AQA A-Level Physics

11.1 Rotational dynamics

Flashcards

What is the moment of inertia for an isolated point mass?

What is the moment of inertia for an isolated mass?

A measure of how difficult it is to alter an object's rotational speed:

$$I = mr^2$$

I = moment of inertia (kg m^2), m = mass (kg)

r = distance from axis of rotation (m)

What is the moment of inertia of an extended object?

What is the moment of inertia of an extended object?

$$I = \sum mr^2$$

Add the individual moments of inertia for each point mass that makes up the object.

If a small mass m is added to a rod at radius r from the axis of rotation, what is the new moment of inertia?

If a small mass m is added to a rod at radius r from the axis of rotation, what is the new moment of inertia?

$$I_{new} = I_{initial} + mr^2$$

Where mr^2 is the moment of inertia for the small mass added.

What affects the moment of inertia of a rotating object?

What affects the moment of inertia of a rotating object?

The mass and mass distribution of the object, the position of the axis of rotation and how far away the mass is from it.

What is the rotational kinetic energy of an object?

What is the rotational kinetic energy of an object?

$$E_k = \frac{1}{2} I\omega^2$$

I is the moment of inertia (kg m^2) and ω is the angular speed (rad s^{-1}).

What is Torque?

What is Torque?

A measure of how much a force causes an object to rotate about an axis.

Measured in Newton meters (N m).

What is a flywheel?

What is a flywheel?

Flywheels are heavy wheels with a high moment of inertia and angular momentum that convert inputted torque to rotational kinetic energy. They are used to store energy in a machine to be used at another point in a system.

What factors affect the energy storage capacity of a flywheel?

What factors affect the energy storage capacity of a flywheel?

Shape and mass: Increased moment of Inertia, increased E_k. Flywheels shaped as wheels instead of discs can store more energy as r is greater. Spoked wheels store more energy.

Material: ω_{max} is restricted by the breaking stress of the flywheel, higher ω_{max} higher E_k.

How are flywheels used for storing energy in braking vehicles?

How are flywheels used for storing energy in braking vehicles?

Electric vehicles use regenerative braking. When the brakes are applied, a flywheel is engaged, which charges up with the energy being lost. The energy is used to move the wheels when the vehicle accelerates and is then disengaged.

How are flywheels used for smoothing torque and angular velocity?

How are flywheels used for smoothing torque and angular velocity?

Flywheels use each burst of power to charge and then smoothly deliver the energy to rotating components. For systems that exert a varying force when the load torque is too high, the flywheel decelerates to top up the system and vice versa when engine torque is higher than load torque.

How are flywheels used in production processes?

How are flywheels used in production processes?

Most production, such as piercing sheets of metal, require constant uniform action. Attaching a flywheel to the motor reduces problems by smoothing out fluctuations.

What are the advantages of flywheels?

What are the advantages of flywheels?

- Very efficient.
- Long working life.
- Short recharge time.
- Environmentally friendly.

What are the disadvantages of flywheels?

What are the disadvantages of flywheels?

- Larger and heavier than other storage methods.
- Safety risk as wheel could break at high speeds.
- Energy lost through friction.
- Can oppose changes in direction for moving vehicles (but also helps improve stability).

What is angular displacement?

What is angular displacement?

The angle through which an object on a circular path moves through. Measured in radians.

What are angular velocity and angular speed?

What are angular velocity and angular speed?

Angular speed = change in angle / time (magnitude only). Measured in rad s^{-1}

Angular velocity = change in angular displacement / time (magnitude and direction). Measured in rad s^{-1}

What is the relation between angular acceleration, angular velocity and angular displacement?

What is the relation between angular acceleration, angular velocity and angular displacement ?

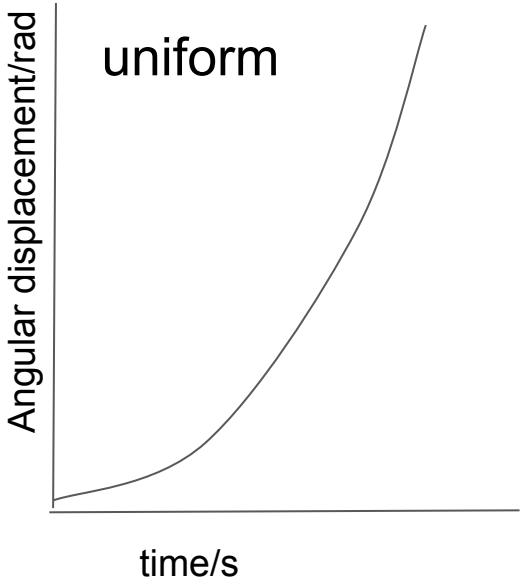
$\omega = d\theta/dt$ (where d represents 'change in')

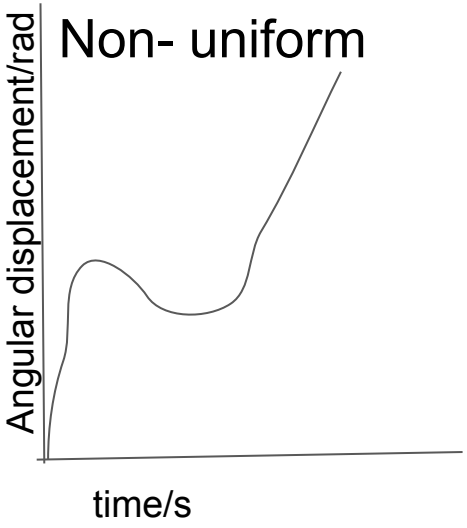
$\alpha = d\omega/dt$

$\alpha = d^2\theta/dt^2$

Plot graphs of angular displacement against time for uniform and non-uniform acceleration.

Plot graphs of angular displacement against time for uniform and non-uniform acceleration.

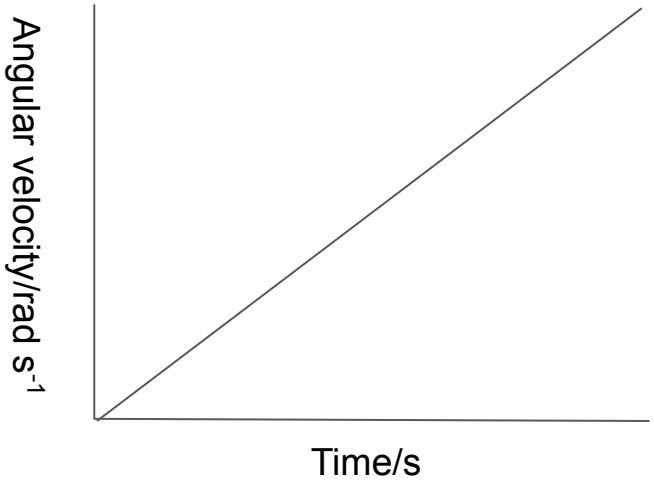




For constant angular acceleration, angular displacement $\propto t^2$ shown by a smooth curve through the origin.

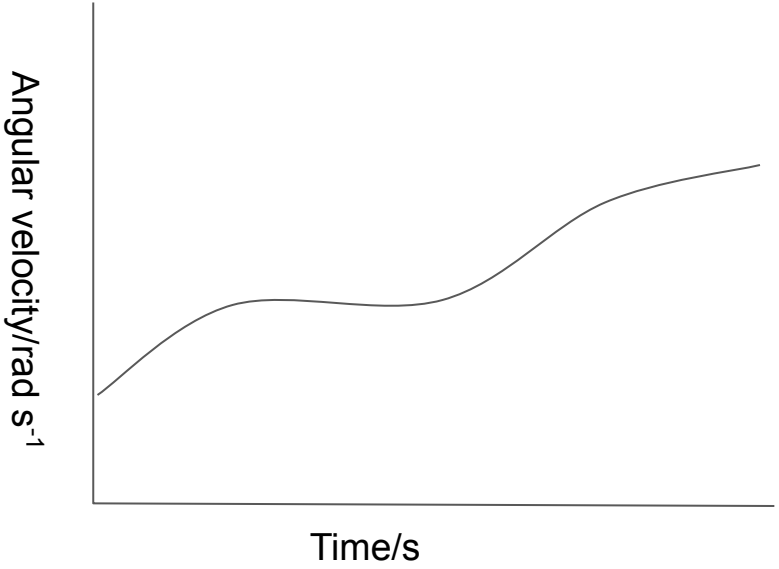
Draw the graph for angular velocity against time when angular acceleration is constant.

Draw the graph for angular velocity against time when angular acceleration is constant.



Draw the graph for angular velocity against time when angular acceleration is not constant.

Draw the graph for angular velocity against time when angular acceleration is not constant



Match up the linear quantities with their rotational equivalent.

$s =$

$v =$

$a =$

Match up the linear quantities with their rotational equivalent.

s = θ, angle through which a point has been rotated.

v = ω, angle a point rotates through per second.

a = α, rate of change of angular velocity.

What are the uniform acceleration formulae (suvat) in terms of uniform angular acceleration?

What are the uniform acceleration formulae (suvat) in terms of uniform angular acceleration?

$\omega_2 = \omega_1 + \alpha t$

$\theta = \omega_1 t + \frac{1}{2} \alpha t^2$

$\omega_2^2 = \omega_1^2 + 2\alpha\theta$

$\theta = \frac{1}{2} (\omega_1 + \omega_2) t$

What equations can be used to calculate torque?

What equations can be used to calculate torque?

T = Fr = Force x perpendicular distance from axis of rotation to point of applied force

$T = I\alpha$ = Moment of Inertia x angular acceleration.

What is angular momentum?

What is angular momentum?

$I\omega$ = moment of inertia x angular velocity.

Measured in N m s

When is angular momentum conserved?

When is angular momentum conserved?

It is conserved only when no external forces act on the object.

What is Angular Impulse?

What is Angular Impulse?

The change in angular momentum or equivalently a product of a constant torque and time duration of that change.

$$T\Delta t = \Delta(I\omega)$$

How does angular impulse relate to torque graphically?

How does angular impulse relate to torque graphically?

Angular impulse is the area under the torque-time graph.

Similar to Impulse = area under force-time graph.

How can you calculate the work done when rotating an object?

How can you calculate the work done when rotating an object?

$$W = T\theta$$

Work done = Torque x Angular displacement

How can the work done be calculated graphically with a non-constant torque?

How can the work done be calculated graphically with a non-constant torque?

The work done is the area under the torque-angular displacement graph.

How can you calculate the power expended in rotating an object?

How can you calculate the power expended in rotating an object?

$$P = T\omega$$

Power = Torque x Angular velocity

Is there a frictional torque when rotating an object?

Is there a frictional torque when rotating an object?

Yes, there is a frictional force resisting motion which causes a frictional torque, and some work will need to be expended in overcoming the frictional torque.