# 5 Rotational motion and torque – Part 1

Name: _____ Class: _____ Date: _____

## Vocabulary 词汇

*Write each word three times.* 把每个单词抄写三遍。

| **English** | **中文** | **Write it 3 times** (English) | | |
|---|---|---|---|---|
| angular displacement | 角位移 | | | |
| radians | 弧度 | | | |
| angular velocity | 角速度 | | | |
| Torque | 力矩 | | | |
| moment arm | 力臂 | | | |

## 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.

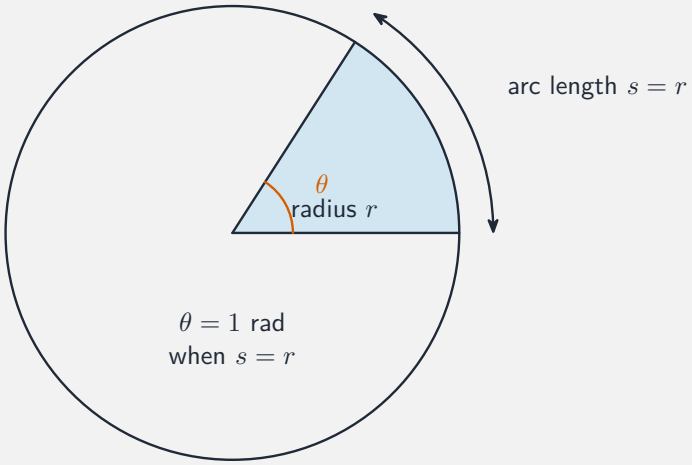
This sheet gives these ideas exact names and formulas. Each idea has a worked example.

## New ideas

### ■ 1 Angular quantities

Rotation copies straight-line motion, with new names:

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




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

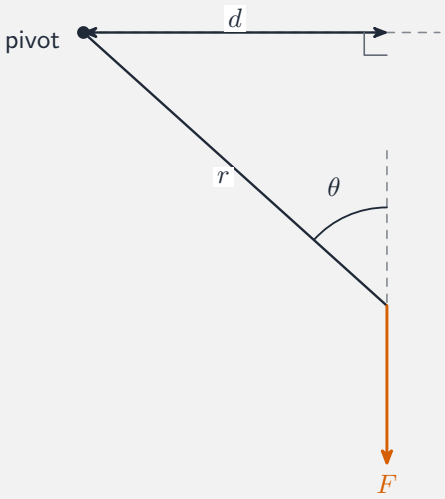
*Worked example.* A bicycle wheel of radius 0.35 m spins at 12 rad/s, so the rim (and the bike) moves at $v = r\omega = 0.35 \times 12 = 4.2$ m/s.

## 3 Torque –the turning effect

**Torque** 力矩 (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** 力臂–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 $\tau = Fr = 20 \times 0.30 = 6.0$ 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

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]

**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]