

5.3 Torque

Name: _____ Class: _____ Date: _____

Total: 12 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:**

- 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)

1 Worked examples

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

■ Torque formula

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

■ Maximum torque

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

■ Example

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

2 Practice

2.1 A 30 N force acts perpendicular to a door, 0.80 m from the hinge. Find the torque.^[1]

2.2 State the angle between the force and the lever arm that gives the maximum torque.^[1]

2.3 A 40 N force acts at 30° to a 0.60 m arm. Find the torque. ^[2]

2.4 Explain why a longer wrench makes it easier to loosen a tight bolt. ^[2]

3 Exam-style questions

3.1 Torque is greatest when the force is applied ^[1]

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

3.2 A 10 N force acts at a perpendicular distance of 0.20 m from an axis. The torque is ^[1]

- **A** 0.02 N m
- **B** 2.0 N m
- **C** 10 N m
- **D** 50 N m

3.3 A seesaw pivots at its centre. A 300 N child sits 1.5 m from the pivot.

(a) Find the torque this child produces.

[2]

(b) Find where a 450 N child must sit to balance the seesaw.

[2]

Solutions

2.1 $\tau = 30 \times 0.80 = 24 \text{ N m}$.

2.2 90° (perpendicular).

2.3 $\tau = rF \sin \theta = 0.60 \times 40 \times \sin 30^\circ = 12 \text{ N m}$.

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

3.1 C.

3.2 B — $\tau = 10 \times 0.20 = 2.0 \text{ N m}$.

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