6.3 Angular Momentum and Angular Impulse

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

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 (kg m^2 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 $I = 3$ kg m^2 at $\omega = 2$ rad s^{-1} has $L = 6$ kg m^2 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 $\Delta L = 12$ kg m^2 s^{-1}.

■ **The rate form**

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

2 Practice

Now apply the methods above.

2.1 A flywheel with $I = 5$ 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 $I = 2$ kg m^2 at $\omega = 3$ 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 $I = 4$ 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]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **6.3 Angular Momentum and Angular Impulse** lesson on the **Learn** page;
- read the **Energy and Momentum of Rotating Systems** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

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

2.2 kg m^2 s^{-1}.

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

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

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

3.2 B —$L = I\omega$.

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

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