

Exercise walk-through

6.2

Torque and Work

AP Physics 1

You must be able to

- calculate the **work done by a torque** , $W = \tau \Delta\theta$
- relate the work done by a net torque to the change in **rotational kinetic energy**
- define **rotational power** as $P = \tau\omega$
- find the work from the **area** under a torque-versus-angle graph

1

The method

Method — Work by a torque

$W = \tau \Delta\theta$, with $\Delta\theta$ in radians. This is the rotational partner of
 $W = Fd$.

Exercises 2.1-2.3

2.1 A torque of 5.0 N m turns a wheel through 4.0 rad . Find the work done. [1]

2.2 A motor applies 20 N m at $\omega = 15 \text{ rad s}^{-1}$. Find its power output. [2]

2.3 A net work of 30 J is done on a flywheel starting from rest. State its final rotational kinetic energy. [1]

Exercises 2.1-2.3

2.1 A torque of 5.0 N m turns a wheel through 4.0 rad. Find the work done. [1]

2.1

$$W = \tau \Delta\theta = (5.0 \text{ N m})(4.0 \text{ rad}) = \mathbf{20 \text{ J}}$$

2.2 A motor applies 20 N m at $\omega = 15 \text{ rad s}^{-1}$. Find its power output. [2]

2.2

- the rotational form of $P = Fv$:

$$P = \tau\omega = (20 \text{ N m})(15 \text{ rad s}^{-1})$$

- $P = \mathbf{300 \text{ W}}$

2.3 A net work of 30 J is done on a flywheel starting from rest. State its final rotational kinetic energy. [1]

2.3

- 30 J (all the net work becomes rotational kinetic energy)

Exercises 3.1·3.2

3.1 The work done by a torque is

[1]

☐

A $\tau\omega$

B $\tau \Delta\theta$

C $I\alpha$

D $\frac{1}{2}I\omega^2$

3.2 Rotational power is equal to

[1]

☐

A τ/ω

B $\tau\omega$

C $\tau + \omega$

D $I\alpha$

Exercises 3.1-3.2

3.1 The work done by a torque is

[1]

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A $\tau\omega$

B $\tau \Delta\theta$

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D $\frac{1}{2}I\omega^2$

3.1 B

- $\tau \Delta\theta$.

3.2 Rotational power is equal to

[1]

☐

A τ/ω

B $\tau\omega$

C $\tau + \omega$

D $I\alpha$

3.2 B

- $\tau\omega$.

Exercise 3.3 (a)

3.3 A wheel of $I = 0.40 \text{ kg m}^2$, initially at rest, has a 2.0 N m torque applied through 10 rad .

(a) Find the work done.

[2]

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(a) Find the work done.

[2]

(a)

$$W = \tau \Delta\theta = (2.0 \text{ N m})(10 \text{ rad})$$

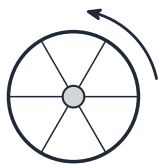
- $W = \mathbf{20 \text{ J}}$

Exercise 3.3 (b)

3.3 A wheel of $I = 0.40 \text{ kg m}^2$, initially at rest, has a 2.0 N m torque applied through 10 rad .

(b) Find the final angular velocity.

[2]



$\tau = 2.0 \text{ N m}$ through 10 rad

$I = 0.40 \text{ kg m}^2$

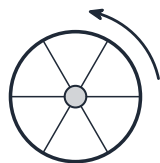
starts at rest

Exercise 3.3 (b)

3.3 A wheel of $I = 0.40 \text{ kg m}^2$, initially at rest, has a 2.0 N m torque applied through 10 rad .

(b) Find the final angular velocity.

[2]



$\tau = 2.0 \text{ N m}$ through 10 rad

$I = 0.40 \text{ kg m}^2$

starts at rest

(b)

- from rest, all the work becomes rotational KE : $\frac{1}{2}I\omega^2 = W$, rearranged:

$$\omega = \sqrt{\frac{2W}{I}} = \sqrt{\frac{2(20 \text{ J})}{0.40 \text{ kg m}^2}}$$

- $\omega = 10 \text{ rad s}^{-1}$