Introductory Astronomy

Week 2: Newton's Universe

Clip 3: Newton!!

Motion

- State of motion is velocity $\vec{v}$ - speed and direction in $\frac{\mathrm{m}}{\mathrm{s}}$
- Rate of change of $\vec{v}$ is acceleration $\vec{a}$ in $\frac{\mathrm{m/s}}{\mathrm{s}} = \frac{\mathrm{m}}{\mathrm{s}^2}$
- Acceleration can be speeding, slowing, or turning and is directed in direction of change

Circular motion

- We found that $\vec{a}$ directed to center and of constant magnitude. If radius is R and speed v what is magnitude of a ?

Mechanics

- Acceleration due to a force applied by another object: $\vec{F} = m\vec{a}$
- m is a property of object mass in kg
- $\vec{F}$ is measured – in $\mathrm{N} = \frac{\mathrm{kg\,m}}{\mathrm{s}^2}$
- When object *A* applies a force $\vec{F}$ to *B*, then *B* applies a force $-\vec{F}$ to *A*

Weight and Mass

- Weight of an object is the force gravity applies to it
- We know objects fall with acceleration $g = 9.82 \, \frac{\mathrm{m}}{\mathrm{s}^2}$ so force of gravity is $F = mg$
- g is property of Earth
- My mass is $59 \ \mathrm{kg}$. My weight on Earth is

Conservation Laws

- Mathematical theorems follow from Newton
- Momentum $\vec{p} = m\vec{v}$ then $\vec{F}$ is rate of change of $\vec{p}$
- So if *A* and *B* act on each other, $\vec{p}_A + \vec{p}_B$ does not change – they exchange momentum but can't create or destroy it. Momentum conserved

More Conservation

- With a little more math, see that a circular version – angular momentum $L = mvR$ is also conserved
- This will be incredibly important to us – things in space spin

Energy

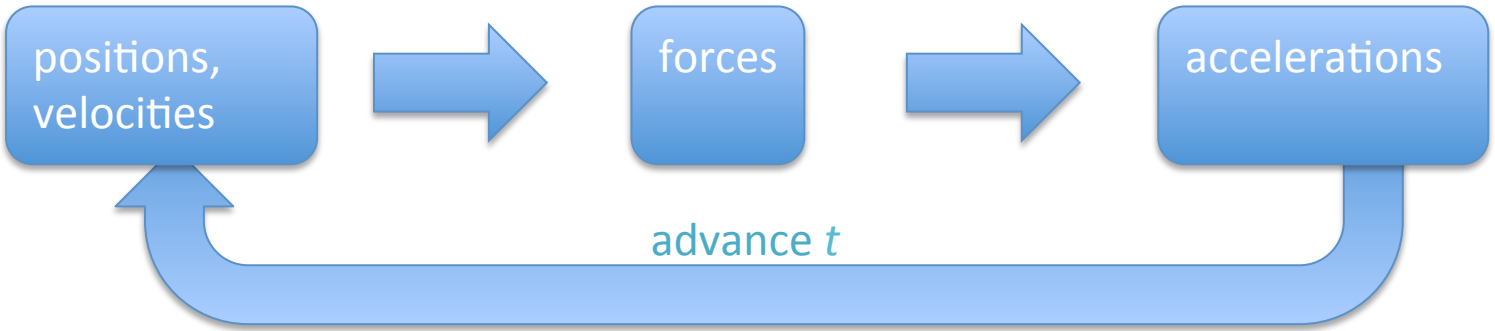
- If gravity is the only force acting on an object, can show that total energy is constant

$$E = \frac{mv^2}{2} + mgh$$

- In general, other forces act. Find that this introduces more kinds of energy: sound, light, heat, chemical, electric, nuclear, etc. but total is conserved
- Units of energy: $\mathrm{J} = \frac{\mathrm{kg\,m^2}}{\mathrm{s^2}}$

This is Everything

- $\vec{F} = m\vec{a}$. The rest is details
- If we can figure out forces this is a way to predict from where things are today where they will be in future (or were in past):



Credits

- Circular Motion animation: Mathematica
- Demonstration videos: Duke Media Services