

Exercise walk-through

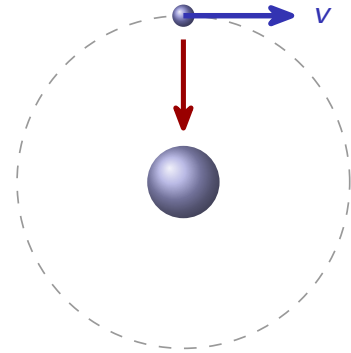
6.2

Torque and Work

AP Physics C: Mechanics

What we will cover

- 1 Rotational kinetic energy
- 2 Work and power of a torque
- 3 Angular momentum and impulse
- 4 Conservation of angular momentum
- 5 Rolling without slipping
- 6 Orbiting satellites



Rotational kinetic energy

Energy of spin

$$K_{rot} = \frac{1}{2} I \omega^2$$

A rolling body has **both**: $K = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2$.

A **flywheel** stores energy in its spin – and $K \propto \omega^2$.

Torque and work

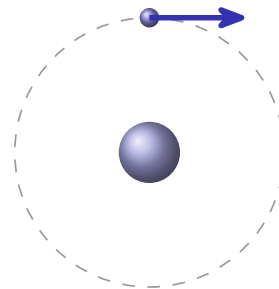
$$W = \int \tau d\theta, \quad P = \tau \omega$$

Area under a τ - θ graph; $W_{net} = \Delta K_{rot}$.

$\tau = 15$, $\Delta\theta = 8$: $W = 120$ J; at $\omega = 20$,
 $P = 300$ W.

Check yourself

- 1 Write the net torque as a rate of change of angular momentum.
- 2 A skater pulls their arms in – what happens to ω ?
- 3 Does the static friction on a rolling wheel do work?
- 4 A satellite moves to a bigger orbit – faster or slower?



Answers 1. $\vec{\tau} = d\vec{L}/dt$ 2. it speeds up 3. no 4. slower

Exercises 2.1-2.3

2.1 A 6 N m torque turns a wheel through 4 rad. Find the work done. [2]

2.2 A motor supplies 8 N m at 5 rad s^{-1} . Find the power. [2]

2.3 State what the net rotational work done on a body equals. [1]

Exercises 2.1-2.3

2.1 A 6 N m torque turns a wheel through 4 rad. Find the work done. [2]

2.1

- $W = \tau\theta = 6 \times 4 = 24 \text{ J}$

2.2 A motor supplies 8 N m at 5 rad s⁻¹. Find the power. [2]

2.2

- $P = \tau\omega = 8 \times 5 = 40 \text{ W}$

2.3 State what the net rotational work done on a body equals. [1]

2.3

- The change in its rotational kinetic energy

Exercises 2.4·3.1

2.4 In $W = \tau\theta$, in what unit must θ be? [1]

3.1 The work done by a constant torque is [1]

☐

A τ/θ

B $\tau\theta$

C $\tau\omega$

D $I\alpha$

Exercises 2.4-3.1

2.4 In $W = \tau\theta$, in what unit must θ be? [1]

2.4

- Radians

3.1 The work done by a constant torque is [1]

- ☐ **A** τ/θ
B $\tau\theta$
C $\tau\omega$
D $I\alpha$

3.1 B

- $W = \tau\theta$

Exercise 3.2

3.2 Rotational power is the analogue of

[1]

☐

A $W = Fd$

B $P = Fv$

C $F = ma$

D $p = mv$

Exercise 3.2

3.2 Rotational power is the analogue of

[1]

☐

A $W = Fd$

B $P = Fv$

C $F = ma$

D $p = mv$

3.2 B

- $P = \tau\omega$ mirrors $P = Fv$

Exercise 3.3 (a)

3.3 A motor applies 10 N m while a wheel turns through 3 rad in 2 s .

(a) Find the work done.

[2]

Exercise 3.3 (a)

3.3 A motor applies 10 N m while a wheel turns through 3 rad in 2 s.

(a) Find the work done.

[2]

(a)

- $W = 10 \times 3 = 30 \text{ J}$

Exercise 3.3 (b)

3.3 A motor applies 10 N m while a wheel turns through 3 rad in 2 s .

(b) Find the average power.

[2]

Exercise 3.3 (b)

3.3 A motor applies 10 N m while a wheel turns through 3 rad in 2 s.

(b) Find the average power.

[2]

(b)

- $P = W/t = 30/2 = 15 \text{ W}$

Exercise 3.4 (a)

3.4 A net torque does 50 J of work on a wheel with $I = 4 \text{ kg m}^2$, starting from rest.

(a) State the change in rotational kinetic energy.

[1]

Exercise 3.4 (a)

3.4 A net torque does 50 J of work on a wheel with $I = 4 \text{ kg m}^2$, starting from rest.

(a) State the change in rotational kinetic energy. [1]

(a)

- $\Delta K_{rot} = 50 \text{ J}$

Exercise 3.4 (b)

3.4 A net torque does 50 J of work on a wheel with $I = 4 \text{ kg m}^2$, starting from rest.

(b) Find the final angular speed.

[2]

Exercise 3.4 (b)

3.4 A net torque does 50 J of work on a wheel with $I = 4 \text{ kg m}^2$, starting from rest.

(b) Find the final angular speed.

[2]

(b)

- $\frac{1}{2}I\omega^2 = 50 \Rightarrow \omega = \sqrt{100/4} = 5 \text{ rad s}^{-1}$