

# 5 Rotational motion and torque – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary

*Write each word three times.*

| English              | Write it 3 times (English) |
|----------------------|----------------------------|
| angular displacement | _____                      |
| radians              | _____                      |
| angular velocity     | _____                      |
| Torque               | _____                      |
| moment arm           | _____                      |

## Recall

You already know spinning things – wheels, gears, a spinning top:

- A wheel turns through an angle; you have measured angles in degrees.
- A point on the edge of a big wheel moves faster than one near the middle.
- You have used a **seesaw** and a spanner: pushing farther from the pivot turns things more easily.

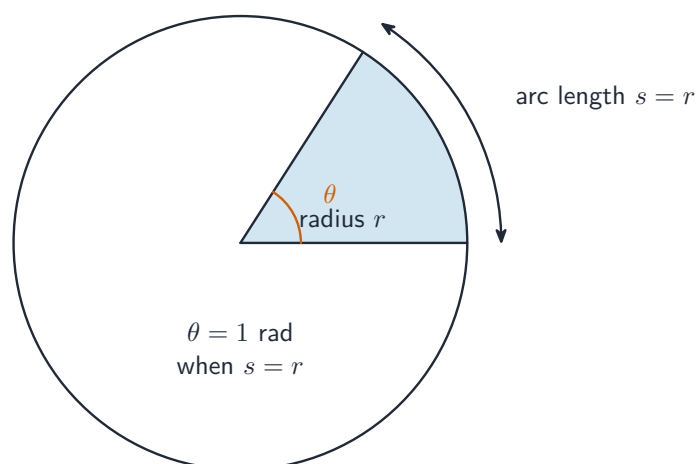
This sheet gives these ideas exact names and formulas. Each idea has a worked example.

## New ideas

### ■ 1 Angular quantities

Rotation copies straight-line motion, with new names:

- **angular displacement**  $\theta$  – the angle turned, measured in **radians** (one radian is the angle whose arc length equals the radius).
- **angular velocity**  $\omega = \frac{\Delta\theta}{\Delta t}$  – how fast it spins.



*Worked example.* A wheel turns 20 rad in 4.0 s, so  $\omega = \frac{20}{4.0} = 5.0 \text{ rad/s}$ .

## ■ 2 Linking spin to straight-line speed

A point at distance  $r$  from the axis moves at speed

$$v = r\omega.$$

Points farther from the axis move faster.

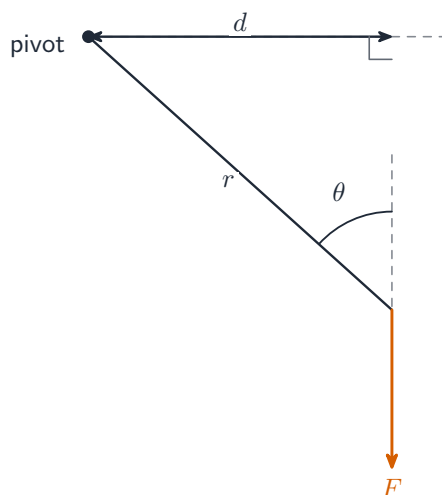
*Worked example.* A bicycle wheel of radius 0.35 m spins at 12 rad/s, so the rim (and the bike) moves at  $v = r\omega = 0.35 \times 12 = 4.2 \text{ m/s}$ .

## ■ 3 Torque – the turning effect

**Torque** (also called the moment) is how strongly a force turns something about a pivot:

$$\tau = F \times r_{\perp},$$

where  $r_{\perp}$  is the **moment arm** – the perpendicular distance from the pivot to the line of the force.



*Worked example.* Pushing with 20 N at the end of a 0.30 m spanner, at right angles, gives  $\tau = Fr = 20 \times 0.30 = 6.0 \text{ N m}$ .

**Watch out:** a force pointing straight **through** the pivot has zero moment arm, so it makes **no** torque. Push at a right angle, as far out as you can, for the biggest turning effect.

## Practice

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Try these in order. The methods are all above.

**2.1** A wheel turns through 18 rad in 3.0 s. Find its angular velocity. [2]

**2.2** A point on a rim of radius 0.20 m has the wheel spinning at 10 rad/s. Find the speed of the point. [2]

**2.3** A force of 15 N is applied at right angles 0.40 m from a pivot. Find the torque. [2]

**2.4** Explain why a door handle is placed far from the hinges, not near them. [2]

**2.5** Two points sit on a spinning disc, one at the rim and one halfway to the centre. State which moves faster and why. [2]

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**2.6** A spanner is 0.25 m long. You push with 30 N at right angles to it. Find the torque, then state what happens to the torque if you push at the same force but only halfway along. [3]