Physics Class Notes

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Physics Class Notes

Try to do all 20 chapters. (cut out fluids?) 4 hours 20 minutes of class time every week.

Scientific notation review SI system: m (meters), kg (kilograms), s (seconds)

http://www.scaleofuniverse.com

Physics is the study of energy

Magnitude of a vector is another name for its length. It's essentially a quantity. It's the size of the thing you are measuring. Arrows are really useful for this.... How do I find components? Vectors have components. You've gotta have a reference frame. Usually we use the XY grid. Euclidean space. How do I find the magnitude of a vector if I have the angle and the magnitude?

Cross product review.

Note: R's built in %*% and crossprod do not give the correct results.
USE `pracma`

```
A <- 1:3
B <- c(-1, 0, 2)
C <- c(1, 1, 0)
library(pracma)
BC <- cross(B, C)
cross(A, BC)
```

```
## [1] -8 -5  6
```

```
# same result
(B * dot(A, C)) - (C * dot(A, B))
```

```
## [1] -8 -5  6
```

Motion

What do we mean when we say something is relative?

First we need to choose a reference frame.

X will represent the position of objects. X_0 is our initial position. X_f is our final position. Change is found by

$$\Delta x = x_f - x_0$$

How fast are we changing? Velocity vs. Speed, what's the difference.
Velocity is a vector. Position is technically a vector too.

$$v = \frac{\Delta x}{\Delta t}$$

This is only the average velocity. In general, X is a function of **time**. Time is the independent variable here. $X(t)$.

This is instantaneous velocity

$$v = \frac{dx}{dt}$$

What if velocity is changing?

$$\Delta v = v_f - v_0$$

Average acceleration is

$$a = \frac{\Delta v}{\Delta t}$$

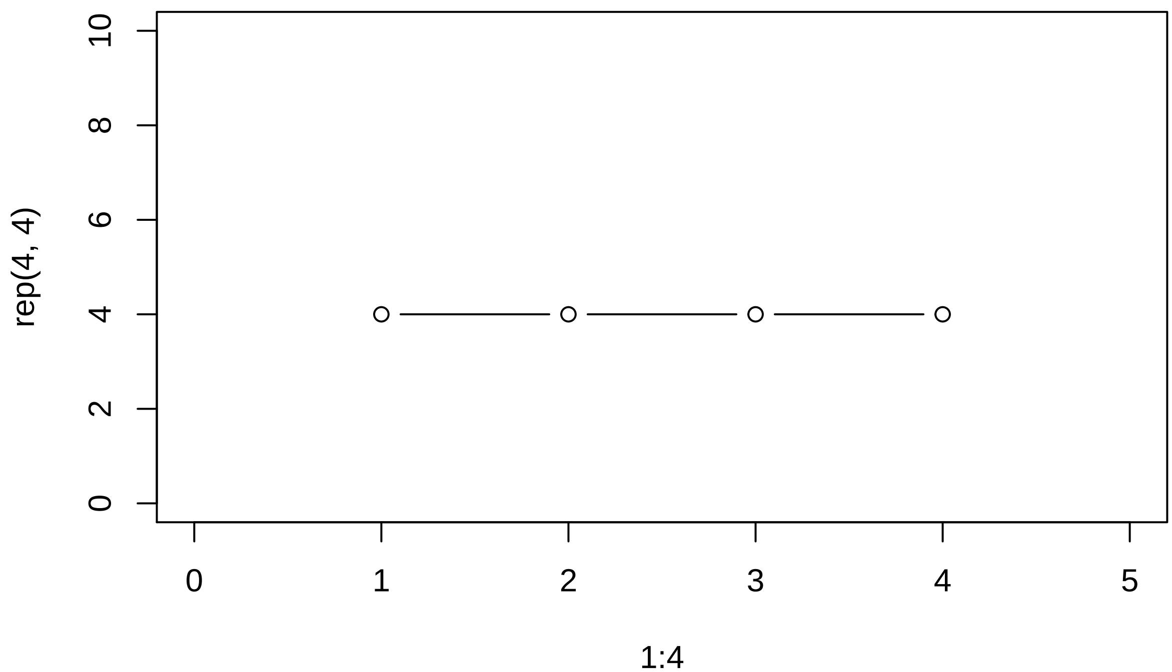
Instantaneous acceleration is

$$a = \frac{dv}{dt}$$

The derivative of acceleration is referred to as **jerk**.

Draw an x-t graph for an object that isn't moving.

```
plot(1:4, rep(4, 4), type = "b", ylim = c(0, 10), xlim = c(0, 5))
```



Try this:

$$a = \frac{dv}{dt}$$

$$dv = adt$$

$$\int dv = \int adt$$

First kinematic equation

$$v(t) = at + v_0$$

8-29-17

Still talking about linear motion.

$$x(t) = 3t^2 - 5t + 21$$

- What is the initial position of a particle?

$x(0) = 21$

- What is the initial velocity of the particle?

$x'(0) = -5$

- Find the acceleration of the particle?

$x''(0) = 6$

- How far has the particle traveled after 8 seconds?

$x(8) = `r3 * 8^2 - 5 * 8 + 21$

- How long does it take the particle to travel a distance of 52m?
  Set $x(t) = 52$ and solve for t. $52 = 3t^2 - 5t + 21 = 3t^2 - 5t - 31 = 0$ and just use the quadratic equation to solve.

- How fast is the particle traveling when it reaches this position?

Plug in the positive solution to the above quadratic into the first derivative of our function. $v(4.07) = 6(4.07) - 5$.

Reminder of our first kinematic equation

$$v(t) = at + v_0$$

$$v = \frac{dx}{dt}$$

$$dx = vdt$$

$$\int dx = \int vdt$$

$$x = \int v_0 + atdt = \int v_0 dt + \int atdt = v_0 t + \frac{1}{2}at^2 + C$$

where C is x_0, our initial position.

This is our second kinematic equation:

$$x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$$

Set $t = \frac{v - v_0}{a}$ and $a = \frac{v - v_0}{t}$ and solve.

Kinematic Equations

$$v_f = v_o + at$$

$$x_f = x_o + v_o t + \tfrac{1}{2} a t^2$$

$$v_f^2 = v_o^2 + 2a(x_f - x_o)$$

$$x_f = x_o + \tfrac{1}{2}(v_f + v_o) t$$

Figure 1:

How long does it take a rocket, traveling at a constant speed of 600 m/s to travel 1300 m?

Everything is known for this problem except time. So pick one of the equations that includes t in an easy way. (we used the 4th one).

If a car is initially traveling at a speed of 20 m/s and is accelerating at a constant rate of $6 m/s^2$. How long will it take to reach a speed of 40 m/s?

What is known? a, v_0, v_f.
Not known? t, x_f.
Use the first one for this.

Suppose you throw a rock straight up in the air with an initial speed of 20 m/s. Find the maximum height of the rock. (homework problem).

Known: $x_0 = 0, v_0 = 20 m/s, a = -9.8 m/s^2, v_f = 0$ Not : x_f, t

Don't forget that a is a vector. Make sure your signs are correct!!

Use the third one.

You are driving your car down state street at a constant speed of 15 m/s. All of a sudden a lost cow wonders onto the road 20 meters in front of you. You immediately apply the breaks and your car comes to a stop after 2.6 s. Do you hit the cow?

Use the 4th one.

Moving on to motion in 2D and 3D.

Orthogonality is important. The basis are independent from one another. (video of shooting and dropping a bullet and bowling ball feather drop in the worlds largest vacuum chamber. Spoiler alert: the hit the ground at the same time).

A component is simply a projection of a vector onto another reference frame.

Gravity doesn't care when dealing with orthogonal basis.

Recall def for vectors.

$$\bar{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

What about

$$\bar{r(t)} = x(t)\hat{i} + ...$$

Note: kinematic equations only work with one direction.

Time is NOT a vector. It is a scalar.

8-31-17

Two projection angles that add to 90 degrees will have the same projection distance.

(Phet interactive web app.) phet.colorado.edu

We want to know the range given two values, initial velocity and angle. v_0, θ. Start with y dimension since it helps us more to find t since we have $a = acceleration = 9.8\frac{m}{s^2}$.

$$v_{fy} = v_{v0y} + a_y t$$

With our example in class:

$$t = \frac{2v_0 sin(\theta)}{g}$$

$$R = \frac{2v_0^2 sin\theta cos\theta}{g} = \frac{v_0^2 sin(2\theta)}{g}$$

Now on to orbital mechanics.

Acceleration. If you are moving in a circle you are constantly changing direction so you are constantly accelerating.

Centripetal force is

$$F = \frac{mv^2}{r}$$

where m is the mass v is the velocity and r is the radius from the center.

Centripetal force always points towards the center. In this equation

$$a = \frac{v^2}{r}$$

Period is the amount of time it takes for something to happen once.

The orbital period is

$$time = \frac{2\pi r}{v}$$

9-5-17

Newton's Laws: - Inertia - $F = ma$ - $F_{12} = F_{21}$

Inertia is the tendency of an object to resist changes in its motion.

Newton's 2nd Law is often considered the most fundamental law of nature. The foundation for all motion.

$$F_{net} = ma$$
$$\sum F = ma$$