Advanced Higher Physics

Rotational Motion and Astrophysics

Study Guide

1.1 Kinematic Relationships

- ❑ 1 Derive the equations

$$v = u + at, \qquad s = ut + \frac{1}{2}at^2, \qquad v^2 = u^2 + 2as$$

for linear motion with a constant acceleration from

$$a = \frac{dv}{dt} \text{ i.e. } \quad a = \frac{d^2s}{dt^2}$$

- ❑ 2 Carry out calculations using the equations above.
- ❑ 3 State what is represented by the gradient of a displacement-time graph.
- ❑ 4 State what is represented by the gradient of a velocity-time graph
- ❑ 5 Calculate displacement from a velocity-time graph by integration between limits.

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1.2 Angular Motion

- ❑ 1 State and explain what is meant by angular displacement.
- ❑ 2 Use the radian as a measure of angular displacement.
- ❑ 3 Convert between degrees and radians.
- ❑ 4 Carry out calculations involving the equation $s = r\theta$.
- ❑ 5 State and explain what is meant by angular velocity.
- ❑ 6 Carry out calculations using the equation $\omega = \frac{d\theta}{dt}$.
- ❑ 7 Carry out calculations involving $\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$.
- ❑ 8 Carry out calculations involving the following equations:

$$\omega = \omega_0 + \alpha t$$

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$ where α is a constant angular acceleration.

- ❑ 9 State and explain what is meant by tangential velocity.
- ❑ 10 Carry out calculations involving $v = r\omega$.
- ❑ 11 Carry out calculations involving $\omega = \frac{2\pi}{T}$ where T = period.
- ❑ 12 State and explain what is meant by tangential acceleration.
- ❑ 13 Carry out calculations involving $a_t = r\alpha$.
- ❑ 14 State and explain what is meant by radial (centripetal) acceleration.
- ❑ 15 Explain the difference between tangential and radial acceleration.
- ❑ 16 Carry out calculations using $a = \frac{v^2}{r} = r\omega^2$.
- ❑ 17 Describe how a centripetal force allows an object to rotate in a circular motion.
- ❑ 18 Carry out calculations involving $F = \frac{mv^2}{r} = mr\omega^2$.

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1.3 Rotational Dynamics

- ❑ 1 Explain what is meant by Torque.
- ❑ 2 Carry out calculations involving

$$T = Fr$$

where F is the force applied at right angles to the axis of rotation.

- ❑ 3 Describe the effect of applying an unbalanced Torque.
- ❑ 4 Explain how an unbalanced Torque affects angular acceleration.
- ❑ 5 Define *Moment of Inertia*.
- ❑ 6 State what factors affect Moment of Inertia. $I = \sum mr^2$
- ❑ 7 Calculate Moment of Inertia for different shapes given the

equations:

rod about centre	$I = \frac{1}{12}ml^2$
Rod about end	$I = \frac{1}{3}ml^2$
Disc about centre	$I = \frac{1}{2}mr^2$
Sphere about centre	$I = \frac{2}{5}mr^2$

- ❑ 8 Carry out calculations involving $T = I\alpha$.
- ❑ 9 Explain what is meant by angular momentum.
- ❑ 10 Carry out calculations using $L = I\omega$.
- ❑ 11 Carry out calculations using $L = mvr = mr\omega^2$.
- ❑ 12 State and explain the Principle of Conservation of Angular Momentum.
- ❑ 13 Explain the difference between Linear and Rotational Kinetic Energy.
- ❑ 14 Carry out calculations using $E_{k(rotational)} = \frac{1}{2}\mathrm{I}\omega^2$.
- ❑ 15 Carry out calculations using $E_p = E_{k(translational)} + E_{k(rotational)}$.