Physics: from studies to space

Overview

1. Mechanics: how matter moves
2. Thermodynamics: how energy is transferred
3. Optics: how and what we see
4. Astronomy: how space and our universe operates

Mechanics: the study of motion

Keywords

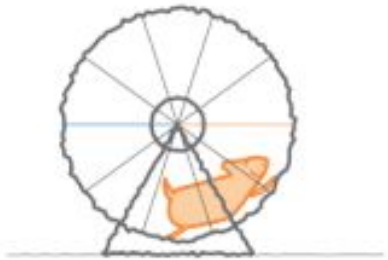
- Mass and inertia
  - Center of mass
- Force
- Momentum
  - Conservation of momentum
- Angular motion
- Moment of inertia
- Torque
- Angular momentum
  - Conservation of angular momentum

Mass

- Mass is the amount of matter in an object.
- The more mass an object has, the harder it is to move.
- Sometimes, mass is called inertia: the resistance of an object to motion.

Inertia Example #1: Why you need to wear a seatbelt (especially if you are a giraffe)

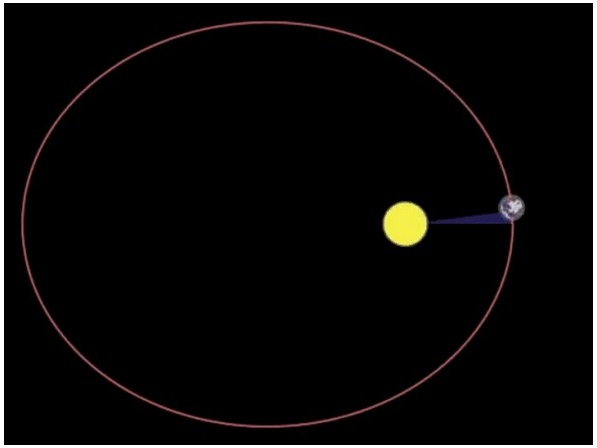
Inertia Example #3: What happens when a hamster stops running?



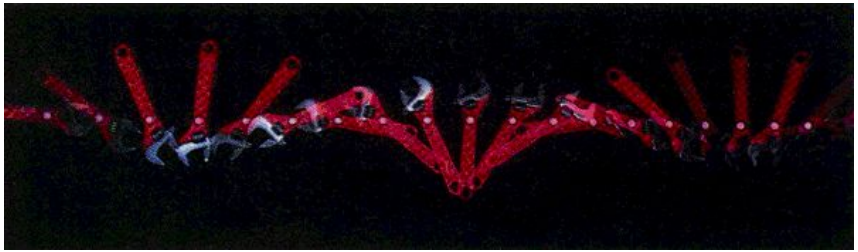
Demo: ball drop

Forces

- A force is anything that pushes or pulls on an object.
- Forces always cause objects to either speed up or slow down.



Center of mass



- Every object has a “center” when it comes to mass.
- All forces (things that push and pull) will act on the object’s center of mass.

Demo: human center of mass

Demo: center of mass of weird shape

Momentum

- Newton's first law: objects in motion will stay in motion until acted upon by an outside force.
- Momentum is a measure of how much an object wants to stay moving!
- If two objects are moving at the same speed, the heavier one has more momentum.

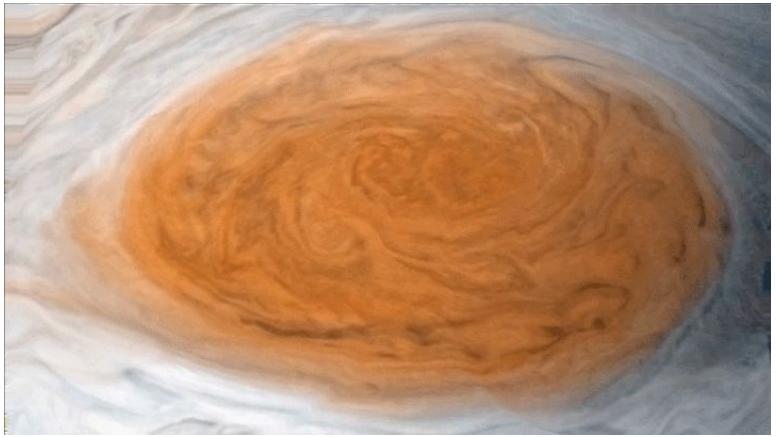
Conservation of momentum

- The total momentum of a system (in the absence of force) is conserved. That means it cannot change.
- If one object stops moving, another has to start moving faster and vice versa!

Demo: ball drop

Angular motion

- Objects can not only translate (move in a straight line), but they can also rotate.
- We can track how much an object rotates using angles!
- This is why rotation is called “angular” motion.



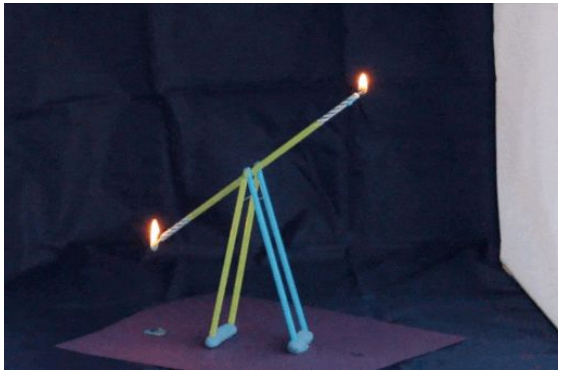
Demo: tangent

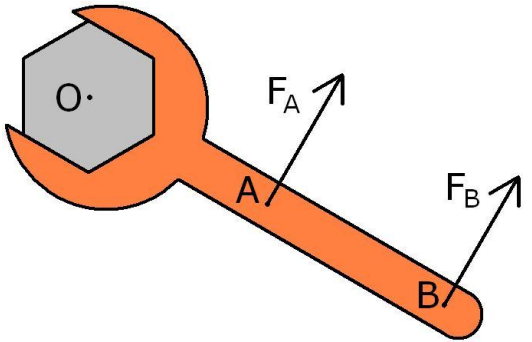
Moment of inertia

- Moment of inertia is the rotational analogue of mass.
- Objects with a higher moment of inertia are harder to rotate.
- If the mass of an object is spread out far, it is harder to spin!

Torque

- Force is what causes objects to speed up or slow down.
- Torque is what causes objects to rotate faster or slower.





Angular momentum

$L = I\omega$

L: angular momentum

I: moment of inertia

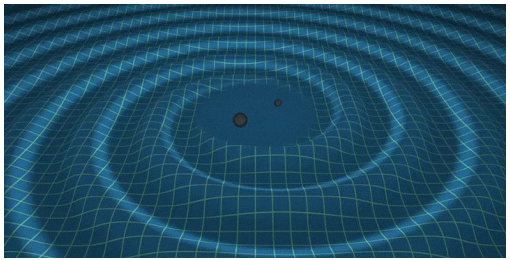
ω: angular velocity

- Objects that are spinning carry an angular momentum.
- Like regular momentum, objects with angular momentum want to keep spinning!
- Objects with higher moment of inertia will have higher angular momentums when rotating at the same speed.

Demo: spinning with weights

Conservation of angular momentum

- Unless a torque is applied, rotating objects will continue rotating.
- Decreasing the moment of inertia will cause an object to rotate faster!



Demo: bike wheel