

# 5.5 Rotational Equilibrium and Newton's First Law in Rotational Form

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

Total: 11 marks

**KEY WORDS** net torque 净力矩 • rotational equilibrium 转动平衡 • static equilibrium 静平衡  
• torque 力矩

## Objective

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Build the skills to answer exam questions on **rotational equilibrium** and Newton's first law in rotational form.

**You must be able to:**

- state that **rotational equilibrium** 转动平衡 needs zero **net torque** 净力矩
- describe **static equilibrium** 静平衡 as zero net force **and** zero net torque
- apply the equilibrium conditions to beams, seesaws, and hanging signs
- choose a convenient **axis** to solve for unknown forces or distances

## 1 Worked examples

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Study these first. Each one shows the method for a question type used later.

### ■ Two conditions for static equilibrium

$$\sum \vec{F} = 0 \quad \text{and} \quad \sum \tau = 0.$$

### ■ Choosing the axis

Take torques about the point where an **unknown** force acts — that force then has zero lever arm and drops out, leaving one unknown.

### ■ Example

A uniform 60 N beam 3.0 m long rests on a support at each end; a 30 N weight sits 1.0 m from the left support. Torques about the right support:  $L(3.0) = 60(1.5) + 30(2.0) = 150$ , so  $L = 50$  N.

## 2 Practice

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**2.1** State the two conditions for an object to be in static equilibrium. [2]

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**2.2** A seesaw balances with a 200 N child 1.0 m left of the pivot. Find the clockwise torque needed on the right to balance it. [1]

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**2.3** A uniform 40 N plank 4.0 m long rests on a support at each end. State the force on each support, with reasoning. [2]

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## 3 Exam-style questions

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**3.1** An object in rotational equilibrium has [1]

|   |   |
|---|---|
| A | B |
| C | D |

**A** zero net force

**B** zero net torque

**C** constant speed

**D** the maximum possible torque

**3.2** To balance a seesaw, the clockwise and counterclockwise torques about the pivot must be [1]

|   |   |
|---|---|
| A | B |
| C | D |

**A** both zero

**B** equal in size

**C** as large as possible

**D** opposite in sign only

**3.3** A uniform 80 N beam 4.0 m long rests on a support at each end. A 120 N box sits 1.0 m from the left support.

(a) Taking torques about the right support, find the force on the left support. [3]

(b) Find the force on the right support. [1]