Life in Two Dementias

Auburn Mountainview: Physics

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Hidden Benefits

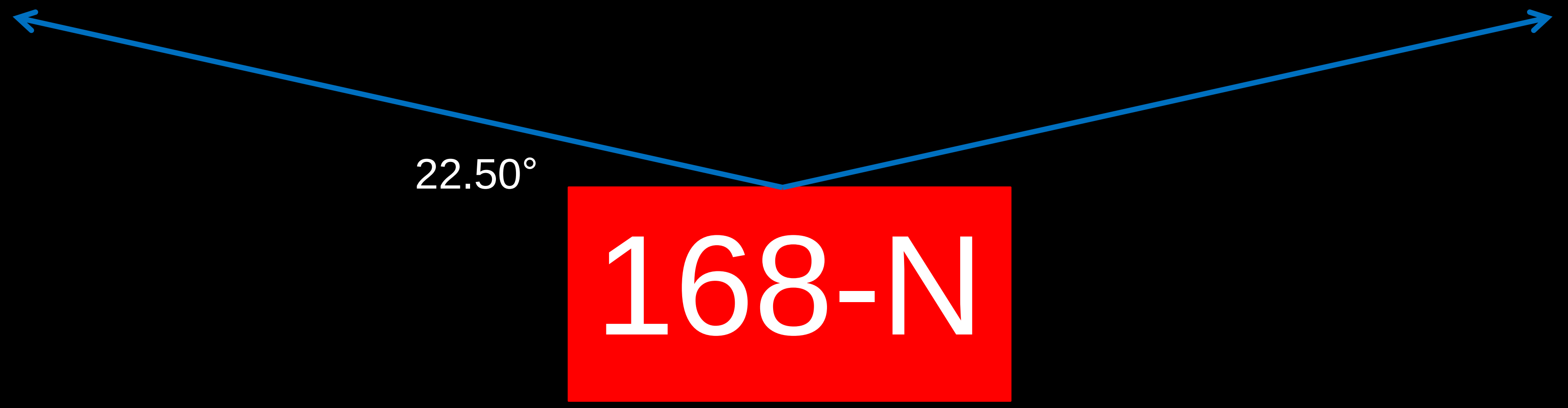
- During the first look at kinematics moving in multiple dimensions at the same time was avoided.
  - It would be rather boring to only walk back and forth. (2D)
  - Airplanes would also be ineffective if they could not move up and down while traveling. (3D)

Forces in 2D

- In the last unit it was sometimes necessary to break down a vector into x and y components.
  - Forces not parallel or perpendicular.
- This will be the main principle guiding Forces and Motion in 2D.
  - Break down the vector into x and y components!

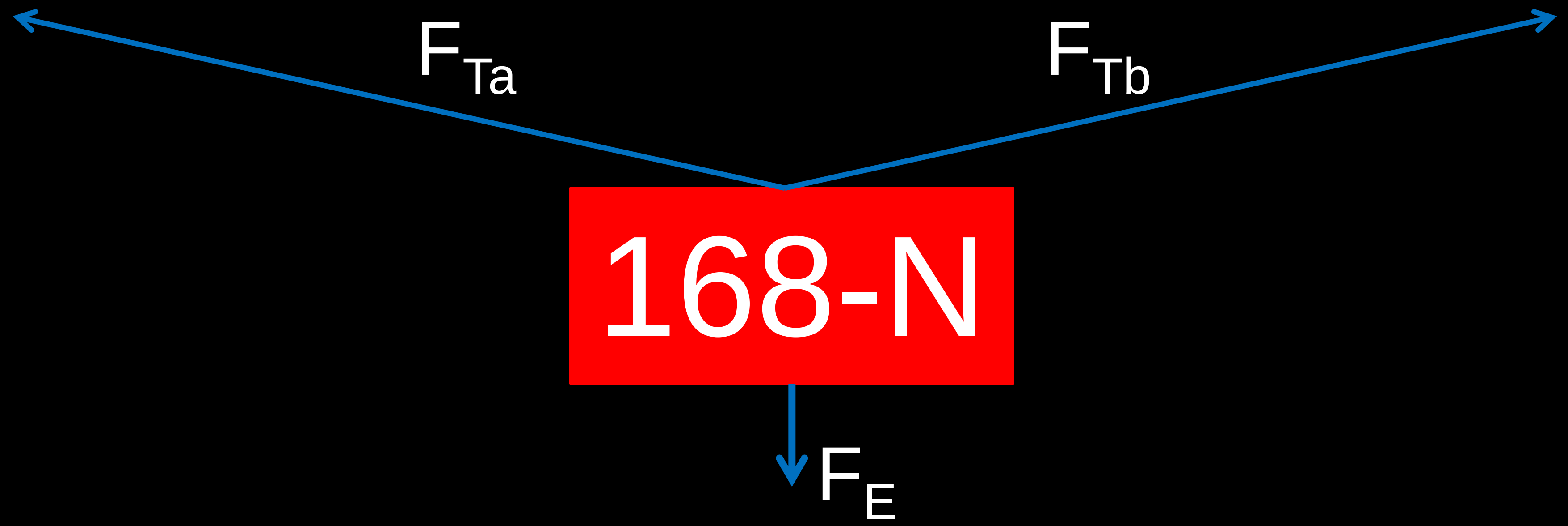
2D Forces Example

- A sign (168.00-N) is hanging over the road, suspended by two cables both attached at a 22.50° angle. What is the tension in one of the ropes?



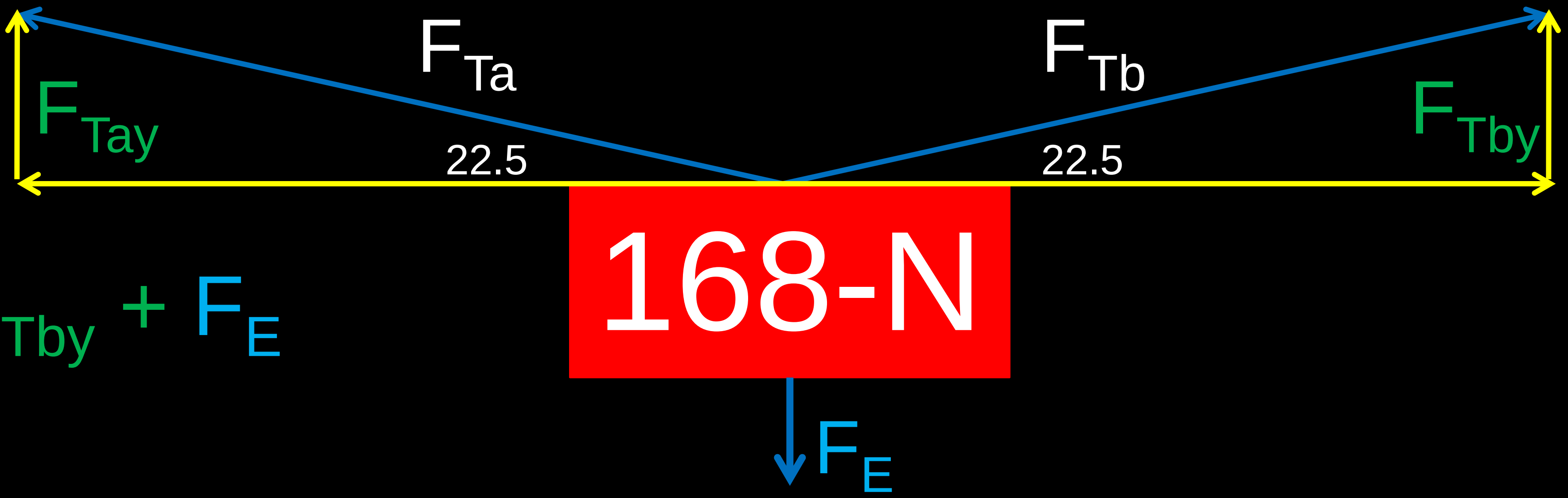
2D Forces Example

- The sign is at rest ∴ both F_{NETy} and F_{NETx} = 0.
- Both ropes are at an angle and should be broken down into individual x and y components.



2D Forces Example

- Both ropes hold half the Weight ($F_{Ta} = F_{Tb}$)



$F_{NETy} = 0\text{-N}$

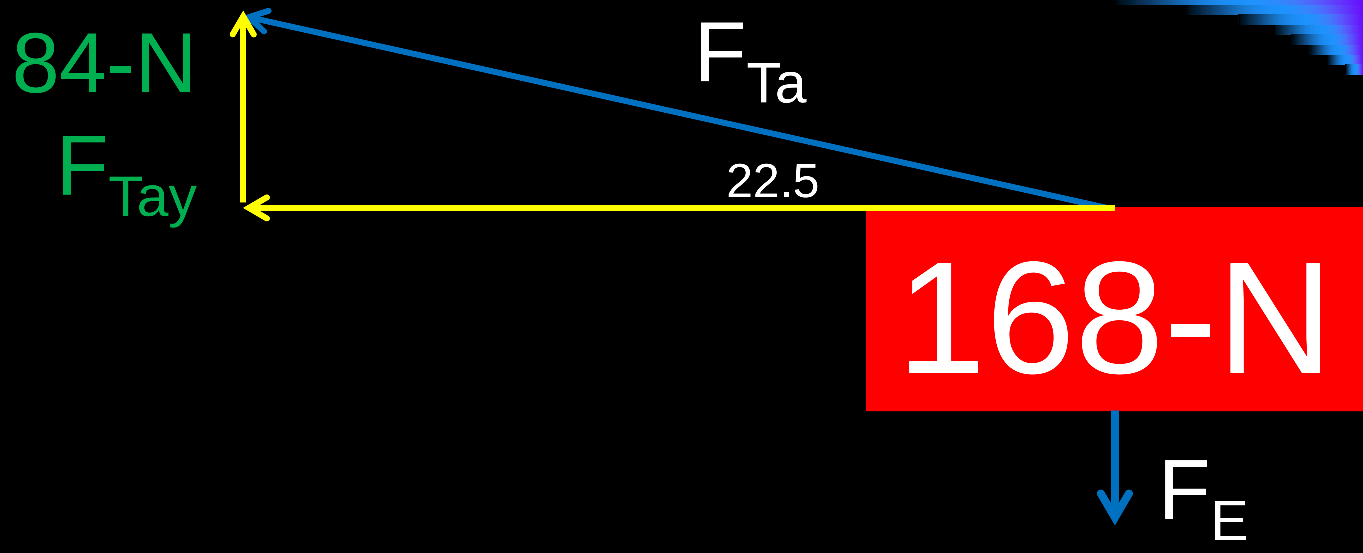
$F_{NETy} = F_{Tay} + F_{Tby} + F_E$

$F_{Tay} = F_{Tby}$

$0\text{-N} = 2F_{Tay} - 168.00\text{-N}$

$F_{Tay} = 84.00\text{-N}$

2D Forces Example



$$Sin\ \theta = \frac{O}{H} \ \ldots\ Sin\ \theta = \frac{F_{Tay}}{F_{Ta}}$$

$$F_{Ta} = \frac{84 - N}{Sin\ 22.5}$$

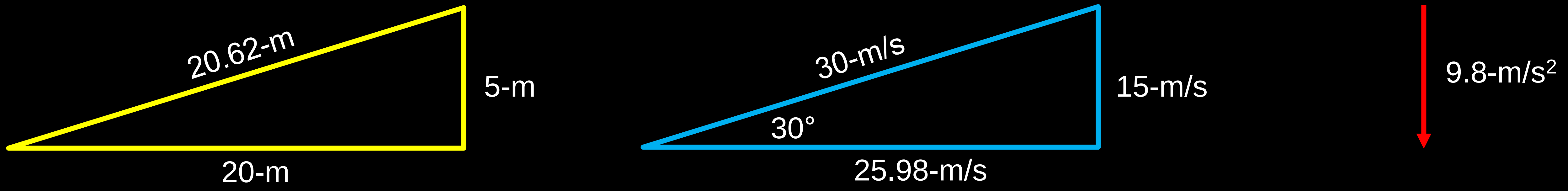
$$F_{Ta} = 219.50 - N$$

Motion in 2D: Starting Steps

- Break vectors apart into components.
  - Treat theses initial motions separately!
- KEY: An object will only change v due to the force of gravity which is only in the y direction.
  - y axis: solve for v_{yo} and know a = (-)9.8-m/s^2.
  - x axis: solve for v_{xo} and know a = 0-m/s^2 $\therefore$ $v_{xo} = v_x$.

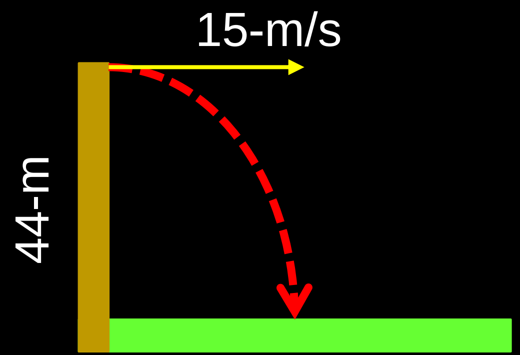
Motion in 2D: Starting Steps

- Do not mix d, v & a vectors
  - A ball is kicked 20-m and reaches a max height of 5-m.
    - This is actually not a very helpful triangle.
  - A ball is kicked 30° at 30-m/s.
    - Must break into components.
  - No acceleration in x after kick so nothing to break down.

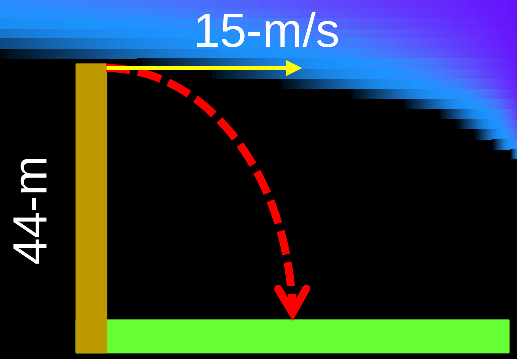


2D Motion Example I

- A stone is thrown horizontally 15.00-m/s off the top of a 44.00-m cliff.
  A. How far from the base of the cliff does the stone land?
  B. How fast is it moving before it hits the ground?
- While it seems very little information is given, this is all that’s needed.



2D Motion Example I cont.



A. How far from the base of the cliff does the stone land?

- Start: Time to land? (determined by gravity: y axis).

$$p_y = v_{oy} + .5at^2$$

$$-44-m = 0 - 4.9 - \frac{m}{s^2}t^2$$

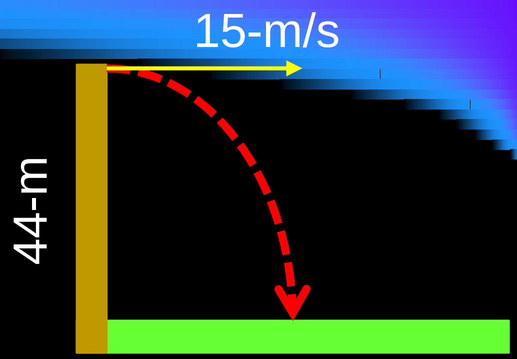
$$t^2 = 8.97 - s^2$$

$$t = 2.9965 - s$$

p_y = -44-m
v_{0y} = 0-m/s
a_y = -9.8-m/s^2
t = x

Time is the only variable that is always the same in both axes!

2D Motion Example I cont.



A. How far from the base of the cliff does the stone land?

- Since v_{ox} does not change $v_{ox} = \bar{v}$. KISS!

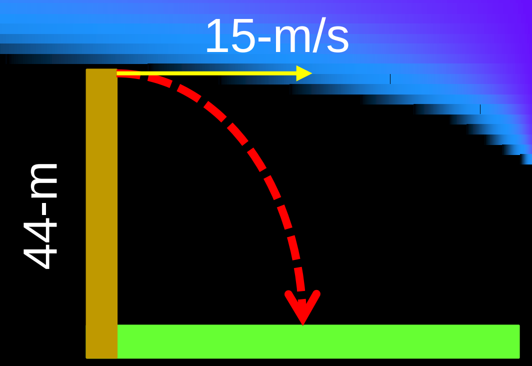
$$v_{ox} = \frac{p_x}{t}$$

$$15 - \frac{m}{s} = \frac{p_x}{2.99 - s}$$

p_x = x
v_{0x} = 15.00-m/s
t = 2.99-s

$$p_x = 44.95 - m$$

2D Motion Example I cont.



B. How fast is it moving before it hits the ground?

- The final velocity of both x and y is needed.

$$v_{fy}^2 = v_{oy}^2 + 2ap$$

$$v_{fy}^2 = 0 + 2 \cdot -9.8 - \frac{m}{s^2} \cdot -44 - m$$

$$v_{fy}^2 = 862.40 - \frac{m^2}{s^2}$$

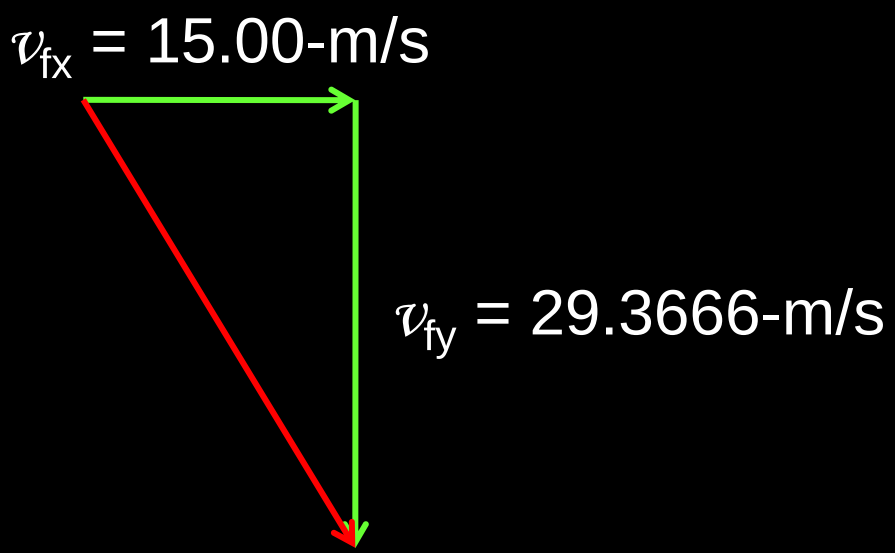
$$v_{fy} = 29.3666 - \frac{m}{s}$$

v_{0y} = 0-m/s
v_{fy} = x-m/s
a_y = -9.8-m/s^2
p = -44.00-m

2D Motion Example I cont.

B. How fast is it moving the instant before it hits the ground?

- Add the vectors. (Pythagorean theory)



$$v_f^2 = v_{fy}^2 + v_{fx}^2$$

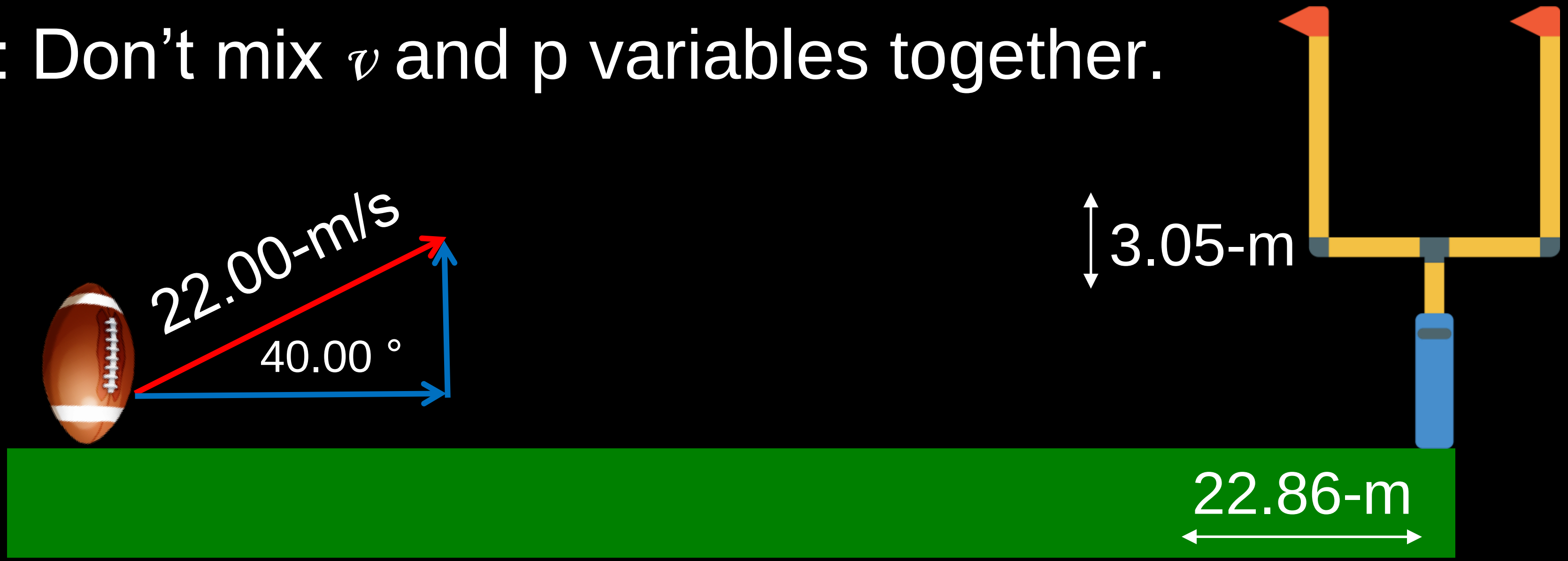
$$v_f^2 = (29.36 - \frac{m}{s})^2 + (15 - \frac{m}{s})^2$$

$$v_f^2 = 1087.40 - \frac{m^2}{s^2}$$

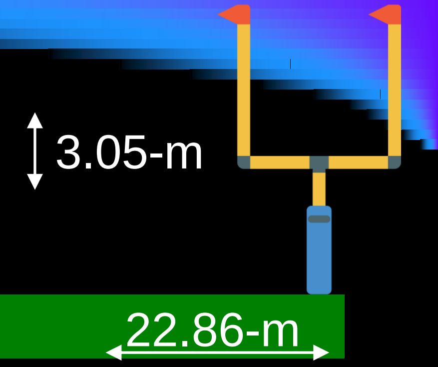
$$v_f = 32.98 - \frac{m}{s}$$

2D Motion Example II

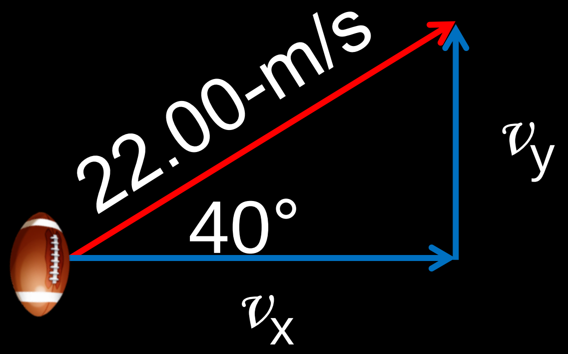
- A kicker attempts to make a 25-yd (22.86-m) field goal with a initial kick of 22.00-m/s at 40.00° to the horizontal. If the goal post is 3.05-m high, is it a good kick?
  - A good way to set this up is with a T chart for the variables
  - Picture: Don’t mix v and p variables together.



2D Motion Example II cont



- Start: Break down the vector and make a T-Chart for reference.



x	y
$\bar{v}$ = 16.85=m/s	v_o = 14.14=m/s
p = 22.86-m	p > 3.05-m?
t =	a = -9.8-m/s^2
	t =

Position in the y is not really given, rather it is a number to test for,

$$H \cdot \cos\theta = A$$

$$\bar{v}_x = 22 - \frac{m}{s} \cdot \cos 40$$

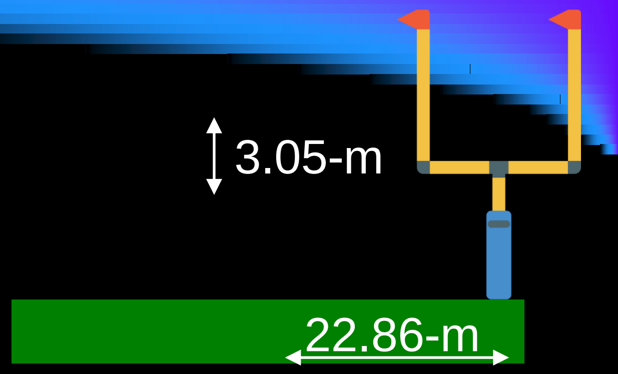
$$\bar{v}_x = 16.8529 - \frac{m}{s}$$

$$H \cdot \sin\theta = O$$

$$v_{oy} = 22 - \frac{m}{s} \cdot \sin 40$$

$$v_{oy} = 14.1413 - \frac{m}{s}$$

2D Motion Example II cont



- At what time does it to get (p_x) to the post (t)
- How high the ball is at that time (p_y)
- Is the height more or less than 3.05-m?

x	y
$\overline{v}$ = 16.85=m/s	v_o = 14.14=m/s
p = 22.86-m	p > 3.05-m?
t =	a = -9.8-m/s^2
	t =

$$\bar{v}_x = \frac{\Delta p}{\Delta t}$$

$$16.85 - \frac{m}{s} = \frac{22.86 - m}{\Delta t}$$

$$\Delta t = 1.3564 - s$$

$$p_y = v_{oy}t + .5at^2$$

$$p_y = 14.14 - \frac{m}{s} \cdot 1.36 - s + .5 \cdot -9.8 - \frac{m}{s^2} \cdot (1.36 - s)^2$$

$$p_y = 19.18 - m - 9.02 - m$$

$$p_y = 10.17 - m$$

$$p_y > height\ of\ goal \ldots yes$$

Circular Motion

- Newton's 1st Law states that an object tends to travel in the same direction, so how do things travel in a circle?
  - A force must ‘pull’ the object off course.
- Thought: If a yo-yo is swung overhead and the string gets cut what happens to the yo-yo?
  - The string (which is held by the hand) keeps it from going in a straight direction.

Getting math involved

- Period (T): Time an object takes to go one revolution (s).
  - Period is inverse of frequency. $f = 1/T$ (Hz).
- $v_c = 2\pi r / T$
- $a_c = v^2 / r$. (Always towards center)

So when related to forces:

$$F_{NETc} = ma_c \text{ (Also towards the center)}$$

- Combined
  $$F_{NETc} = m \cdot v_c^2 / r$$

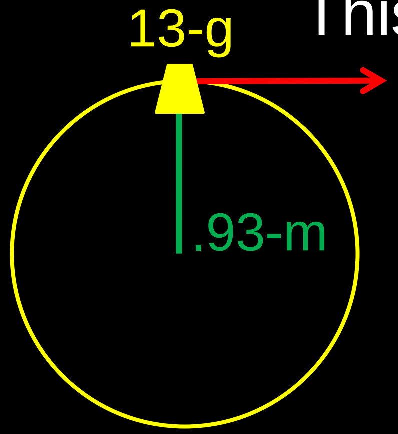
  Expanded
  $$F_{NETc} = m(4\pi^2 r / T^2)$$

Against Conventional Wisdom

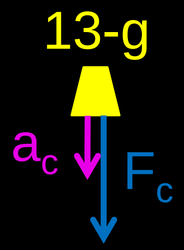
- Why then, when driving in a car and going around a curve, are passengers thrown to the outside of the car (away from the F_{NET})?
  - Remember Newton's first law… all passengers will want to travel in the direction they were moving.
  - The car door/seatbelt pushes you back into the curve.

Circular Motion Example

- A 13.00-g rubber stopper is attached to a .93-m string. The stopper is swung overhead, making one revolution every 1.18-s. What is the tension force by the string on the stopper?



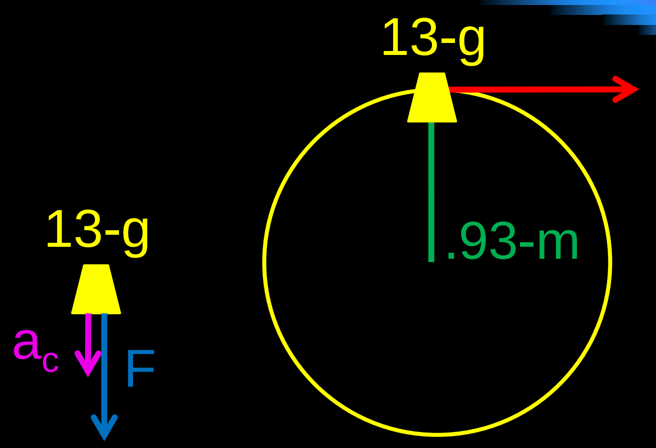
This picture is an overhead view.



Free Body ($F_{gravity}$ is into the screen) so it does not interact with the F_c.

CM Example cont.

- Solve using the expanded F_{NET} formula.



$$F_T = \frac{m4\pi^2 r}{T^2}$$

$$F_T = \frac{.013 - kg \cdot 4\pi^2 \cdot .93 - m}{(1.18 - s)^2}$$

$$F_T = \frac{.4772 - kg \cdot m}{1.3924 - s^2}$$

$$F_T = .3427 - N$$

m = .013-kg
r = .93-m
T = 1.18-s

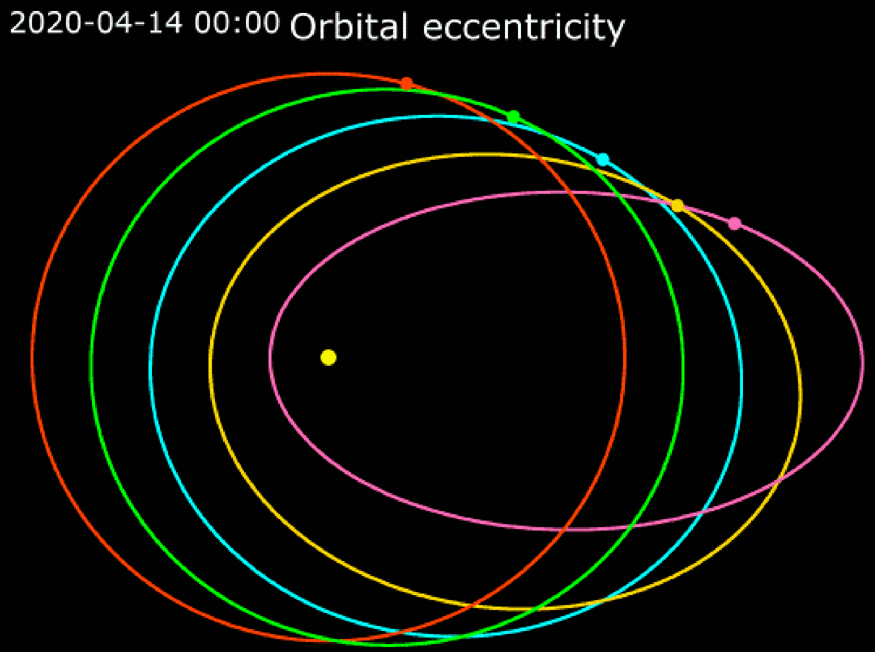
$$F_T = 3.43x10^{-1} - N$$

Kepler's Laws of Planetary Motion

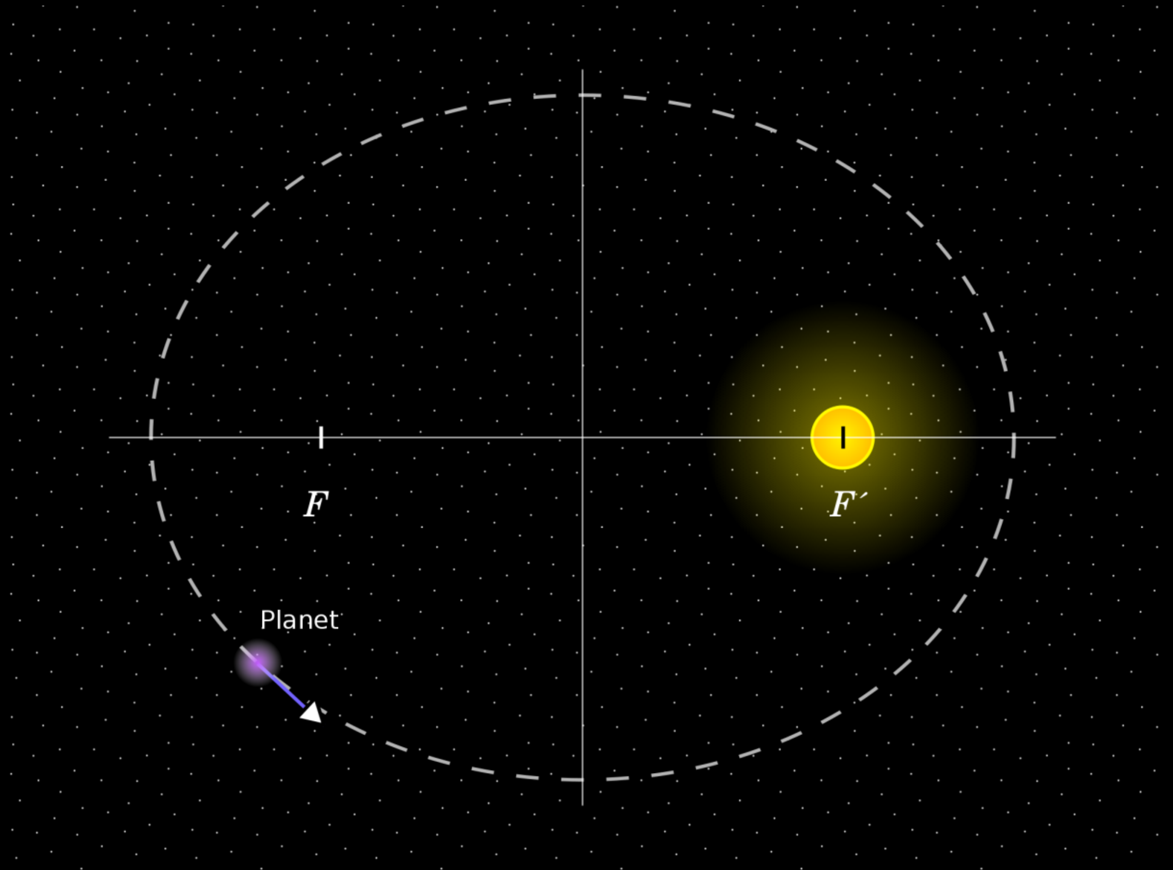
- Astronomer Johannes Kepler using the precise observations and data of Tycho Brahe developed three laws of planetary motion.
  - These laws further validated the sun centered model and led way for Galileo's laws of gravitation.

Kepler's Laws of Planetary Motion

1. The orbit of every planet is an ellipse with the Sun at one of the two foci.

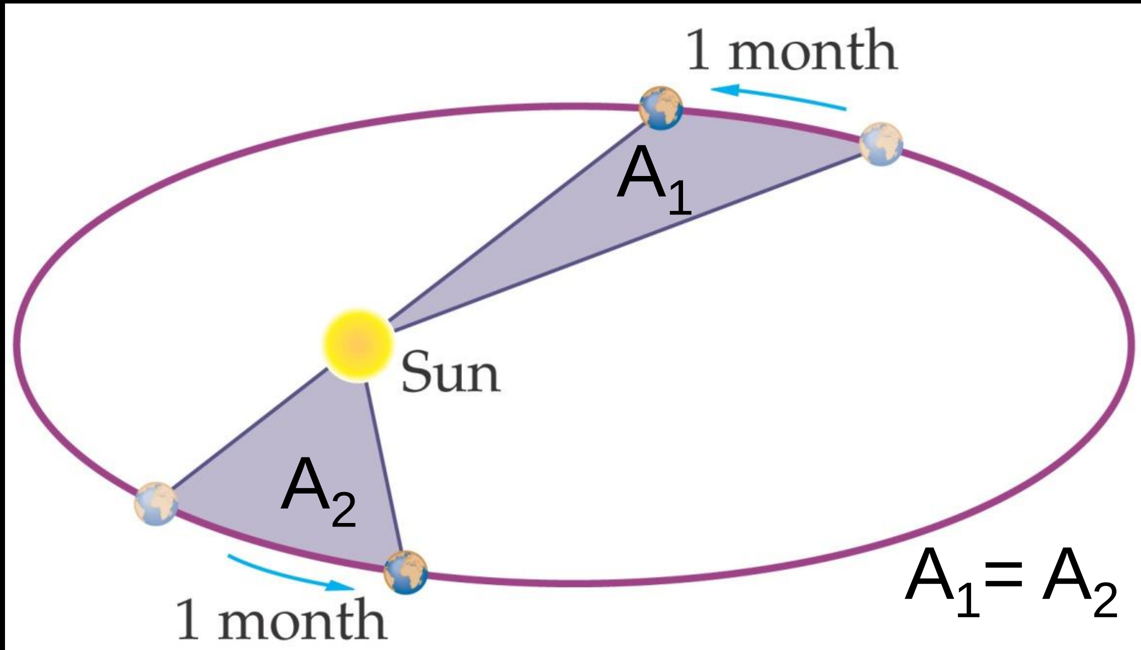


Eccentricity: 0 .2 .4 .6 .8



Kepler's Laws of Planetary Motion

2. A line joining a planet and the Sun sweeps out equal areas during equal intervals of time.
   - A planet will travel faster the closer it is to the sun.



Kepler's Laws of Planetary Motion

3. The square of the orbital period (T) of a planet is proportional to the cube of the semi-major axis (R) of its orbit.

$$\frac{T^2}{R^3} \propto k$$

$$\frac{T_p{}^2}{R_p{}^3} = \frac{T_E{}^2}{R_E{}^3}$$

If a planet's (Earth) data is known, then the formula becomes solvable. (365.25-days, 1-AU)

Kepler's Laws of Planetary Motion

- Mercury orbits the sun every 88 earth days. How far is it from the Sun (in AU)?

T_m= 88-d
R_m=
T_E= 365.25-d
R_E= 1.00-AU

$$\frac{T_m^2}{R_m^3} = \frac{T_E^2}{R_E^3}$$

$$\frac{(88 - days)^2}{R_m^3} = \frac{(365.25 - days)^2}{(1 - AU)^3}$$

$$R_m = \sqrt[3]{\frac{7744}{133407} - AU^3}$$

$$R_m = .3871 - AU$$

$$\boxed{R_m = 3.87x10^{-1} - AU}$$