

4.1 Forces and equilibrium

Name: _____ Class: _____ Date: _____

Total: 14 marks

Objective

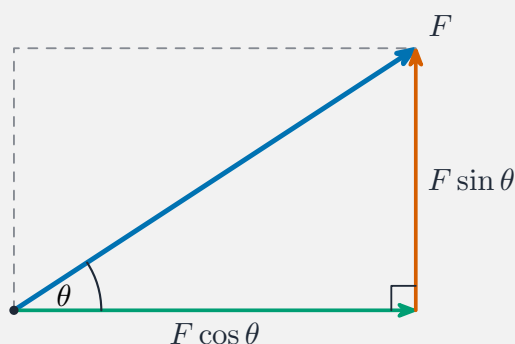
Build the skills to answer exam questions on **forces and equilibrium** 力与平衡—resolving forces into **components** 分量, the condition for **equilibrium** 平衡, and **friction** 摩擦 ($F \leq \mu R$). Take $g = 10 \text{ m s}^{-2}$.

You must be able to:

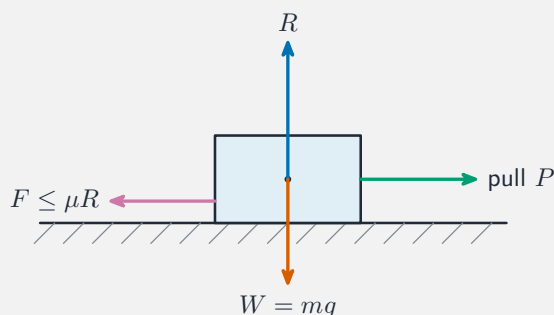
- resolve a force into horizontal and vertical components
- use "components in any direction sum to zero" for equilibrium
- use $F \leq \mu R$ and limiting friction $F = \mu R$

1 Worked examples

■ Resolving & friction



A force at angle θ has parts $F \cos \theta$ (horizontal) and $F \sin \theta$ (vertical)



The contact force splits into the normal reaction R and friction $F \leq \mu R$

A 5 kg block rests on a rough horizontal floor ($\mu = 0.3$). Max friction = $\mu R = 0.3 \times 50 = 15$ N —a horizontal pull below 15 N will not move it.

2 Practice

2.1 A force of 20 N acts at 60° above the horizontal. Find its horizontal component. [2]

2.2 A block of weight 40 N rests on a rough surface, $\mu = 0.25$. Find the maximum friction available. [2]

3 Exam-style questions

3.1 A particle is in equilibrium under three forces. The sum of the forces is: [1]

- **A** maximum
- **B** zero
- **C** equal to the weight
- **D** equal to μR

3.2 A box of mass 8 kg rests on a rough horizontal floor. A horizontal force of 30 N is applied but the box does not move.

(a) Find the normal reaction. [1]

(b) Given the box is on the point of slipping, find the coefficient of friction. [3]

3.3 A particle of weight W hangs in equilibrium from two light strings making angles 30° and 60° with the horizontal. The tensions are T_1 and T_2 . Given $W = 20$ N, find T_1 and

T_2 .

[5]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **4.1 Forces and equilibrium** past-paper sheet in the Library, or try these in **Practice mode**:

- 9709/41 N25 —Q3 (forces / equilibrium)
- 9709/42 N25 —Q7 (friction)
- 9709/41 J25 —Q2 (equilibrium)

Solutions

2.1 $20 \cos 60^\circ = 20 \times 0.5 = 10 \text{ N}.$

2.2 $F_{\max} = \mu R = 0.25 \times 40 = 10 \text{ N}.$

3.1 B. In equilibrium the resultant (vector sum) of the forces is zero.

3.2 (a) $R = mg = 8 \times 10 = 80 \text{ N}.$

(b) on the point of slipping $F = \mu R$ and $F = 30 \text{ N}$; $\mu = \frac{30}{80} = 0.375.$

3.3 resolve: horizontal $T_2 \cos 60^\circ = T_1 \cos 30^\circ$; vertical $T_1 \sin 30^\circ + T_2 \sin 60^\circ = 20$; from the first $T_2(0.5) = T_1(0.866) \Rightarrow T_2 = 1.732 T_1$; substitute: $0.5T_1 + 0.866(1.732T_1) = 20 \Rightarrow 2T_1 = 20 \Rightarrow T_1 = 10 \text{ N}, T_2 = 17.3 \text{ N}.$