

3 Dynamics – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
force	_____	_____	_____
Weight	_____	_____	_____
resultant force	_____	_____	_____
mass	_____	_____	_____
acceleration	_____	_____	_____
friction	_____	_____	_____
linear momentum	_____	_____	_____
collision	_____	_____	_____
conservation of momentum	_____	_____	_____

Recall

At IGCSE you learned that forces change motion. Bring this with you:

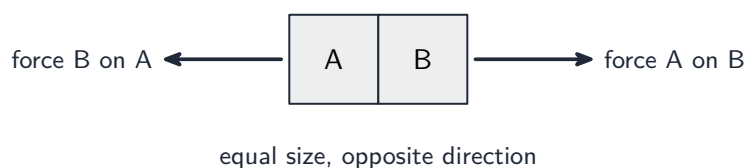
- A **force** is a push or a pull, measured in newtons (N).
- A bigger force gives a bigger push; a heavier object is harder to speed up.
- **Weight** is the downward pull of gravity: $\text{weight} = mg$.

At AS we state these ideas exactly with Newton's laws, and add momentum.

New ideas

■ 1 Newton's three laws

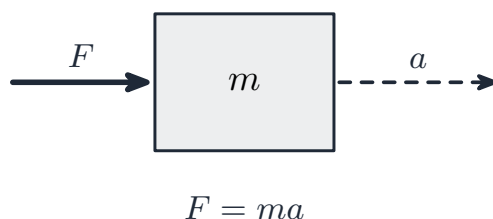
- **First law:** an object stays at rest, or keeps moving at constant velocity, unless a **resultant force** (the single force left after adding all the forces) acts on it.
- **Second law:** the resultant force equals **mass** times **acceleration** :
 $F = ma$.
- **Third law:** if A pushes B, then B pushes A back with an equal and opposite force.



■ 2 Using $F = ma$

Method: add up the forces to get the resultant, then use $a = F/m$.

Worked example. A box of mass 3.0 kg is pushed with 20 N, while **friction** pushes back with 5.0 N. Resultant force = $20 - 5.0 = 15$ N, so $a = \frac{F}{m} = \frac{15}{3.0} = 5.0 \text{ m s}^{-2}$.

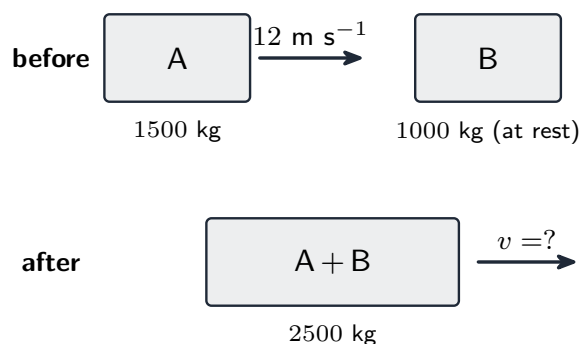


Watch out: in $F = ma$, the F is the *resultant* force (all forces added together), not just the push you apply – subtract friction first.

■ 3 Momentum

The **linear momentum** of an object is $p = mv$ (mass $\times$ velocity); it is a vector.

In any **collision** or explosion with no outside force, **conservation of momentum** holds: the total momentum **before** = **after**.



Worked example. A 2.0 kg trolley at 3.0 m s^{-1} hits a stationary 1.0 kg trolley and they stick together. Before: $p = (2.0)(3.0) + 0 = 6.0 \text{ kg m s}^{-1}$. After: combined mass 3.0 kg, so $v = \frac{6.0}{3.0} = 2.0 \text{ m s}^{-1}$.

Practice

3.1 State Newton's second law as an equation and say what each symbol means. [2]

3.2 A resultant force of 12 N acts on a 4.0 kg mass. Find the acceleration. [2]

3.3 A 1500 kg car moves at 20 m s^{-1} . Find its momentum. [2]

3.4 A 0.50 kg ball at 4.0 m s^{-1} hits a stationary 0.50 kg ball and they stick together. Find their common velocity afterwards. [3]

3.5 Find the weight of a 6.0 kg bag (take $g = 9.8 \text{ m s}^{-2}$). [1]

3.6 Challenge. A rocket in empty space has nothing to push against, yet it speeds up. Explain how, using Newton's third law (or conservation of momentum). [2]
