Exercise walk-through

Torque ▪ 5.3

eXercise

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)

Method — 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 ($\theta = 90^\circ$): $\tau = 0.5 \times 10 \times 1 = 5$ N m.

Method — 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.

Method — Balancing torques

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

Practice 2.1 ▪ 2 marks

A 20 N force acts perpendicular to a spanner 0.3 m from the bolt. Find the torque.

Solution 2.1

Method: The torque formula

Worked steps

$\tau = rF = 0.3 \times 20 = 6$ N m M1 A1.

Practice 2.2 ▪ 1 mark

State the torque when a force acts straight along the line toward the axis.

Solution 2.2

Method: The lever arm

Worked steps

Zero (the lever arm is zero) B1.

Practice 2.3 ▪ 1 mark

Define the lever arm.

Solution 2.3

Worked steps

The perpendicular distance from the axis to the line of the force B1.

Practice 2.4 ▪ 2 marks

A 50 N force acts at $30°$ to a 0.4 m arm. Find the torque.

Solution 2.4

Method: The torque formula

Worked steps

$\tau = rF\sin\theta = 0.4 \times 50 \times \sin 30^\circ = 10$ N m M1 A1.

Exam-style 3.1 ▪ 1 mark

The torque of a force is greatest when the force acts

A along the arm toward the axis

B perpendicular to the arm

C at $45°$ to the arm

D at the axis

Solution 3.1

Method: The torque formula

A along the arm toward the axis

B perpendicular to the arm ✓

C at 45° to the arm

D at the axis

Worked steps

B — perpendicular gives the maximum torque.

Exam-style 3.2 ▪ 1 mark

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

A 2 N m

B 32 N m

C 0.03 N m

D 8 N m

Solution 3.2

Method: The torque formula

A 2 N m ✓

B 32 N m

C 0.03 N m

D 8 N m

Worked steps

A — $\tau = 0.25 \times 8 = 2$ N m.

Exam-style 3.3 ▪ 2 marks

Two children sit on a seesaw. A 300 N child sits 1.5 m from the pivot.
(a) Find the torque this child produces.
(b) State where a 450 N child must sit on the other side to balance it.

Solution 3.3

Method: The torque formula

Worked steps

(a) $\tau = 1.5 \times 300 = 450$ N m M1 A1. (b) $450 = 450 \times d \Rightarrow d = 1.0$ m from the pivot M1 A1.

Exam-style 3.4 ▪ 2 marks

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

Solution 3.4

Method: The torque formula

Worked steps

(a) $\tau = 0.8 \times 40 \times \sin 60^\circ = 27.7$ N m M1 A1. (b) Apply it perpendicular to the door (or farther from the hinge) B1.