

Exercise walk-through

5.1

Rotational Kinematics

AP Physics 1

Rotation mirrors straight-line motion

Spinning is described by angles:

- **angular velocity** ω – rate the angle turns
- **angular acceleration** α – rate ω changes

For constant α , the equations have the **same form** as the linear ones. Rotation rate: $\omega = 2\pi f$.



Rotation links angle, angular speed, and linear speed

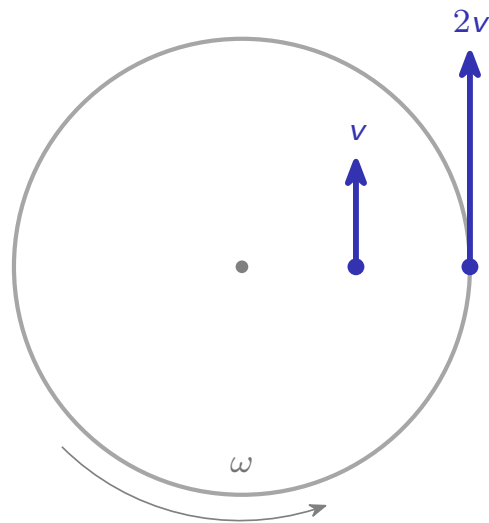
Linking linear and rotational motion

Every point on a spinning body moves along a curve, tied to the **radius** r :

Same ω , different v

$$v = r\omega, \quad a_t = r\alpha, \quad s = r\theta$$

All points share one ω , but points farther out move **faster**.



The angular quantities, and the moment arm

Angular displacement

Angular displacement $\Delta\theta$ in radians, with $s = r\Delta\theta$ linking it to the arc travelled.

Angular velocity

$\omega = d\theta/dt$, and $v = r\omega$ for a point on a rotating body – the further out, the faster.

Moment arm

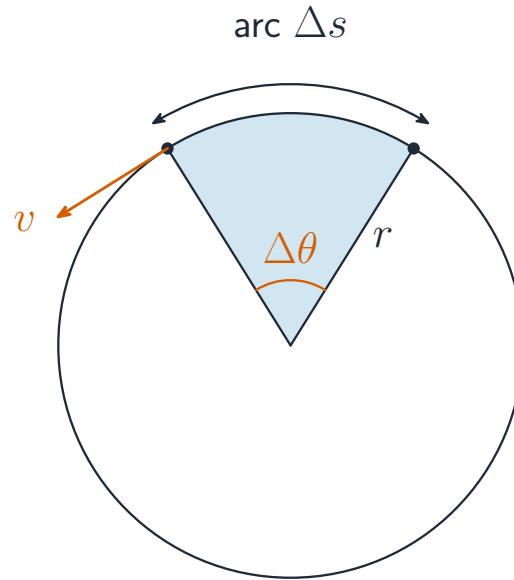
The **moment arm** is the perpendicular distance from the axis to the line of the force: $\tau = r_{\perp}F = rF\sin\theta$.

Why perpendicular

A force pointing at the axis has zero moment arm, so it produces no torque however large it is.

Every rotational quantity mirrors a linear one. Write the linear equation first, then substitute the angular partner.

As the radius turns through an angle



As the radius turns through an angle, a point moves along an arc at speed v

Exercises 2.1-2.3

2.1 A disc accelerates from rest at $\alpha = 4.0 \text{ rad s}^{-2}$ for 5.0 s. Find its final angular velocity. [1]

2.2 Find the angle turned by the disc in that time. [2]

2.3 State the rotational quantity that plays the role of velocity in the linear equations. [1]

Exercises 2.1·2.3

2.1 A disc accelerates from rest at $\alpha = 4.0 \text{ rad s}^{-2}$ for 5.0 s. Find its final angular velocity. [1]

2.1

- $\omega = 0 + 4.0(5.0) = 20 \text{ rad s}^{-1}$

2.2 Find the angle turned by the disc in that time. [2]

2.2

- $\theta = \frac{1}{2}(4.0)(5.0)^2 = 50 \text{ rad}$

2.3 State the rotational quantity that plays the role of velocity in the linear equations. [1]

2.3

- angular velocity ω

Exercises 3.1-3.2

3.1 Angular acceleration is the rate of change of

[1]

☐

A angular displacement

B angular velocity

C torque

D period

3.2 A wheel spinning at 10 rad s^{-1} decelerates at 2.0 rad s^{-2} . The time to stop is

[1]

☐

A 2.0 s

B 5.0 s

C 8.0 s

D 20 s

Exercises 3.1-3.2

3.1 Angular acceleration is the rate of change of

[1]

- ☐ **A** angular displacement
B angular velocity
C torque
D period

3.1 B

- angular velocity.

3.2 A wheel spinning at 10 rad s^{-1} decelerates at 2.0 rad s^{-2} . The time to stop is [1]

- ☐ **A** 2.0 s
B 5.0 s
C 8.0 s
D 20 s

3.2 B

- $$t = \frac{0 - 10}{-2.0} = 5.0 \text{ s}$$

Exercise 3.3 (a)

3.3 A fan blade slows from 20 rad s^{-1} to 8.0 rad s^{-1} in 4.0 s .

(a) Find the angular acceleration.

[2]

Exercise 3.3 (a)

3.3 A fan blade slows from 20 rad s^{-1} to 8.0 rad s^{-1} in 4.0 s .

(a) Find the angular acceleration.

[2]

(a)

- $$\alpha = \frac{8.0 - 20}{4.0} = -3.0 \text{ rad s}^{-2}$$

Exercise 3.3 (b)

3.3 A fan blade slows from 20 rad s^{-1} to 8.0 rad s^{-1} in 4.0 s .

(b) Find the angle turned during this time.

[2]

Exercise 3.3 (b)

3.3 A fan blade slows from 20 rad s^{-1} to 8.0 rad s^{-1} in 4.0 s .

(b) Find the angle turned during this time.

[2]

(b)

- $\theta = \frac{1}{2}(\omega_0 + \omega)t = \frac{1}{2}(20 + 8.0)(4.0) = 56 \text{ rad}$