

A 0.058 kg tennis ball leaves a racket at 50 m s^{-1} from rest, with a contact time of 5.0 ms.

(a) Find the impulse on the ball.

(b) Find the average force during contact.

Solution 3.3

Method: Longer time means smaller force

Worked steps

(a) $J = \Delta p = 0.058 \times 50 = 2.9$ N s M1 A1. (b) $F = \dfrac{J}{\Delta t} = \dfrac{2.9}{5.0 \times 10^{-3}} = 580$ N A1.