4.4 Newton's laws of motion

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

KEY WORDS connected particles • newton's laws • thrust • mass • acceleration

Objective

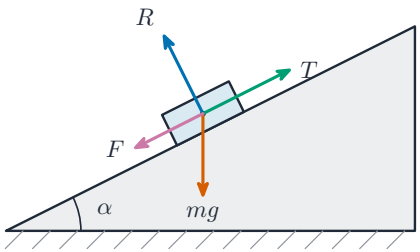
Build the skills to answer exam questions on **Newton's laws** – $F = ma$, weight $W = mg$, motion on an **inclined plane**, and **connected particles**. Take $g = 10$ m s^{-2}.

You must be able to:

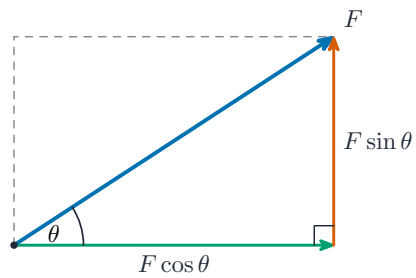
- apply $F = ma$ with weight, tension, friction and thrust
- resolve along and perpendicular to a slope
- analyse connected particles (string over a pulley)

1 Key knowledge and 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 ($\mu = 0.4$), $a = 2$ m s^{-2}: $R = 120\cos 20° = 112.8$ N; $F = \mu R = 45.1$ N. Up the slope: $T - mg\sin 20° - F = ma$, so $T = 24 + 41.0 + 45.1 = 110$ N.

Key knowledge: Two connected masses

Treat the system as a whole to find acceleration, then use one body to find the internal tension. The same tension assumption requires a light string and smooth pulley.

Worked example: Two connected masses

A 3 kg body on a smooth horizontal table is connected to a hanging 2 kg body; take $g = 10$. For the whole system, $a = 2g/(3+2) = 4\,\mathrm{m\,s^{-2}}$. For the table body, $T = 3a = 12$ N. Check the hanging body: $2g - T = 2a$, since $20 - 12 = 8$ 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]