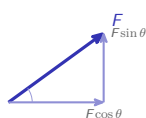


Mechanics

A-Level Mathematics • Topic 4

A-Level Mathematics



Mechanics

What we will cover

- 1 Forces & equilibrium
- 2 Kinematics
- 3 Momentum
- 4 Newton's laws
- 5 Energy work & power
- 6 Recap



1 Forces

Mechanics

└ Forces

Forces and equilibrium

Resolve every force into perpendicular components. At equilibrium the vector sum is zero:

$$\sum F_x = 0, \quad \sum F_y = 0.$$

A particle in equilibrium can be drawn as a closed vector triangle.

Mechanics

└ Forces

Friction

$F \leq \mu R$. Equality is limiting friction (on the point of slipping). μ is the coefficient of friction; R is the normal reaction.

Friction always opposes the (potential) slip. If the object is at rest and not about to move, F can be less than μR .

2 Kinematics and momentum

Mechanics

Kinematics and momentum

Kinematics

v - t graph: area = displacement,
gradient = acceleration.

$v = u + at, \quad s = ut + \frac{1}{2}at^2, \quad v^2 = u^2 + 2as$

Rest, $a = 2.5, t = 4$ s

$v = 10$ m/s, $s = 20$ m

Mechanics

Kinematics and momentum

Momentum

before

2 kg

$u = 3$

1 kg

at rest

after

2 kg

1 kg

$v = 2$

$2(3) + 1(0) = (2 + 1)v$

Conservation of momentum 动量守恒:

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2.$

2 kg at 3 hits still 1 kg, stick

$v = \frac{6}{3} = 2$ m/s

3

Newton and energy

Mechanics

Newton and energy

Newton's laws

$F = ma, \quad W = mg.$

On an **inclined plane** 斜面: resolve along and perpendicular to the slope, then apply $F = ma$.

Pull 12 kg up a 20° rough slope

$T \approx 110$ N

Mechanics

Newton and energy

Energy, work and power

$W = Fd \cos \theta, \quad KE = \frac{1}{2}mv^2, \quad PE = mgh.$

No friction $\Rightarrow$ total energy conserved. Power $P = Fv.$

12 kW engine at 20 m/s

$F = \frac{P}{v} = 600$ N

4

Recap

Topic 4 – key takeaways

1 Forces

resolve into components; $F \leq \mu R$

2 Kinematics

suvat; v - t area & gradient

3 Newton

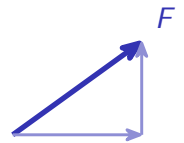
$F = ma$; resolve on a slope

4 Energy

$\frac{1}{2}mv^2$, mgh ; $P = Fv$

Check yourself

- 1 Maximum friction before slipping?
- 2 What does the area under a v - t graph give?
- 3 Driving force of a 10 kW engine at 25 m/s?
- 4 Quantity conserved in a collision?



Answers 1. μR 2. displacement 3. $P/v = 400 \text{ N}$ 4. momentum