

## 3.2 Equilibrium of a rigid body

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 15 marks

**KEY WORDS** centre of mass 质心 • toppling 翻倒 • equilibrium 平衡 • sliding 滑动 • moment 力矩

### Objective

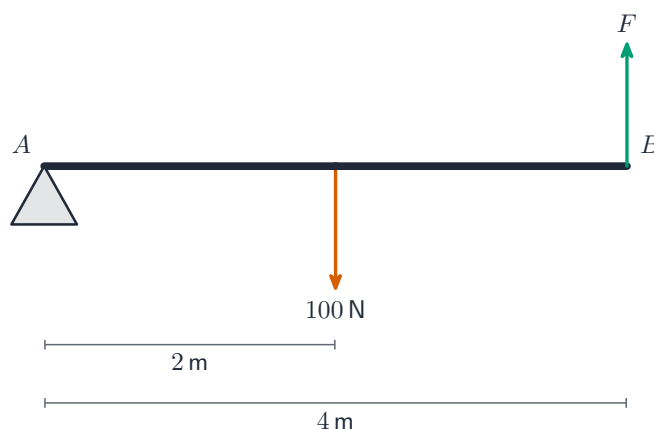
Build the skills to answer exam questions on the **equilibrium of a rigid body** 刚体平衡 — **moments** 力矩, the **centre of mass** 质心, and conditions for **toppling** 翻倒 or **sliding** 滑动. Take  $g = 10 \text{ m s}^{-2}$ .

**You must be able to:**

- take moments about a point (force  $\times$  perpendicular distance)
- apply the two equilibrium conditions (forces and moments both balance)
- decide whether a body topples or slides first

### 1 Worked examples

#### ■ Taking moments



*Taking moments about the pivot A balances the turning effects*

**Uniform beam AB, length 4 m, weight 100 N, pivot at A, force F at B:**  
 moments about A  $\rightarrow F \times 4 = 100 \times 2 \Rightarrow F = 50 \text{ N}$ .

## 2 Practice

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**2.1** A force of 20 N acts 3 m from a pivot, at right angles. Find its moment. [2]

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**2.2** State the two conditions for a rigid body to be in equilibrium. [2]

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## 3 Exam-style questions

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**3.1** The moment of a force about a point is force multiplied by: [1]

- **A** time
- **B** the perpendicular distance
- **C** mass
- **D** velocity

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**3.2** A uniform ladder  $AB$  of weight 200 N and length 6 m rests with  $A$  on rough ground and  $B$  against a smooth vertical wall, at  $60^\circ$  to the horizontal.

(a) By taking moments about  $A$ , find the reaction at the wall. [4]

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(b) Hence find the friction force at the ground. [2]

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**3.3** A uniform rod  $AB$  of length 2 m and weight 40 N rests horizontally on supports at  $A$  and at  $C$ , where  $C$  is 1.5 m from  $A$ . Find the reaction at each support. [4]

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## Solutions

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**2.1** moment =  $20 \times 3 = 60$  N m.

**2.2** the resultant force is zero; the resultant moment about any point is zero.

**3.1 B.** Moment = force  $\times$  perpendicular distance.

**3.2** (a) wall reaction  $S$  is horizontal at  $B$ ; weight 200 N acts at the midpoint (3 m along). Moments about  $A$ :  $S \times 6 \sin 60^\circ = 200 \times 3 \cos 60^\circ$ ;  $S \times 5.196 = 300 \Rightarrow S = 57.7$  N.

(b) horizontal equilibrium: friction =  $S = 57.7$  N.

**3.3** moments about  $A$ :  $R_C \times 1.5 = 40 \times 1 \Rightarrow R_C = 26.7$  N; vertical:  $R_A + R_C = 40 \Rightarrow R_A = 13.3$  N.