Exercise walk-through

Torque and Work ▪ 6.2

eXercise

You must be able to

- calculate **rotational work 转动功**: $W = \tau\theta$
- use **rotational power 转动功率**: $P = \tau\omega$
- apply the rotational work-energy theorem: $W_{net} = \Delta K_{rot}$
- recognise these as analogues of $W = Fd$ and $P = Fv$

Method — Work done by a torque

$$W = \tau\theta,$$

with θ in radians. A 5 N m torque turning a wheel through 2π rad does $W = 5 \times 2\pi \approx 31.4$ J.

Method — Rotational power

$$P = \tau\omega.$$

A motor delivering 4 N m to a shaft at 10 rad s^{-1} outputs $P = 40$ W.

Method — Work-energy theorem

The net rotational work equals the change in rotational kinetic energy:

$$W_{net} = \Delta K_{rot} = \tfrac{1}{2} I\omega_f^2 - \tfrac{1}{2} I\omega_i^2.$$

Practice 2.1 ▪ 2 marks

A 6 N m torque turns a wheel through 4 rad. Find the work done.

Solution 2.1

Method: Work done by a torque

Worked steps

$W = \tau\theta = 6 \times 4 = 24$ J **M1** **A1**.

Practice 2.2 ▪ 2 marks

A motor supplies 8 N m at 5 rad s^{-1}. Find the power.

Solution 2.2

Method: Rotational power

Worked steps

$P = \tau\omega = 8 \times 5 = 40$ W M1 A1.

Practice 2.3 ▪ 1 mark

State what the net rotational work done on a body equals.

Solution 2.3

Method: Work-energy theorem

Worked steps

The change in its rotational kinetic energy B1.

Practice 2.4 ▪ 1 mark

In $W = \tau\theta$, in what unit must θ be?

Solution 2.4

Worked steps

Radians B1.

Exam-style 3.1 ▪ 1 mark

The work done by a constant torque is

A τ/θ

B $\tau\theta$

C $\tau\omega$

D $I\alpha$

Solution 3.1

Method: Work done by a torque

A τ/θ

B $\tau\theta$ ✓

C $\tau\omega$

D $I\alpha$

Worked steps

B — $W = \tau\theta$.

Exam-style 3.2 ▪ 1 mark

Rotational power is the analogue of

A $W = Fd$

B $P = Fv$

C $F = ma$

D $p = mv$

Solution 3.2

Method: Rotational power

A $W = Fd$

B $P = Fv$ ✓

C $F = ma$

D $p = mv$

Worked steps

B — $P = \tau\omega$ mirrors $P = Fv$.

Exam-style 3.3 ▪ 2 marks

A motor applies 10 N m while a wheel turns through 3 rad in 2 s.
(a) Find the work done.
(b) Find the average power.

Solution 3.3

Method: Work done by a torque

Worked steps

(a) $W = 10 \times 3 = 30$ J M1 A1. (b) $P = W/t = 30/2 = 15$ W M1 A1.

Exam-style 3.4 ▪ 1 mark

A net torque does 50 J of work on a wheel with $I = 4$ kg m^2, starting from rest.
(a) State the change in rotational kinetic energy.
(b) Find the final angular speed.

Solution 3.4

Worked steps

(a) $\Delta K_{rot} = 50$ J **B1**. (b) $\frac{1}{2} I\omega^2 = 50 \Rightarrow \omega = \sqrt{100/4} = 5$ rad s^{-1} **M1** **A1**.