

4.4 Newton's laws of motion

Name: _____ Class: _____ Date: _____

Total: 15 marks

KEY WORDS connected particles 连接质点 • newton's laws 牛顿运动定律 • thrust 推力 • mass 质量
• acceleration 加速度

Objective

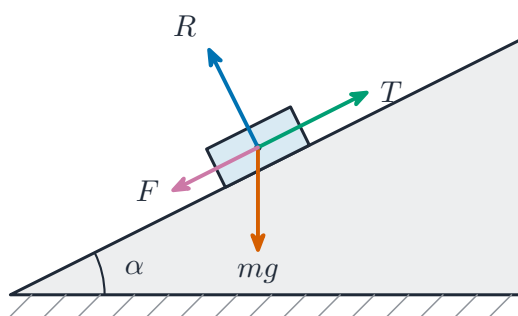
Build the skills to answer exam questions on **Newton's laws** 牛顿运动定律 — $F = ma$, weight $W = mg$, motion on an **inclined plane** 斜面, and **connected particles** 连接质点. Take $g = 10 \text{ m s}^{-2}$.

You must be able to:

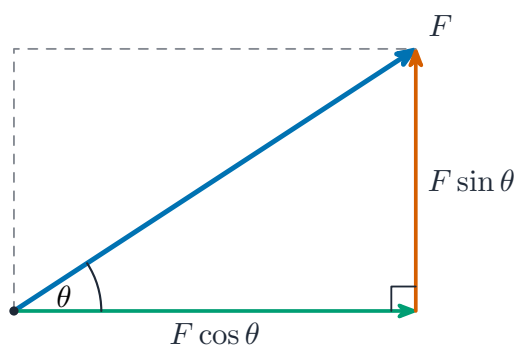
- apply $F = ma$ with weight, tension, friction and thrust
- resolve along and perpendicular to a slope
- analyse connected particles (string over a pulley)

1 Worked examples

■ Inclined plane



On a slope, resolve forces along the slope and at right angles to it, then use $F = ma$ along the slope



Resolving a force into perpendicular components

12 kg block pulled up a 20° rough slope ($\mu = 0.4$), $a = 2 \text{ m s}^{-2}$: $R = 120 \cos 20^\circ = 112.8 \text{ N}$; $F = \mu R = 45.1 \text{ N}$. Up the slope: $T - mg \sin 20^\circ - F = ma$, so $T = 24 + 41.0 + 45.1 = 110 \text{ N}$.

2 Practice

2.1 A resultant force of 18 N acts on a 3 kg mass. Find the acceleration. [2]

2.2 Find the weight of a 7 kg object ($g = 10$). [1]

3 Exam-style questions

3.1 A 5 kg mass is pulled along a smooth horizontal floor by a horizontal force of 20 N. Its acceleration is: [1]

- **A** 2 m s^{-2}
- **B** 4 m s^{-2}
- **C** 5 m s^{-2}
- **D** 25 m s^{-2}

3.2 A block of mass 4 kg is released from rest on a smooth plane inclined at 30° to the horizontal.

(a) Find the acceleration down the slope. [3]

(b) Find the speed after it has slid 5 m. [2]

3.3 Two particles of masses 3 kg and 5 kg are joined by a light inextensible string over a smooth pulley, and released from rest.

(a) Find the acceleration of the system. [4]

(b) Find the tension in the string. [2]

Solutions

2.1 $a = \frac{F}{m} = \frac{18}{3} = 6 \text{ m s}^{-2}.$

2.2 $W = mg = 7 \times 10 = 70 \text{ N}.$

3.1 B. $a = \frac{20}{5} = 4 \text{ m s}^{-2}.$

3.2 (a) along the slope: $mg \sin 30^\circ = ma \Rightarrow a = g \sin 30^\circ = 10(0.5) = 5 \text{ m s}^{-2}.$

(b) $v^2 = u^2 + 2as = 0 + 2(5)(5) = 50 \Rightarrow v = 7.07 \text{ m s}^{-1}.$

3.3 (a) for the system, $5g - 3g = (5 + 3)a$; $20 = 8a \Rightarrow a = 2.5 \text{ m s}^{-2}.$

(b) for the 3 kg mass: $T - 3g = 3a \Rightarrow T = 30 + 3(2.5) = 37.5 \text{ N}.$