

Exercise walk-through

# 6.1

## Rotational Kinetic Energy

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AP Physics 1

## You must be able to

- define **rotational kinetic energy** as  $K_{rot} = \frac{1}{2}I\omega^2$
- explain that it depends on both the **rotational inertia** and the **angular velocity**
- find the **total kinetic energy** of an object that both translates and rotates
- apply **conservation of energy** to systems that include rotation

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The method

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## Method — Rotational kinetic energy

$K_{rot} = \frac{1}{2}I\omega^2$  – the rotational partner of  $\frac{1}{2}mv^2$ .

## Exercises 2.1·2.2

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**2.1** A flywheel of  $I = 0.50 \text{ kg m}^2$  spins at  $\omega = 4.0 \text{ rad s}^{-1}$ . Find its rotational kinetic energy. [2]

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**2.2** A rolling ball has 6.0 J of translational and 2.4 J of rotational kinetic energy. Find its total kinetic energy. [1]

## Exercises 2.1·2.2

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**2.1** A flywheel of  $I = 0.50 \text{ kg m}^2$  spins at  $\omega = 4.0 \text{ rad s}^{-1}$ . Find its rotational kinetic energy. [2]

**2.1**

$$K_{\text{rot}} = \frac{1}{2}I\omega^2 = \frac{1}{2}(0.50 \text{ kg m}^2)(4.0 \text{ rad s}^{-1})^2$$

- $K_{\text{rot}} = \mathbf{4.0 \text{ J}}$

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**2.2** A rolling ball has 6.0 J of translational and 2.4 J of rotational kinetic energy. Find its total kinetic energy. [1]

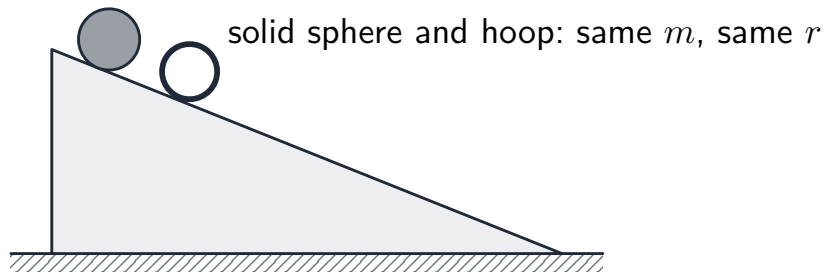
**2.2**

- a rolling object has both forms:  $K = K_{\text{trans}} + K_{\text{rot}} = 6.0 \text{ J} + 2.4 \text{ J} = \mathbf{8.4 \text{ J}}$

## Exercise 2.3

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**2.3** State why a solid sphere rolls down a ramp faster than a hoop of the same mass and radius. [2]



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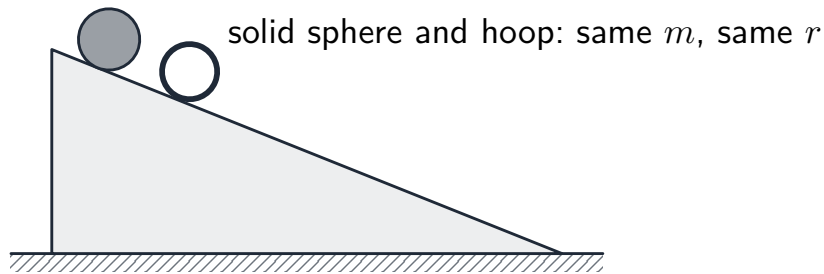
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## Exercise 2.3

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**2.3** State why a solid sphere rolls down a ramp faster than a hoop of the same mass and radius. [2]



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**2.3**

- The sphere has a smaller rotational inertia for its mass, so less energy goes into rotation and more into translation, giving a larger speed

## Exercises 3.1-3.2

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3.1 Rotational kinetic energy is

[1]

☐

- A  $\frac{1}{2}I\omega$
- B  $\frac{1}{2}I\omega^2$
- C  $I\omega$
- D  $\frac{1}{2}mv^2$

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3.2 A hoop and a disc of equal mass and radius roll from rest down the same ramp. The one reaching the bottom first is the

[1]

☐

- A hoop
- B disc
- C they arrive together
- D it depends on the mass

## Exercises 3.1·3.2

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3.1 Rotational kinetic energy is

[1]

☐

- A  $\frac{1}{2}I\omega$
- B  $\frac{1}{2}I\omega^2$
- C  $I\omega$
- D  $\frac{1}{2}mv^2$

3.1 B

- $\frac{1}{2}I\omega^2$ .

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3.2 A hoop and a disc of equal mass and radius roll from rest down the same ramp. The one reaching the bottom first is the

[1]

☐

- A hoop
- B disc
- C they arrive together
- D it depends on the mass

3.2 B

- the disc has the smaller rotational inertia

## Exercise 3.3 (a)

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**3.3** A disc of  $I = 0.10 \text{ kg m}^2$  spins at  $\omega = 12 \text{ rad s}^{-1}$ .

(a) Find its rotational kinetic energy.

[2]

## Exercise 3.3 (a)

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**3.3** A disc of  $I = 0.10 \text{ kg m}^2$  spins at  $\omega = 12 \text{ rad s}^{-1}$ .

(a) Find its rotational kinetic energy.

[2]

(a)

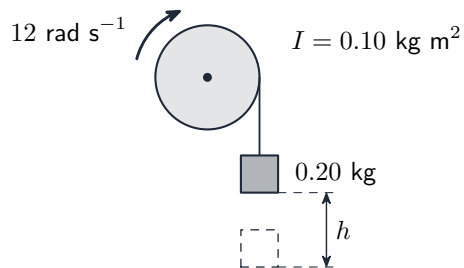
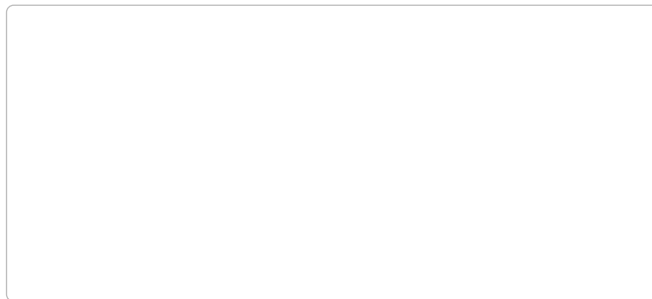
$$K_{\text{rot}} = \frac{1}{2}I\omega^2 = \frac{1}{2}(0.10 \text{ kg m}^2)(12 \text{ rad s}^{-1})^2$$

- $K_{\text{rot}} = \mathbf{7.2 \text{ J}}$

## Exercise 3.3 (b)

**3.3** A disc of  $I = 0.10 \text{ kg m}^2$  spins at  $\omega = 12 \text{ rad s}^{-1}$ .

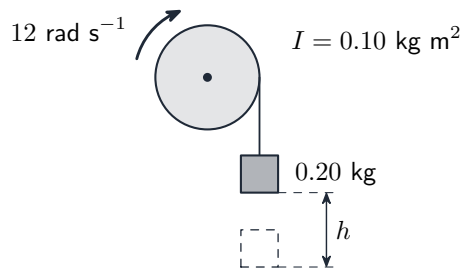
(b) If this energy came from a  $0.20 \text{ kg}$  mass falling, find the height it fell (take  $g = 10 \text{ m s}^{-2}$ ). [2]



## Exercise 3.3 (b)

**3.3** A disc of  $I = 0.10 \text{ kg m}^2$  spins at  $\omega = 12 \text{ rad s}^{-1}$ .

(b) If this energy came from a  $0.20 \text{ kg}$  mass falling, find the height it fell (take  $g = 10 \text{ m s}^{-2}$ ). [2]



(b)

- the mass's lost  $U_g$  supplies this energy:  $mgh = K_{\text{rot}}$ , rearranged:

$$h = \frac{K_{\text{rot}}}{mg} = \frac{7.2 \text{ J}}{(0.20 \text{ kg})(10 \text{ m s}^{-2})}$$

- $h = 3.6 \text{ m}$