

Forces and Newton's laws

A Level Maths · Knowledge organiser

KEY DEFINITIONS

Resultant force

The single force with the same effect as all the forces acting.

Newton's second law

$F = ma$: resultant force = mass $\times$ acceleration.

Normal reaction

The force from a surface, at right angles to it.

Friction

Opposes motion; $F \leq \mu R$, with $F = \mu R$ when the object is moving or about to move.

KEY FORMULAS

Forces $F = ma, W = mg,$
 $F \leq \mu R$ (limiting: $F = \mu R$)

Slope at θ : weight component $mg \sin \theta$ down the slope;
 $R = mg \cos \theta$ if nothing else acts perpendicular to it

WORKED EXAMPLE

A 5 kg box is pulled along a rough horizontal floor by a horizontal force of 30 N. $\mu = 0.4$ and $g = 9.8 \text{ m s}^{-2}$. Find the acceleration.

1. $R = mg = 5 \times 9.8 = 49 \text{ N}$
2. Friction $F = \mu R = 0.4 \times 49 = 19.6 \text{ N}$
3. $30 - 19.6 = 5a$

Answer: $a = 2.08 \text{ m s}^{-2}$

YOU SHOULD BE ABLE TO...

- Draw clear force diagrams showing weight, tension, normal reaction and thrust, and find the resultant of forces acting in one or two dimensions.
- Use Newton's third law to analyse connected particles such as a car towing a trailer, finding the acceleration and the tension or thrust in the connection.
- Resolve forces into perpendicular components, find the resultant of several forces and its direction, and use the components to solve equilibrium problems.
- Solve problems with friction on inclined planes, deciding the direction of friction and whether a particle stays at rest or slides.
- Model static situations such as objects hanging from strings, stating assumptions and finding unknown tensions and angles.
- Solve problems with connected particles, including one on an inclined plane and one hanging over a pulley, with friction where it applies.

COMMON MISTAKES

- ✗ G positive when up is positive
- ✗ Weight given as m
- ✗ Normal reaction missing from the diagram
- ✗ Resultant set to zero in a dynamics question