5.3 Torque

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

KEY WORDS torque • lever arm

Objective

Build the skills to answer exam questions on **torque**.

You must be able to:

- calculate **torque** : $\tau = rF\sin\theta$
- identify the **lever arm** (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 Key knowledge and 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 ($\theta = 90°$): $\tau = 0.5 \times 10 \times 1 = 5$ 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

Each answer shows the steps, then the **result**.

2.1

- $\tau = rF = 0.3 \times 20 = 6$ 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

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

3.1 B

- perpendicular gives the maximum torque

3.2 A

- $\tau = 0.25 \times 8 = 2$ N m

3.3

(a)

- $\tau = 1.5 \times 300 = 450$ N m

(b)

- $450 = 450 \times d \Rightarrow d = 1.0$ m from the pivot

3.4

(a)

- $\tau = 0.8 \times 40 \times \sin 60^\circ = 27.7$ N m

(b)

- Apply it perpendicular to the door (or farther from the hinge)