

5.3 Torque

Name: _____ Class: _____ Date: _____

Total: 15 marks**KEY WORDS** torque 力矩 • lever arm 力臂

Objective

Build the skills to answer exam questions on **torque**.**You must be able to:**

- calculate **torque** 力矩: $\tau = rF \sin \theta$
- identify the **lever arm** 力臂 (perpendicular distance from the axis to the line of the force)
- explain how the angle and distance affect the turning effect
- add torques with signs (clockwise vs anticlockwise)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The torque formula

$$\tau = rF \sin \theta,$$

where r is the distance from the axis to where the force acts and θ is the angle between $\vec{r}$ and $\vec{F}$. A 10 N force at 0.5 m, perpendicular ($\theta = 90^\circ$): $\tau = 0.5 \times 10 \times 1 = 5 \text{ N m}$.

■ The lever arm

The perpendicular distance $r \sin \theta$ is the lever arm. A force pushing straight toward or away from the axis ($\theta = 0$) has zero lever arm and produces no torque.

■ Balancing torques

Anticlockwise torques are usually taken positive, clockwise negative. Sum them to find the net turning effect.

2 Practice

Now apply the methods above.

2.1 A 20 N force acts perpendicular to a spanner 0.3 m from the bolt. Find the torque. [2]**2.2** State the torque when a force acts straight along the line toward the axis. [1]**2.3** Define the lever arm. [1]**2.4** A 50 N force acts at 30° to a 0.4 m arm. Find the torque. [2]

3 Exam-style questions

3.1 The torque of a force is greatest when the force acts [1]

- **A** along the arm toward the axis
- **B** perpendicular to the arm
- **C** at 45° to the arm
- **D** at the axis

3.2 A force of 8 N acts at 0.25 m, perpendicular to the arm. The torque is [1]

- **A** 2 N m
- **B** 32 N m
- **C** 0.03 N m
- **D** 8 N m

3.3 Two children sit on a seesaw. A 300 N child sits 1.5 m from the pivot.

(a) Find the torque this child produces. [2]

(b) State where a 450 N child must sit on the other side to balance it. [2]

3.4 A 40 N force is applied to a door 0.8 m from the hinge, at 60° to the door.

(a) Find the torque about the hinge. [2]

(b) State how to increase the torque without changing the force. [1]

Solutions

2.1 $\tau = rF = 0.3 \times 20 = 6 \text{ N m}$.

2.2 Zero (the lever arm is zero).

2.3 The perpendicular distance from the axis to the line of the force.

2.4 $\tau = rF \sin \theta = 0.4 \times 50 \times \sin 30^\circ = 10 \text{ N m}$.

3.1 B — perpendicular gives the maximum torque.

3.2 A — $\tau = 0.25 \times 8 = 2 \text{ N m}$.

3.3 (a) $\tau = 1.5 \times 300 = 450 \text{ N m}$. (b) $450 = 450 \times d \Rightarrow d = 1.0 \text{ m}$ from the pivot.

3.4 (a) $\tau = 0.8 \times 40 \times \sin 60^\circ = 27.7 \text{ N m}$. (b) Apply it perpendicular to the door (or farther from the hinge).