

6.3 Angular Momentum and Angular Impulse

Name: _____ Class: _____ Date: _____ **Total: 14 marks****KEY WORDS** angular momentum 角动量 • angular impulse 角冲量 • torque 力矩

Objective

Build the skills to answer exam questions on **angular momentum** and **angular impulse**.

You must be able to:

- use **angular momentum** 角动量: $L = I\omega$ (and $L = mvr$ for a point mass)
- use **angular impulse** 角冲量: $\tau \Delta t = \Delta L$
- recognise the analogy with $p = mv$ and $F\Delta t = \Delta p$
- state the unit of angular momentum ($\text{kg m}^2 \text{s}^{-1}$)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Angular momentum

$$L = I\omega.$$

A wheel with $I = 3 \text{ kg m}^2$ at $\omega = 2 \text{ rad s}^{-1}$ has $L = 6 \text{ kg m}^2 \text{s}^{-1}$. For a point mass, $L = mvr$.

■ Angular impulse

A torque acting over a time changes the angular momentum:

$$\tau \Delta t = \Delta L.$$

A 4 N m torque for 3 s adds $\Delta L = 12 \text{ kg m}^2 \text{s}^{-1}$.

■ The rate form

Equivalently $\tau = \frac{dL}{dt}$ — torque is the rate of change of angular momentum.

2 Practice

Now apply the methods above.

2.1 A flywheel with $I = 5 \text{ kg m}^2$ spins at 4 rad s^{-1} . Find its angular momentum. [2]

2.2 State the unit of angular momentum. [1]

2.3 A 3 N m torque acts for 5 s. Find the change in angular momentum. [2]

2.4 A 2 kg ball moves at 3 m s^{-1} in a circle of radius 4 m. Find its angular momentum. [2]

3 Exam-style questions

3.1 Angular momentum is the rotational analogue of [1]

- **A** force
- **B** momentum
- **C** energy
- **D** acceleration

3.2 For a rigid body, L equals [1]

- **A** $I\alpha$
- **B** $I\omega$
- **C** $\frac{1}{2}I\omega^2$
- **D** $\tau\theta$

3.3 A wheel with $I = 2 \text{ kg m}^2$ at $\omega = 3 \text{ rad s}^{-1}$ receives a steady 2 N m torque for 4 s .

(a) Find its initial angular momentum. [1]

(b) Find its angular momentum after the torque acts. [2]

3.4 A skater has $I = 4 \text{ kg m}^2$ spinning at 2 rad s^{-1} .

(a) Find her angular momentum. [1]

(b) State what quantity torque is the rate of change of. [1]

Solutions

2.1 $L = I\omega = 5 \times 4 = 20 \text{ kg m}^2 \text{ s}^{-1}$.

2.2 $\text{kg m}^2 \text{ s}^{-1}$.

2.3 $\Delta L = \tau \Delta t = 3 \times 5 = 15 \text{ kg m}^2 \text{ s}^{-1}$.

2.4 $L = mvr = 2 \times 3 \times 4 = 24 \text{ kg m}^2 \text{ s}^{-1}$.

3.1 B — angular momentum is the rotational analogue of linear momentum.

3.2 B — $L = I\omega$.

3.3 (a) $L_i = 2 \times 3 = 6 \text{ kg m}^2 \text{ s}^{-1}$. (b) $\Delta L = 2 \times 4 = 8$; $L_f = 6 + 8 = 14 \text{ kg m}^2 \text{ s}^{-1}$.

3.4 (a) $L = 4 \times 2 = 8 \text{ kg m}^2 \text{ s}^{-1}$. (b) Angular momentum ($\tau = dL/dt$).