Exercise walk-through

Torque ▪ 5.3

eXercise

You must be able to

- define **torque** **力矩** as the tendency of a force to cause rotation about an axis
- calculate a torque with $\tau = rF\sin\theta$
- identify the **lever arm** **力臂** as the perpendicular distance from the axis to the line of action
- determine the **direction** of a torque (clockwise or counterclockwise)

Method — Torque formula

$\tau = rF\sin\theta = F \times$ (lever arm), measured in N m. The **lever arm** is the perpendicular distance from the axis to the force's line of action.

Method — Maximum torque

Torque is greatest when the force is **perpendicular** to r ($\theta = 90^\circ$) and zero when the force points along r.

Method — Example

A 20 N force at the end of a 0.50 m wrench, perpendicular to it:
$\tau = 20 \times 0.50 = 10$ N m.

Practice 2.1 ▪ 1 mark

A 30 N force acts perpendicular to a door, 0.80 m from the hinge. Find the torque.

Solution 2.1

Method: Torque formula

Worked steps

$\tau = 30 \times 0.80 = 24$ N m B1.

Practice 2.2 ▪ 1 mark

State the angle between the force and the lever arm that gives the maximum torque.

Solution 2.2

Worked steps

90° (perpendicular) B1.

Practice 2.3 ▪ 2 marks

A 40 N force acts at 30° to a 0.60 m arm. Find the torque.

Solution 2.3

Worked steps

$\tau = rF\sin\theta = 0.60 \times 40 \times \sin 30^\circ = 12$ N m (M1)(A1).

Practice 2.4 ▪ 2 marks

Explain why a longer wrench makes it easier to loosen a tight bolt.

Solution 2.4

Worked steps

A longer arm is a larger lever arm r B1, so the same force produces a bigger torque $\tau = rF$ B1.

Exam-style 3.1 ▪ 1 mark

Torque is greatest when the force is applied

A along the arm

B at $45°$ to the arm

C perpendicular to the arm

D at the axis

Solution 3.1

Method: Maximum torque

A along the arm

B at 45° to the arm

C perpendicular to the arm ✓

D at the axis

Worked steps

C.

Exam-style 3.2 ▪ 1 mark

A 10 N force acts at a perpendicular distance of 0.20 m from an axis. The torque is

A 0.02 N m

B 2.0 N m

C 10 N m

D 50 N m

Solution 3.2

Method: Torque formula

A 0.02 N m

B 2.0 N m ✓

C 10 N m

D 50 N m

Worked steps

B — $\tau = 10 \times 0.20 = 2.0$ N m.

Exam-style 3.3 ▪ 2 marks

A seesaw pivots at its centre. A 300 N child sits 1.5 m from the pivot.
(a) Find the torque this child produces.
(b) Find where a 450 N child must sit to balance the seesaw.

Solution 3.3

Method: Torque formula

Worked steps

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