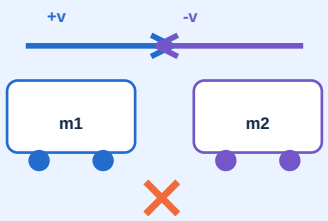
PEARSON EDEXCEL IAL PHYSICS | UNIT 1

LESSON 1.1.4

Momentum, Impulse and Conservation

Momentum tracks motion with direction. Impulse explains how forces change momentum, and conservation links objects during interactions.

MOMENTUM HAS DIRECTION



choose one positive direction

THE CORE RELATIONSHIPS

MOMENTUM

$p = mv$

IMPULSE

$J = F\Delta t$

CHANGE

$J = \Delta p$

MOMENTUM IS A VECTOR

$$p = mv = (0.20)(+15) = +3.0 \text{ kg m s}^{-1}$$

MOMENTUM VS KINETIC ENERGY

MOMENTUM

Vector quantity. Conserved for a closed system when external impulse is negligible.

KINETIC ENERGY

Scalar quantity. Conserved only in an elastic collision; otherwise transferred to other forms.

CORE HABIT

Choose a positive direction before substituting velocities. Momentum and impulse must keep their signs.

1 Impulse changes momentum

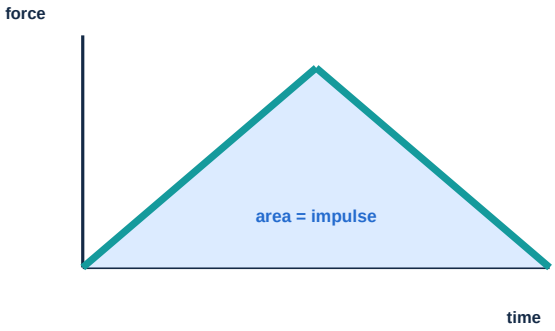
The area under a force-time graph gives impulse. For the same momentum change, increasing the interaction time reduces average force.

FROM FORCE TO MOMENTUM CHANGE

$$\Sigma F = \frac{\Delta p}{\Delta t} \qquad J = F\Delta t = \Delta p$$

$1\ \text{N s} = 1\ \text{kg m s}^{-1}$

FORCE-TIME GRAPH



TRIANGULAR PULSE

Force rises from zero to 600 N and returns to zero in 0.020 s.

$$J = \frac{1}{2}(0.020)(600) = 6.0\ \text{N s}$$

Therefore $\Delta p = 6.0\ \text{kg m s}^{-1}$

WHY SAFETY FEATURES REDUCE FORCE

Crumple zones, seat belts and airbags increase stopping time. The required momentum change is similar, but the average force is smaller because the same impulse is spread over longer.

CONSTANT-FORCE CHECK

$F = 40\ \text{N}$ for $0.50\ \text{s}$

$$J = F\Delta t = (40)(0.50) = 20\ \text{N s} = \Delta p$$

2 Conservation of momentum

Total momentum remains constant for a closed system when the resultant external impulse is zero or negligible.

$$\Sigma p_{before} = \Sigma p_{after}$$

ONE-DIMENSIONAL COLLISION



WORKED STICKING COLLISION

$p_{before} = (2)(+4) + (3)(0) = +8$ kg m s^{-1}

$p_{after} = (2 + 3)v = 5v$

$5v = 8 \rightarrow v = +1.6$ kg m s^{-1} to the right

COLLISION TYPES

ELASTIC COLLISION

Total momentum and total kinetic energy are both conserved for the closed system.

INELASTIC COLLISION

Momentum is conserved, but some kinetic energy is transferred to deformation, sound or thermal energy.

Never add speeds without direction: assign every velocity a sign before calculating momentum.