Momentum and Rotation

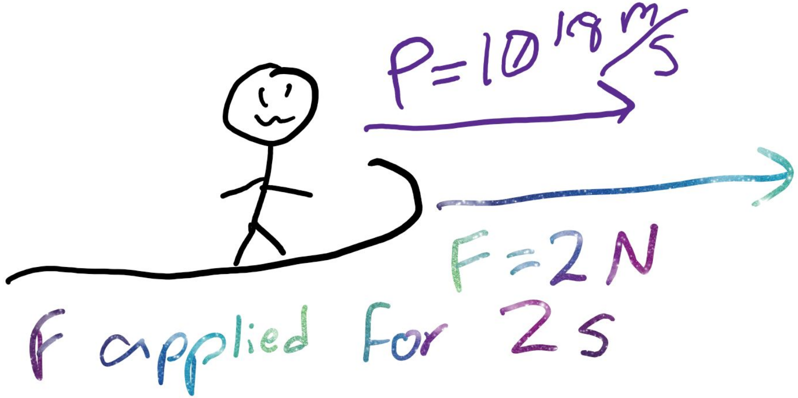
Get it bc I used the theme that has circles and rotational things go in circles just like my brain after I saw the AP Physics C Mech exam

Bruh Momentum

Impulse

Impulse is change in momentum

Mostly, just remember F * t is change in momentum because F = p/t



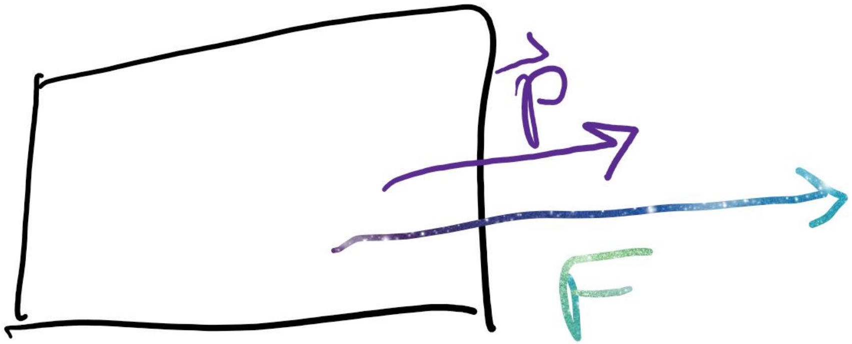
Force - Momentum what?

Pushing something changes speed, so force affects momentum

F = m*a

a = v/t

F = m*v/t = (m*v)/t = p/t



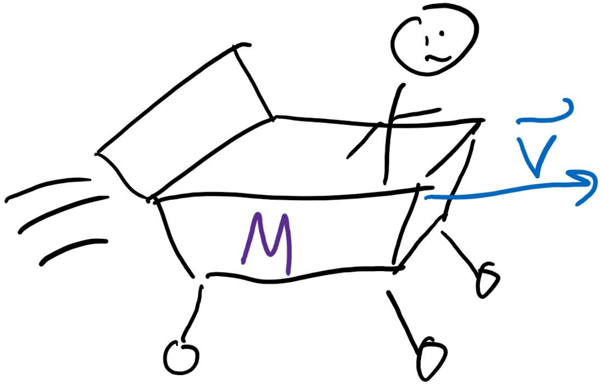
Shopping cart go whee

Newton's First law says things that have mass go whee

In science terms: velocity is constant for a given mass if no other force is applied

Momentum (p) = m * v

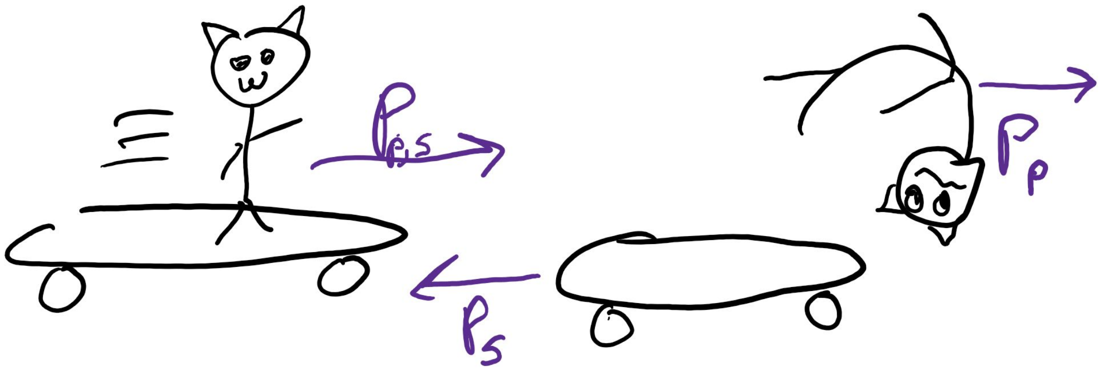
https://www.youtube.com/watch?v=aI20AFLf4n8



Conservation of momentum? Pog?

By Newton's second law, momentum is conserved if no other force is applied.

$$m_1 v_1 = m_2 v_2$$

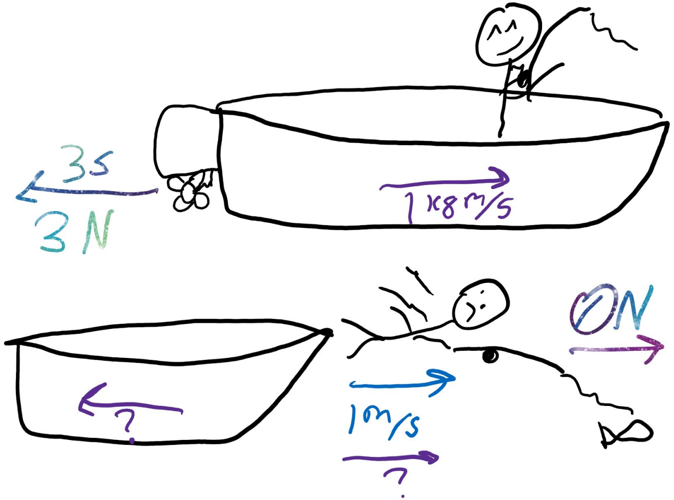


Review

A motor applies a force of 3 N for 3 seconds to a boat with initial momentum 1 kg m/s. What is the new momentum?

If a 1 kg person jumps off the boat at 1 m/s, what momentum does he have?

What is the new momentum of a boat?



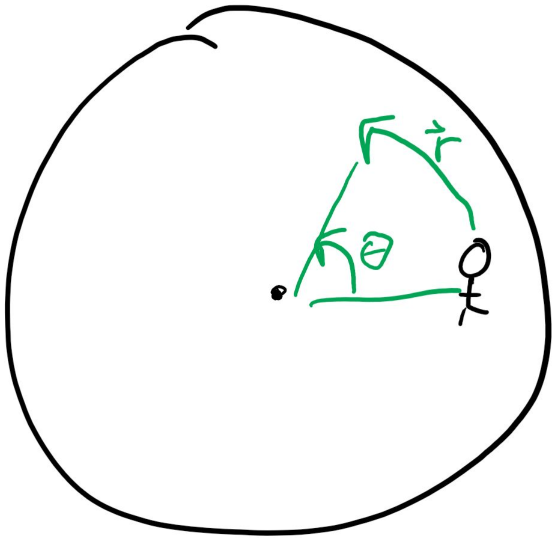
Rotational measurements

Angular distance

How many degrees/radians you rotated

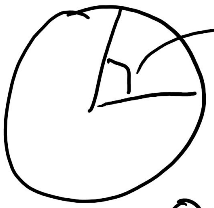
Unitless

Usually measured in radians (a number out of 2pi)



Distance vs angular distance

1. Circumference is?
2. Radians are?
3. Radius times radians is?



$$\frac{\pi}{3}\,rad = \theta$$

$$\frac{\pi}{3} = \frac{1}{6}(2\pi)$$

$$\theta \cdot r = 2\pi r\left(\frac{1}{6}\right)$$

$$= \frac{1}{6}C$$

1. Radius * 2 pi
2. Some fraction of 2 pi
3. The fraction of the circumference we traveled on (a distance!)

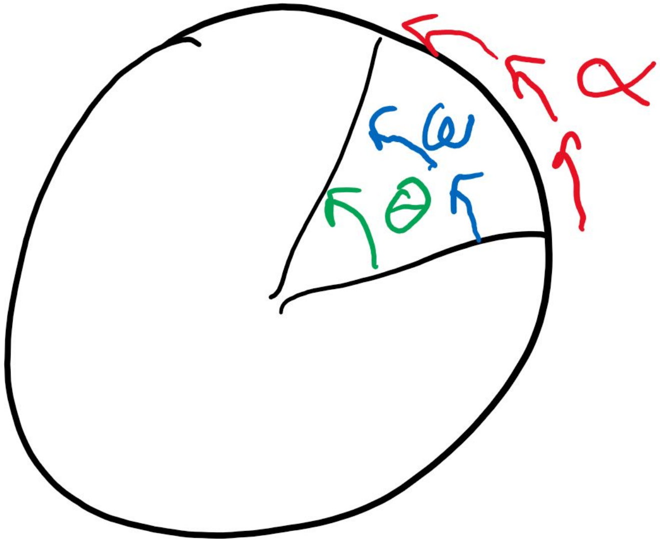
Other angular measures

θ *theta* angular distance

ω *omega* angular velocity

α *alpha* angular acceleration

Any angular measure multiplied by the radius of the rotation gives the linear analog (aka, distance, velocity, acceleration)



Quick rev

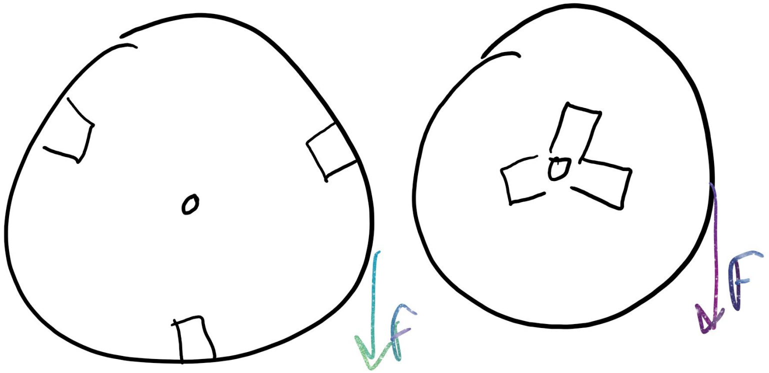
If I travel 2 meters along a circle with a radius of 1 m, what is my angular distance?

If I move at an angular acceleration of 25 rad/s^2 on a circle with a radius of .1 m, what is my linear acceleration?

Moment of Inertia

What is inertia?

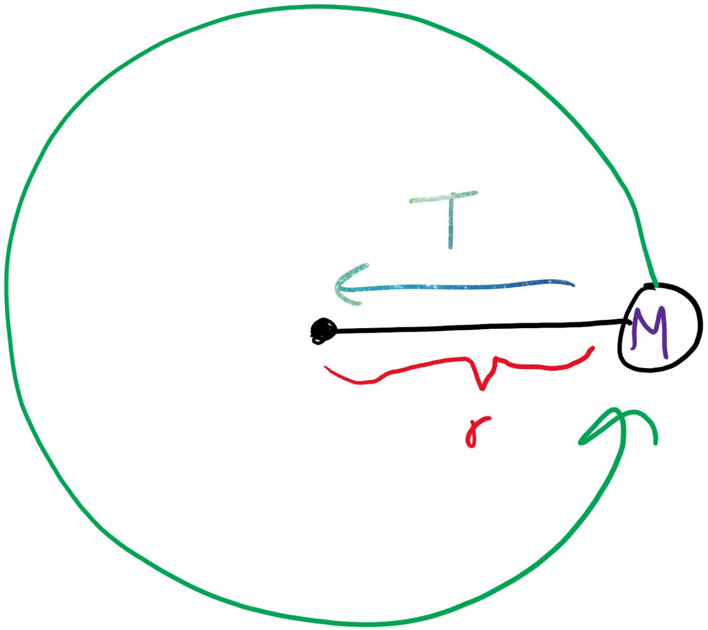
Moment of inertia is inertia, but for rotating objects; aka, it opposes spinning for objects not spinning and opposes stopping for spinning objects.



“Equation”

I = mr^2

Harder to spin more massive things; the further the mass is, the harder it is to rotate.



Rotational analogs of everything

$$E_k = .5mv^2 \text{ becomes } E_k = .5I\omega^2$$

$$p = mv \text{ becomes } L = I\omega$$

$$F = ma \text{ becomes } \tau = I\alpha$$

In order:

Linear kinetic energy -> Rotational kinetic energy

Linear momentum -> Angular momentum

Force -> Torque

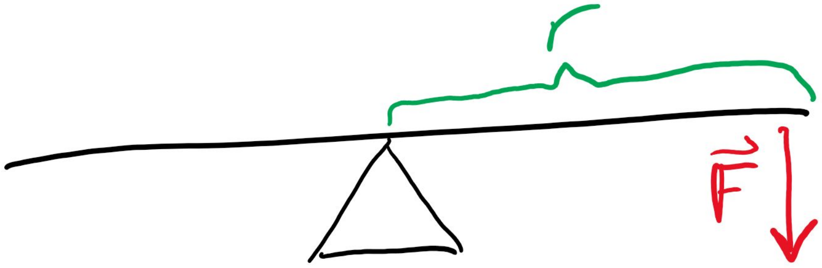
Torque

On a lever

Torque is “spinny” force

Is it harder or easier to push on a longer lever?

Does the thing spin faster or slower with more force applied?



Work vs Torque

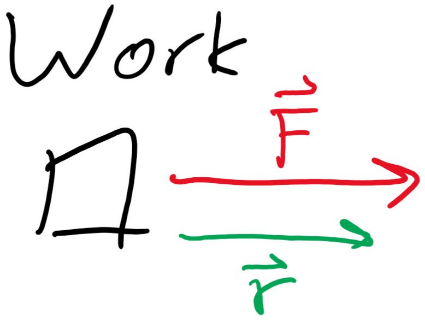
Both are force times distance.

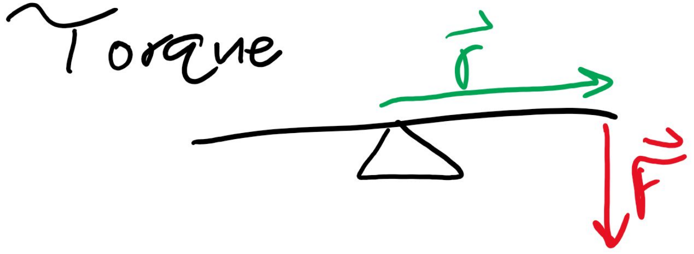
With work, the force is in the direction of the distance traveled

With torque, force is perpendicular to the distance (lever arm)

Work is N * m (Joules)

Torque is m * N (not Joules)

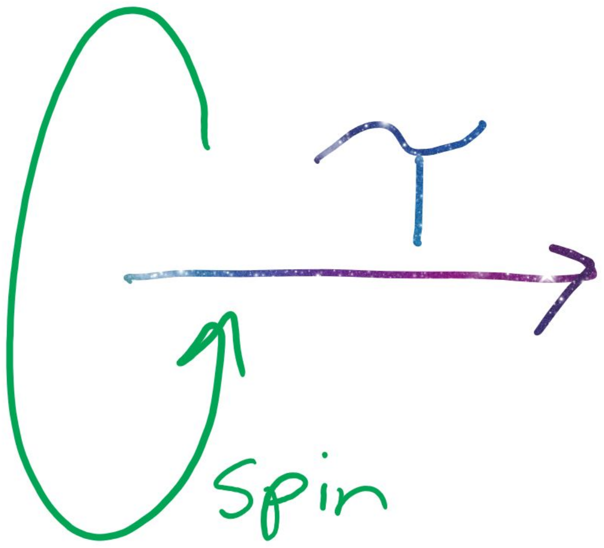




How Torque is represented

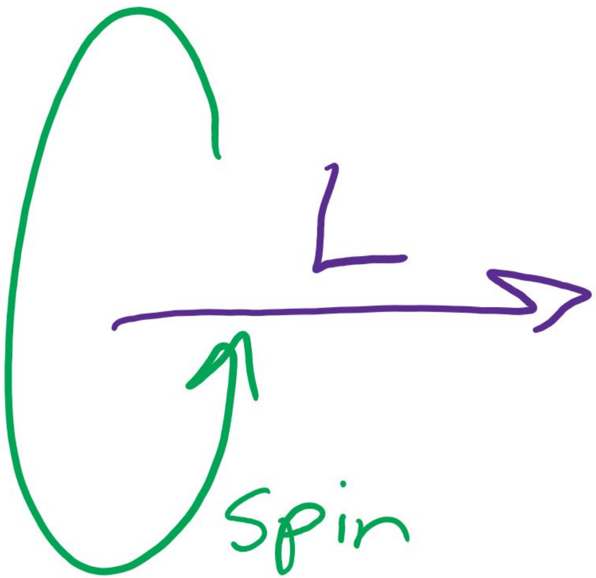
Perpendicular to the plane of motion

Let’s say an object is spinning counterclockwise. Take your right hand and make a thumbs up, so the “curl” of your fingers follows the direction of the spin. Your thumb points to the direction of torque.



Angular momentum representation

Similar to torque, but the magnitude is moment of inertia * angular velocity



Gyroscopic rotation

Gyroscopic precession

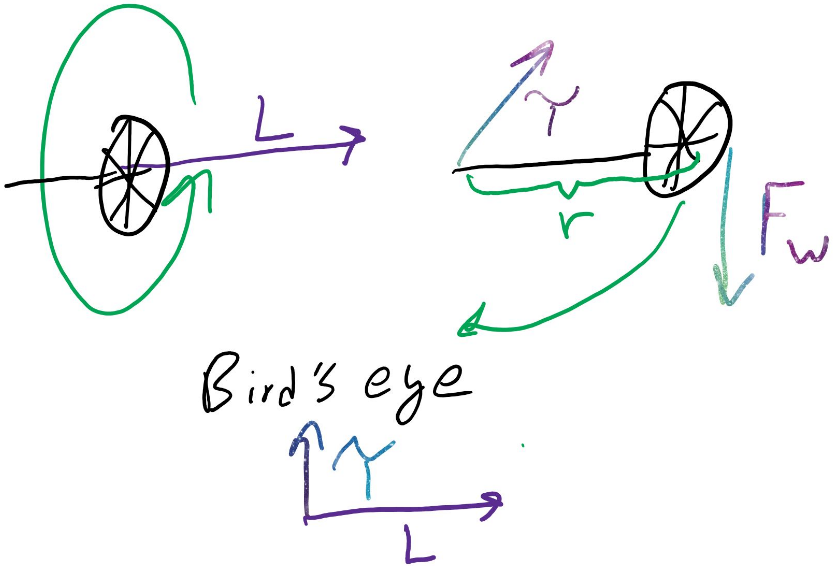
https://www.youtube.com/watch?v=ty9QSiVC2g0

The frick is going on?

Top left: we have angular momentum because the wheel has angular velocity.

Top right: we have torque because weight (force) pulls on a lever (the thing labeled r)

Bottom: putting the two things together



Continued

Left: torque is change in angular momentum over time. . . so the new momentum (denoted L’) points a little upward from what it started as

Right: if the wheel turns that way, by the right hand rule, our angular momentum matches L’

Review get baited we’re doing review I’m so tired

Angular momentum samples

I apply a torque of 5 mN to a my 4 kg m^2 moment of inertia body for 3 seconds. What is my angular momentum?

If I change my moment of inertia to 3 kg m^2, what is my new angular velocity?