A-LEVEL PHYSICS • EXERCISE SHEET

4.1 Turning effects of forces

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

Objective

Build the skills to answer exam questions on the **turning effects of forces** —centre of gravity, moments, couples and torque.

You must be able to:

- use the **centre of gravity** 重心 when drawing weight
- define and calculate the **moment** 力矩 of a force
- define a **couple** and calculate its **torque** 力偶矩

1 Worked examples

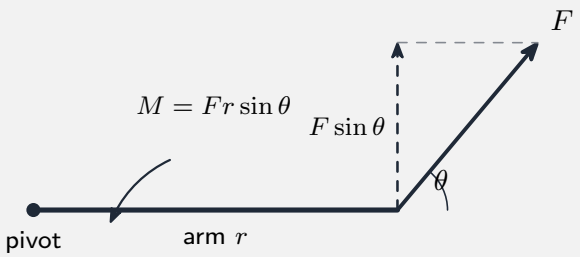
Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

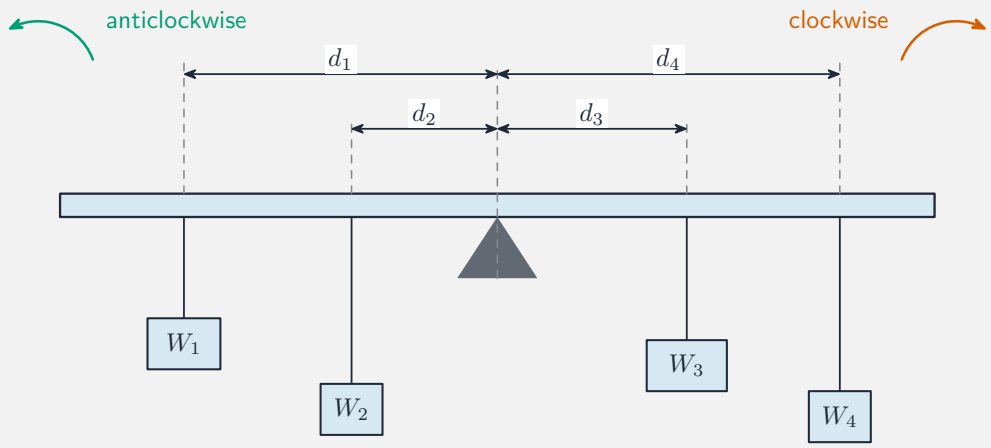
■ Centre of gravity and moment

The whole **weight** acts at the **centre of gravity** (the middle of a uniform shape). The **moment** of a force about a point is

$$M = F \times d,$$

where d is the **perpendicular distance** from the point to the force's line of action. If the force acts at angle θ to a lever arm of length r, then $M = Fr\sin\theta$ —only the part **perpendicular** to the arm turns it:





The principle of moments balances turning effects

Worked example. 50 N at the end of a 0.40 m spanner, at 30° to it:

$$M = 50 \times 0.40 \times \sin 30^\circ = 10 \text{ N m}.$$

Couple and torque

A **couple** is two forces that are **equal, opposite**, and a perpendicular distance apart—it produces **turning only** (zero resultant force). Its **torque** is

$$\tau = F \times d,$$

where d is the distance between the two lines of action. *(Two equal forces in the **same** direction are **not** a couple.)*

2 Practice

Now apply the methods above.

2.1 Define the **moment** of a force. [1]

2.2 A 20 N force acts at right angles to a lever, 0.30 m from the pivot. Find its **moment**. [2]

2.3 State the **two** conditions a pair of forces must meet to be a **couple**. [2]

2.4 State where the **weight** of a uniform rod acts. [1]

3 Exam-style questions

3.1 The **moment** of a force is measured in: [1]

- **A** N
- **B** N m
- **C** N m^{-1}
- **D** J

3.2 A force of 50 N is applied at the end of a 0.40 m spanner, at 30° to the spanner. Calculate the **moment** about the nut. [2]

3.3 Two parallel forces, each 8.0 N, act in opposite directions 0.25 m apart, forming a couple. Calculate the **torque**. [2]

3.4 Explain why two **equal** forces acting in the **same** direction do **not** form a couple. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **4.1 Turning effects of forces** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/11 N25 —Q13 (moments and couples)
- 9702/22 J25 —Q2 (moment of a force)
- 9702/24 N25 —Q2 (turning effects)

- 9702/23 J25 —Q2 (couples and torque)

Solutions

2.1 Force $\times$ the **perpendicular distance** from the pivot to the line of action of the force.

2.2 $M = Fd = 20 \times 0.30 = 6.0$ N m.

2.3 Equal in size and **opposite** in direction; their lines of action are a **perpendicular distance apart** (not the same line).

2.4 At its **centre of gravity** —the midpoint of the uniform rod.

3.1 B —N m.

3.2 $M = Fr\sin\theta = 50 \times 0.40 \times \sin 30° = 50 \times 0.40 \times 0.50 = 10$ N m.

3.3 $\tau = Fd = 8.0 \times 0.25 = 2.0$ N m.

3.4 Two equal forces in the **same** direction have a **resultant force** ($2F$, not zero), so they cause straight-line acceleration (translation), not turning only —a couple needs them **opposite**.