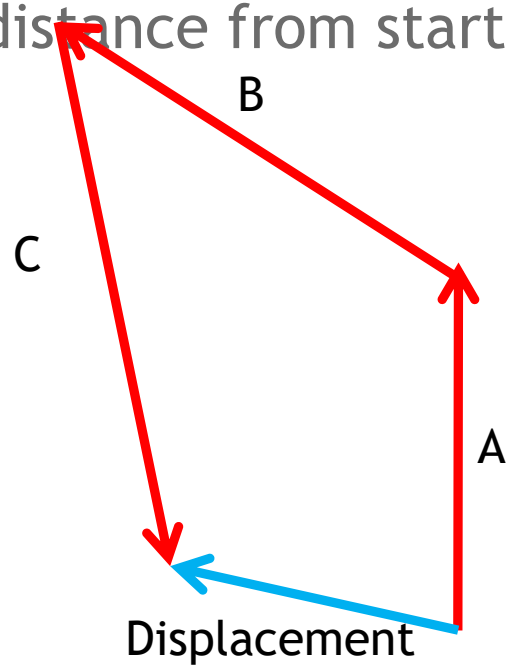
# VECTORS

# VECTOR & SCALAR

- 2 types of quantities
  - Vector
    - Describe magnitude & direction
    - Examples of vector quantities… Velocity, force, acceleration, displacement
  - Scalar
    - Describe only magnitude
    - Examples of scalar quantities… mass, time, distance, speed

# DISTANCE & DISPLACEMENT

- Distance
  - Total length travelled,  what your odometer would read for a car trip.
  - Scalar Quantity
- Displacement
  - Total length from starting point to ending point. Meaning the straight line distance from start to end
  - Vector Quantity

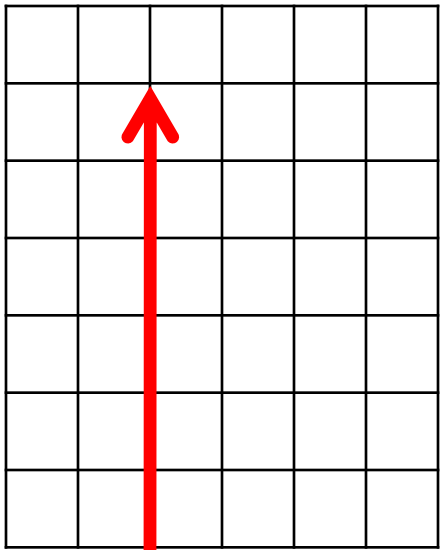



**Distance** equals the sum of the magnitudes of A,B,&C

**Displacement** equals magnitude of blue vector

# HOW TO DRAW VECTORS

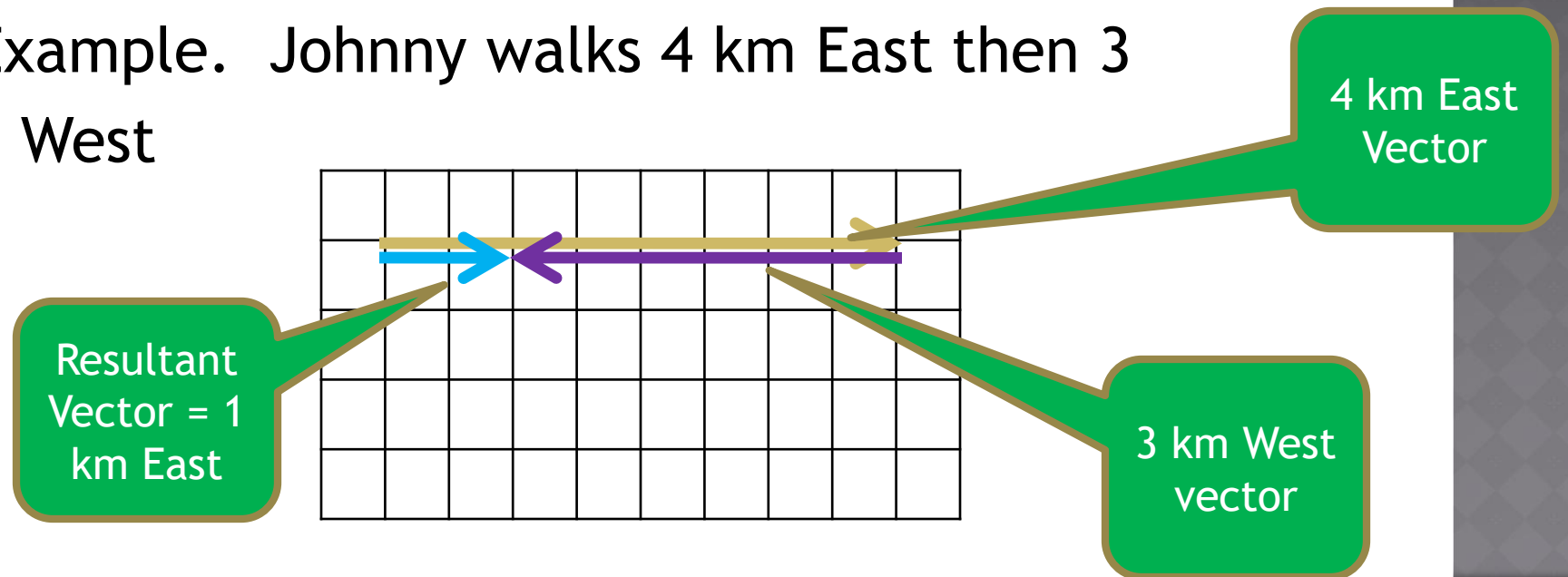
- Vector arrows are scaled representations of a vector quantity
  - The direction of the arrow tells us the direction
  - And the length of the arrow shows (combined with the scale) what the magnitude of the vector is
  - Ex. 30 km North (scale→ 1 cm= 5 km)



# FINDING THE RESULTANT VECTOR ..

- Resultant -- One vector that represents the combination of 2 or more vectors.
- To find the resultant means to combine (or resolve) vectors.
- Any number of vectors can all be combined together to create one resultant vector.

- Example. Johnny walks 4 km East then 3 km West



# FINDING RESULTANT PROCEDURE

- 1) Determine a proper scale for drawing
- 2) Draw first vector to scale
- 3) Draw 2nd vector to scale, with its tail connected to the head of the first
  - Note, it does not matter which vector is drawn first
  - Draw any other vectors (the third, fourth…etc.) in the same fashion
- 4) Draw the Resultant from the **tail of the first vector to the head of the last** to show proper direction
- 5) Determine the magnitude and direction of the resultant.
  - Determine mathematically
  - OR determine graphically

# DETERMINING MAGNITUDE OF RESULTANT MATHEMATICALLY

- When resultant vector creates a right triangle, you can use pythagorean theorem to determine length of the hypotenuse

- $A^2 + B^2 = C^2$ with C being the resultant

- So to solve for C the pythagorean becomes
  - $C = \sqrt{A^2 + B^2}$

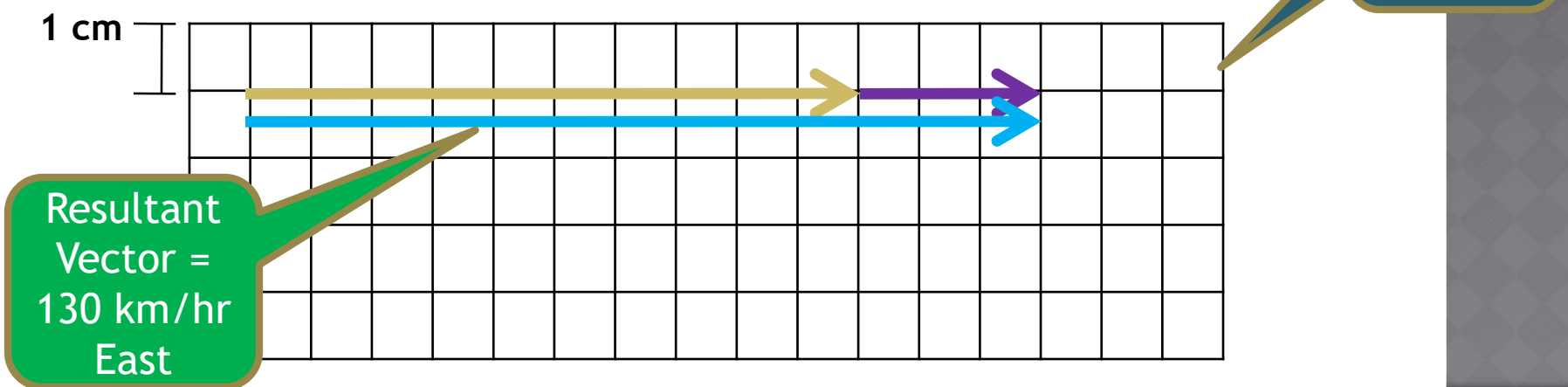
# DETERMINING MAGNITUDE OF RESULTANT GRAPHICALLY

- Measure length of the resultant on your paper
- Use scale to bring back into the vector units
- For example… Scale is 1 cm = 30 m/s
  - You measure resultant to be 5 cm, so this means that the magnitude of your resultant is 5 x 30 or 150 m/s
  - This method involves more measuring and not so much math

  - You should be able to find the magnitude of the Resultant both Mathematically and Graphically!!!!

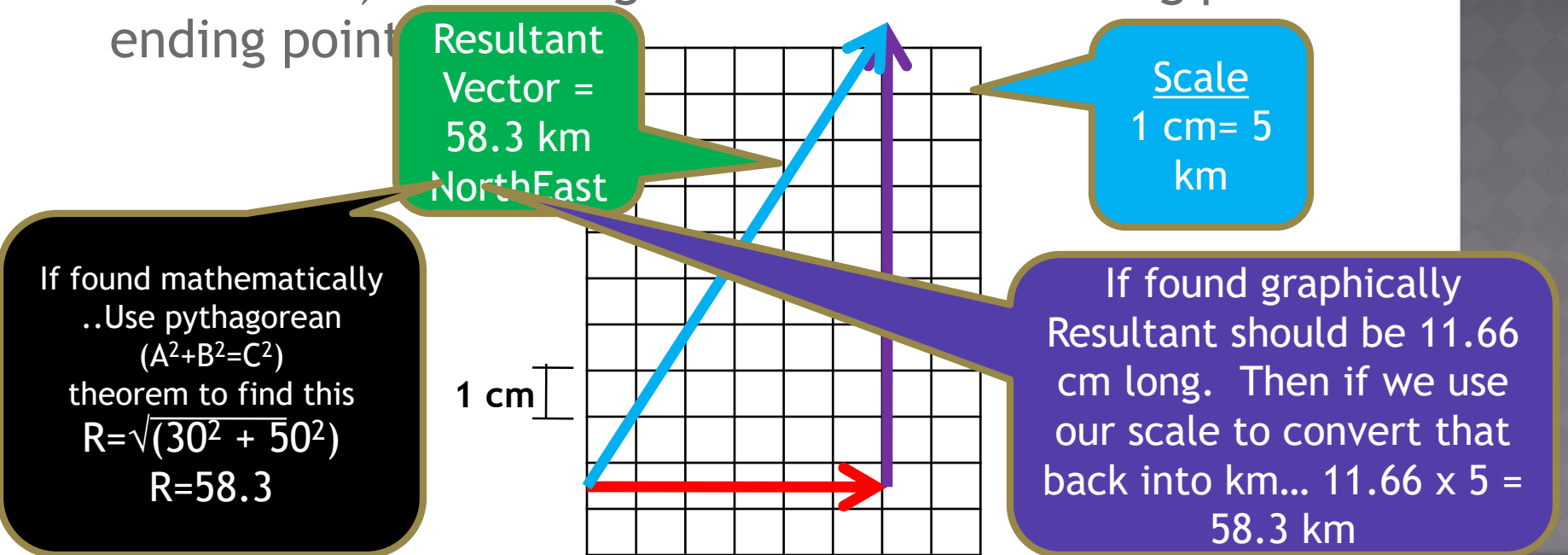
# ANOTHER EXAMPLE

- Even though displacement vectors seem to make the most sense, this process works for any type of vectors
- Ex. A plane is flying with an engine speed of 100 km/hr going East, but it is also encountering a 30 km/hr wind directed towards the East. What is the plane's resultant velocity??



# VECTOR COMBINATIONS IN 2-D

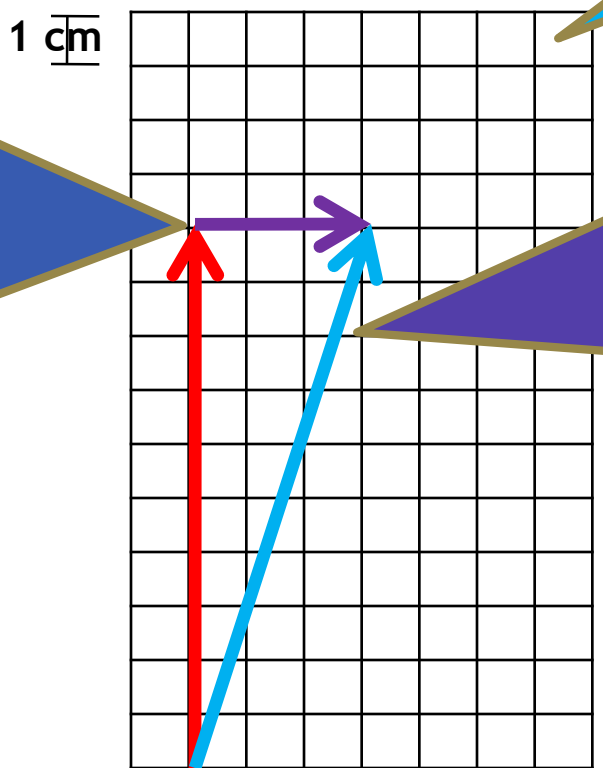
- If vectors are in two different planes (i.e. One going North and another going West) then that would be considered to be in 2 dimensions
- We can also combine vectors this way.
- For example. A car drives 30 km East, then 50 km North. What was the cars resultant displacement?
  - (they are basically asking you what was the car's net movement)…. Drawing an arrow from starting point to ending point



# ANOTHER 2-D EXAMPLE

- A plane flying due North with a speed of 200 km/hr encounters a strong eastern wind of 60 km/hr

Scale
1 cm= 20 km/hr




Red arrow should be 10 cm long, purple arrow should be 3 cm long

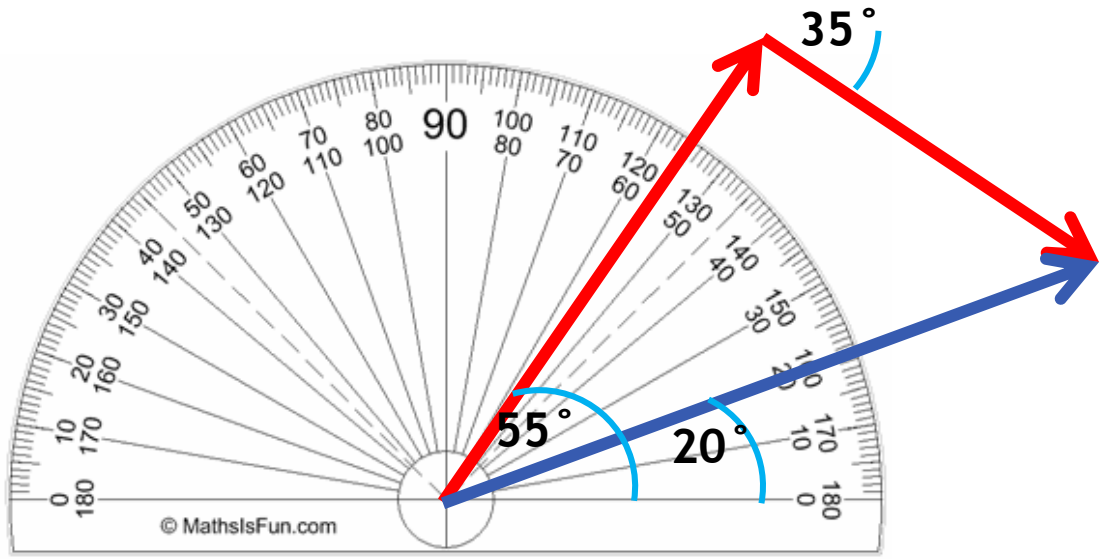
To find GRAPHICALLY.. Resultant will be measured to be 11.44 cm long. Multiply that by 20 to get into km/hr and we get **R = 228 km/hr**

# DIRECTION OF RESULTANT

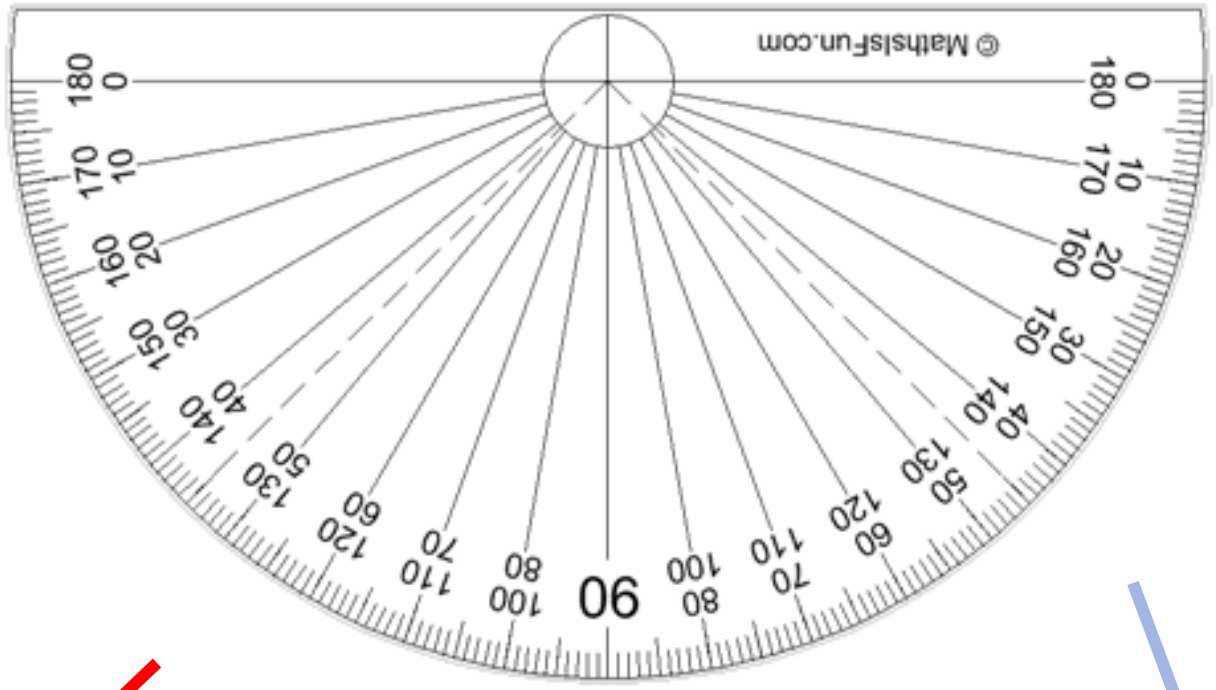
- When finding the resultant it is important to include direction
- Usually resultants will not be directly in one of the four (N,E, S, W) directions
- Use ‘in between’ directions… NE, NW, SE, or SW
- Sometimes you will be asked to include an angle to give a exactly specific direction
- So it could read as 30 degrees N of W
- The original vectors can also have a ‘in between’ directions, and you would have to draw and determine resultant just as before… except you would use a protractor to measure the angle.

# A HARDER EXAMPLE

Find the resultant of these two vectors… 30 km at 55˚ NE and 20 km at 35˚ SE

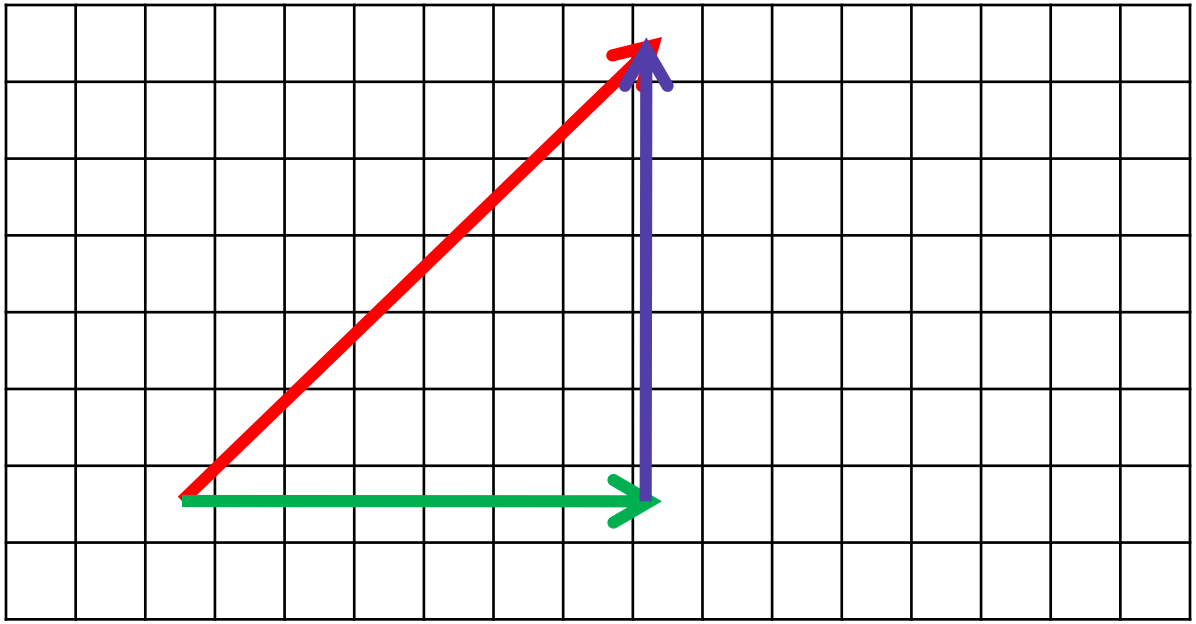


# 15 M/S 42° SW  20 M/S AND 25° SE



# COMPONENTS OF VECTORS

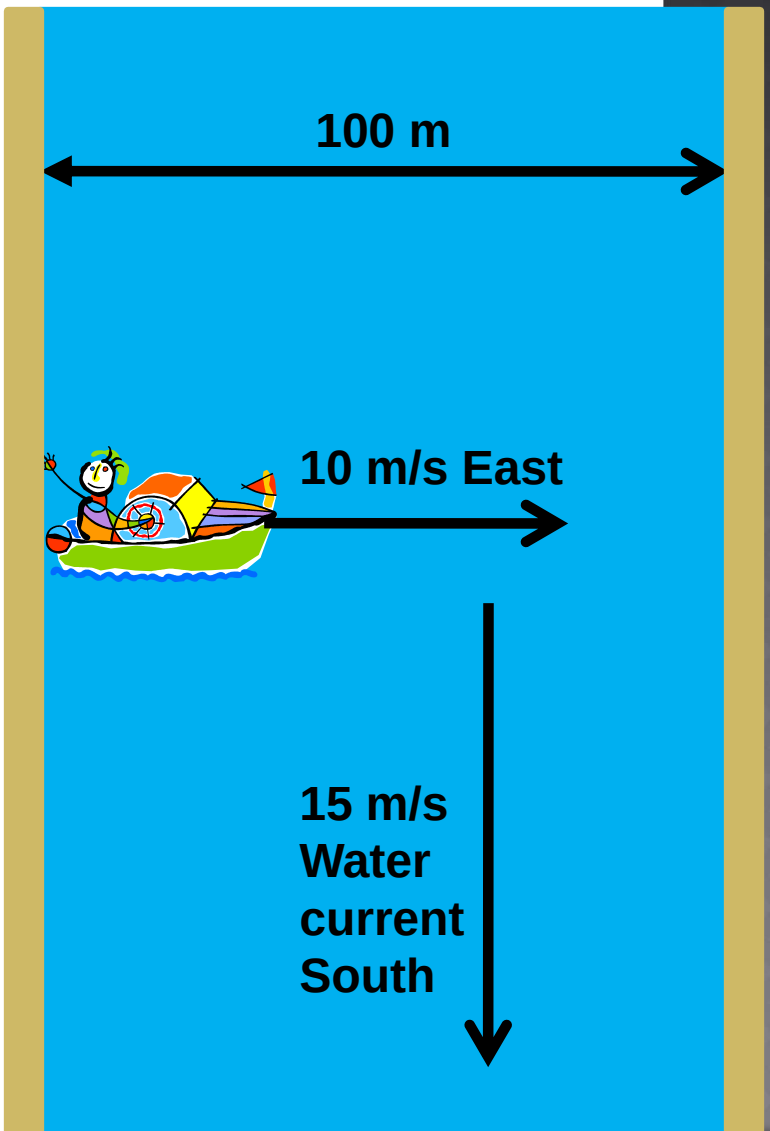
- Now that we know how to find a resultant..
- We can also do the reverse process
- Finding Horizontal and Vertical components of vectors…
- In other words we are breaking down a vector into its two individual parts
  - Ex. Telling someone how far you went East or how far you went North



# COMPONENTS OF VECTORS

- You can find components graphically by the same method as before
  - Using a scale, drawing, etc…
- If a vector is going directly N, E, S, or W , then it has no components
- If N or S then only vertical component
- If E or W then only horizontal component
- **Horizontal and Vertical components do not affect each other !!**
  - **They act separately**
  - **For instance ….  Thrown or launched objects**
  - **Gravity**
  - ***Boat crossing a river***
  - **Monkey / Gun Example**
  - **Bullet Example**

# Which boat reaches the opposite shore first???

# ANSWER

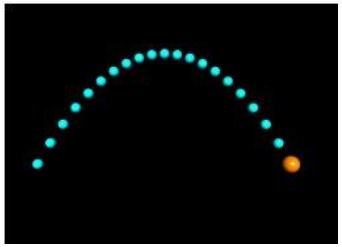
T-Pain is ON A BOAT…. And he says it doesn't matter which one.

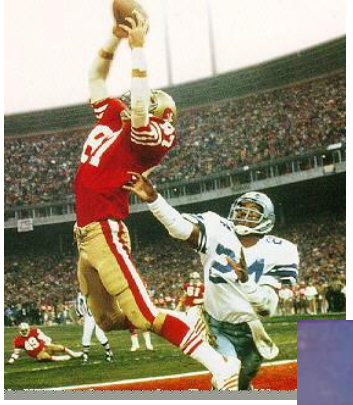
- **Both boats reach at same time** because only the horizontal component affects how long it takes to reach the opposite shore

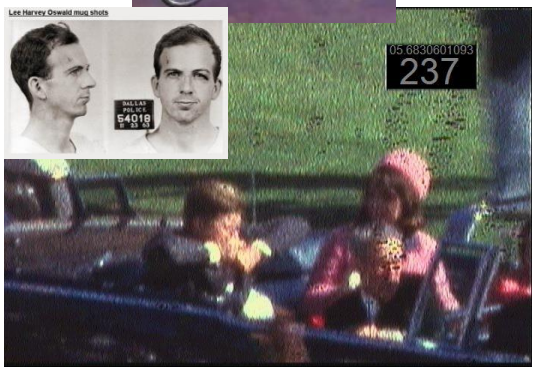
- The boat with current will move faster, take a different path, and go a greater distance…. BUT still reaches the opposite shore at the same time

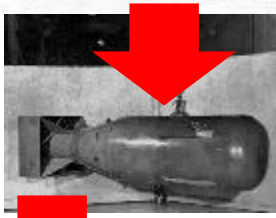
- B/c Horizontal components ARE NOT affected by Vertical components of Velocity

# Projectile Motion





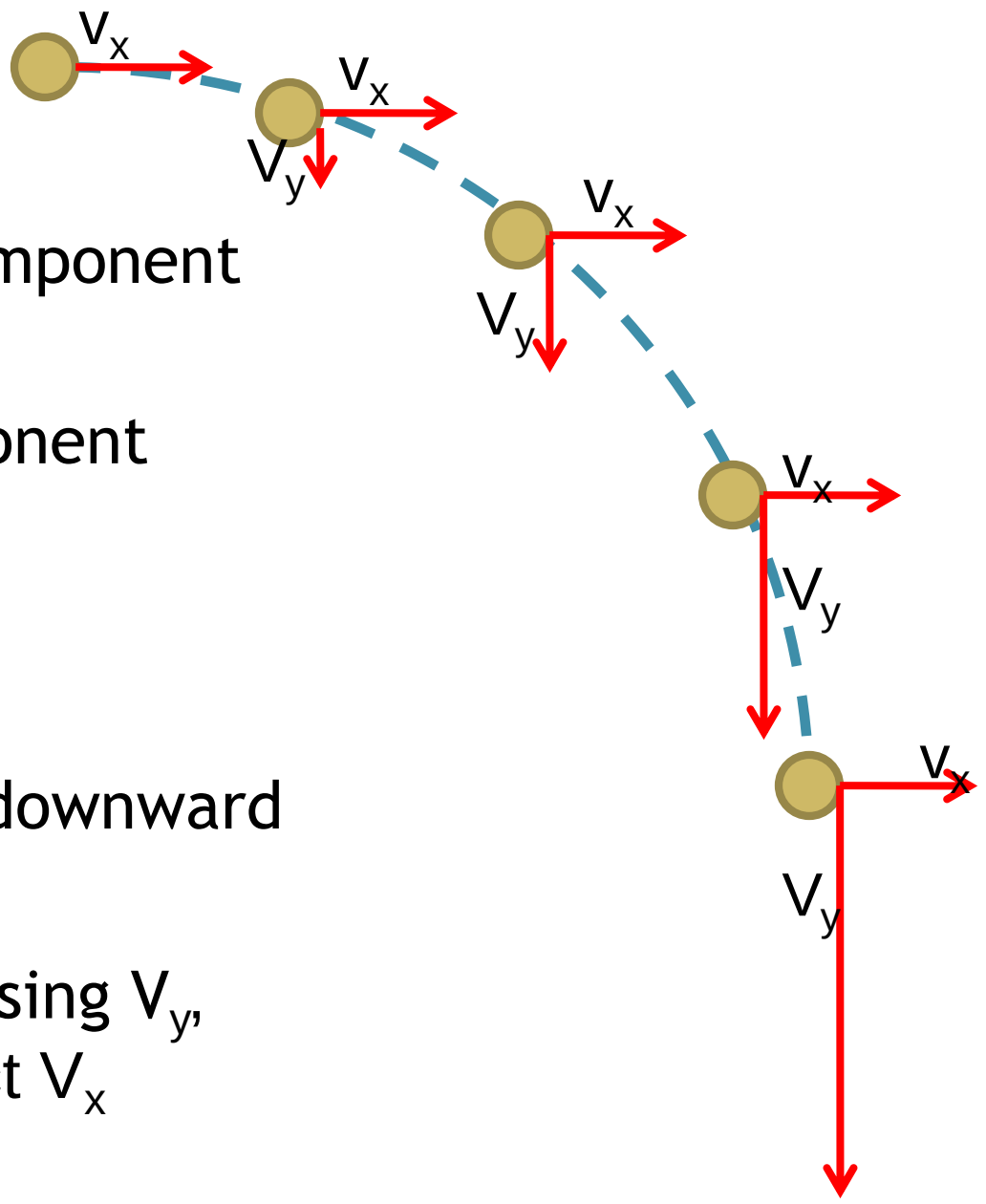



# PROJECTILE MOTION

- Anytime an object is launched and only under the influence of gravity it is considered to be a projectile.
  - Typically moving both horizontally and vertically
- **Acceleration is occurring in the vertical (y)direction**
- **Velocity is constant in the horizontal (x) direction**
- Horizontal is staying constant…..  Vertical component is changing due to the acceleration of gravity**

# PROJECTILE LAUNCHED HORIZONTALLY

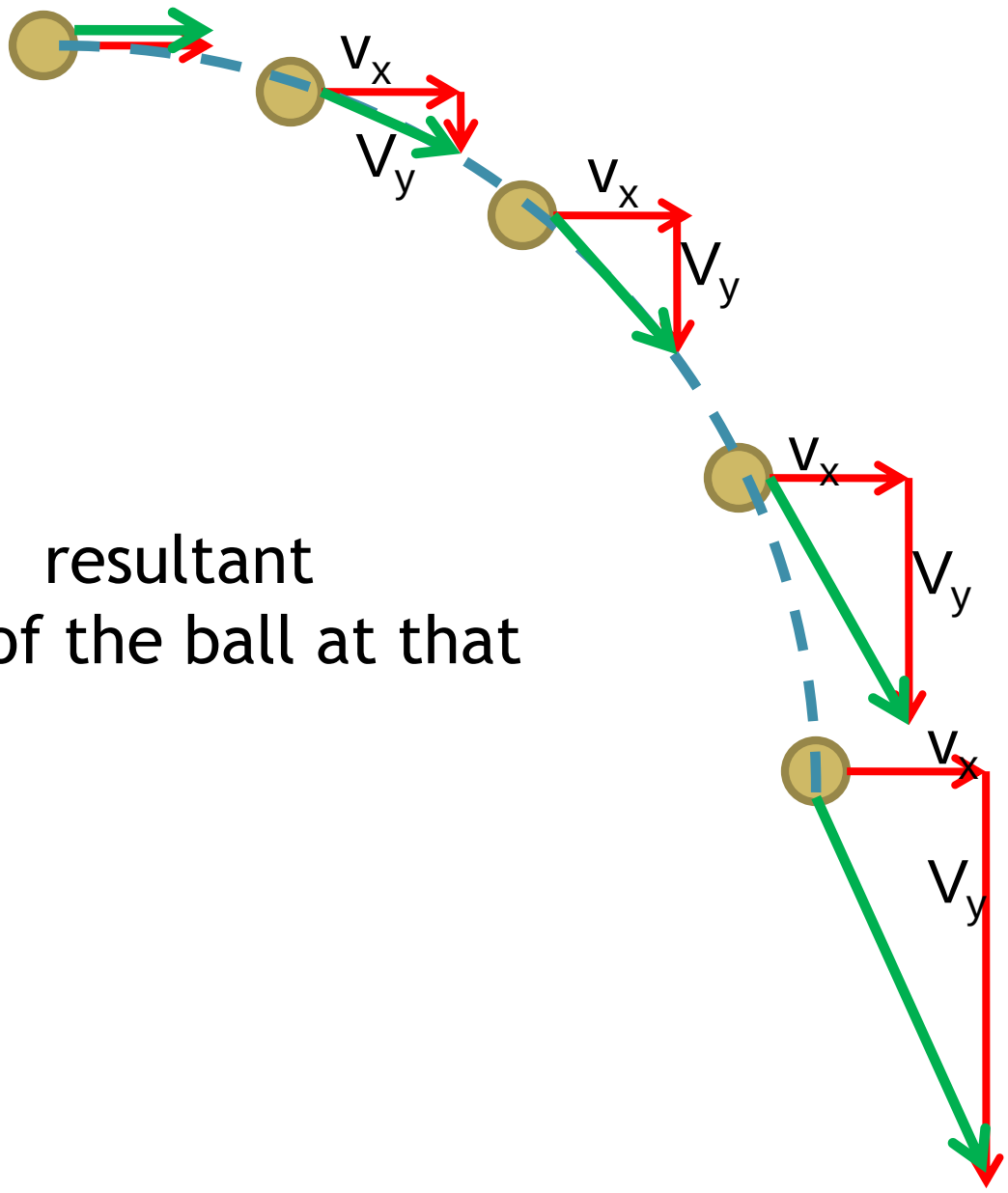



- $V_x$- horizontal component vector of velocity
- $V_y$-vertical component vector of velocity

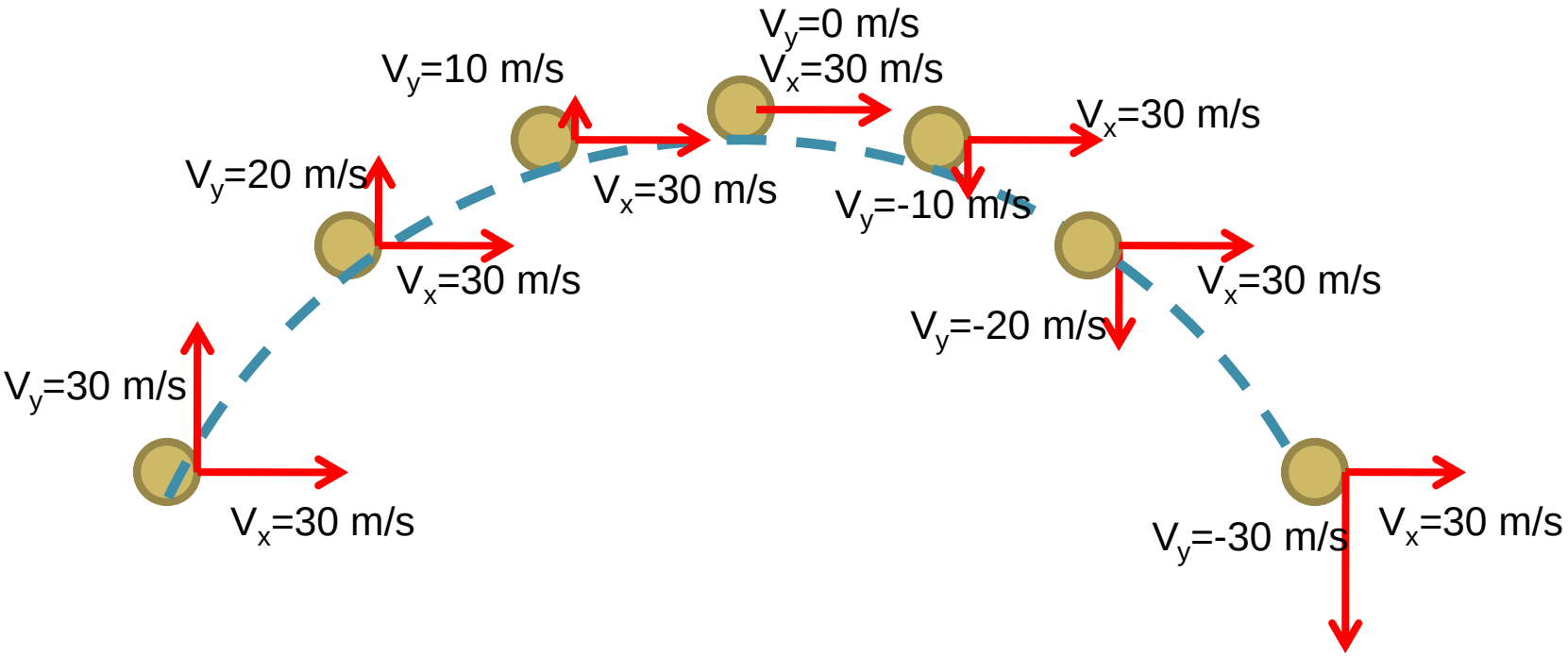
- $V_x$ → Constant
- $V_y$ → increasing downward

- GRAVITY is increasing $V_y$, but does not affect $V_x$

# OR DRAWN A LITTLE DIFFERENTLY…




- Green Arrows → resultant velocity vector of the ball at that point in its path



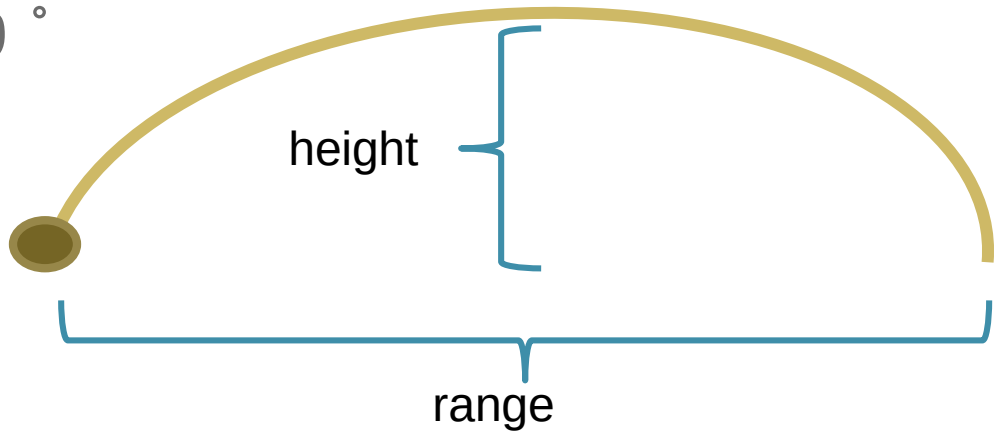

- Object launched upward at an angle of $45^o$ with a velocity of 42.4 m/s.
  - Initial Horizontal Velocity = Vx = +30 m/s
  - Initial Vertical Velocity = Vyi = +30

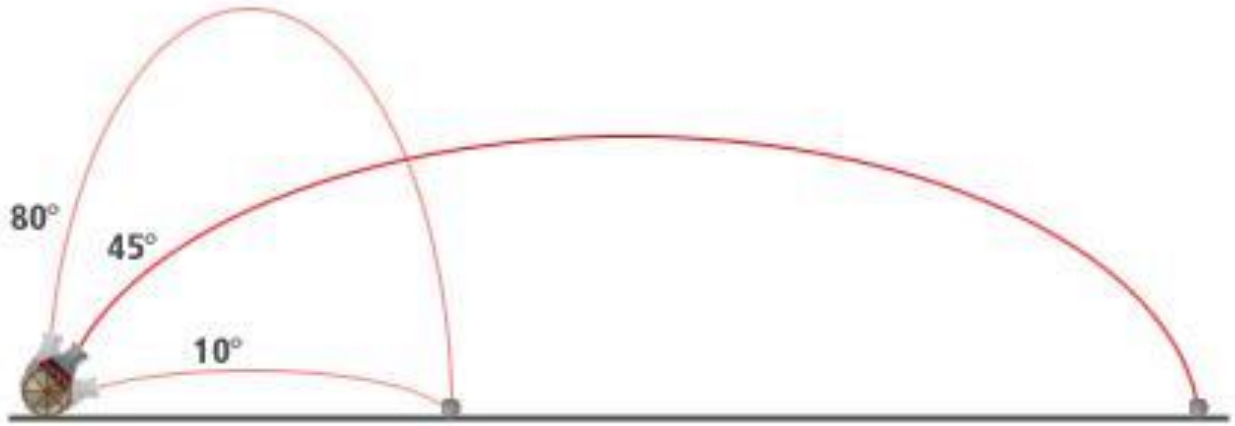
# BULLET FIRED & DROPPED AT SAME TIME


**X- components are independent of Y-Components and the acceleration of gravity.. So both bullets fall at the same rate and reach ground at same time**

# RANGE AND HEIGHT

- **Range** - how far an object travels horizontally
- **Height** - how far an object travels vertically
- How to produce max height??
  - Launch at 90º (straight up)
- How to produce max range??
  - Launch at 45º
- Objects launched at complementary angles will produce equal ranges
  - Ex. 30 ˚ and 60 ˚

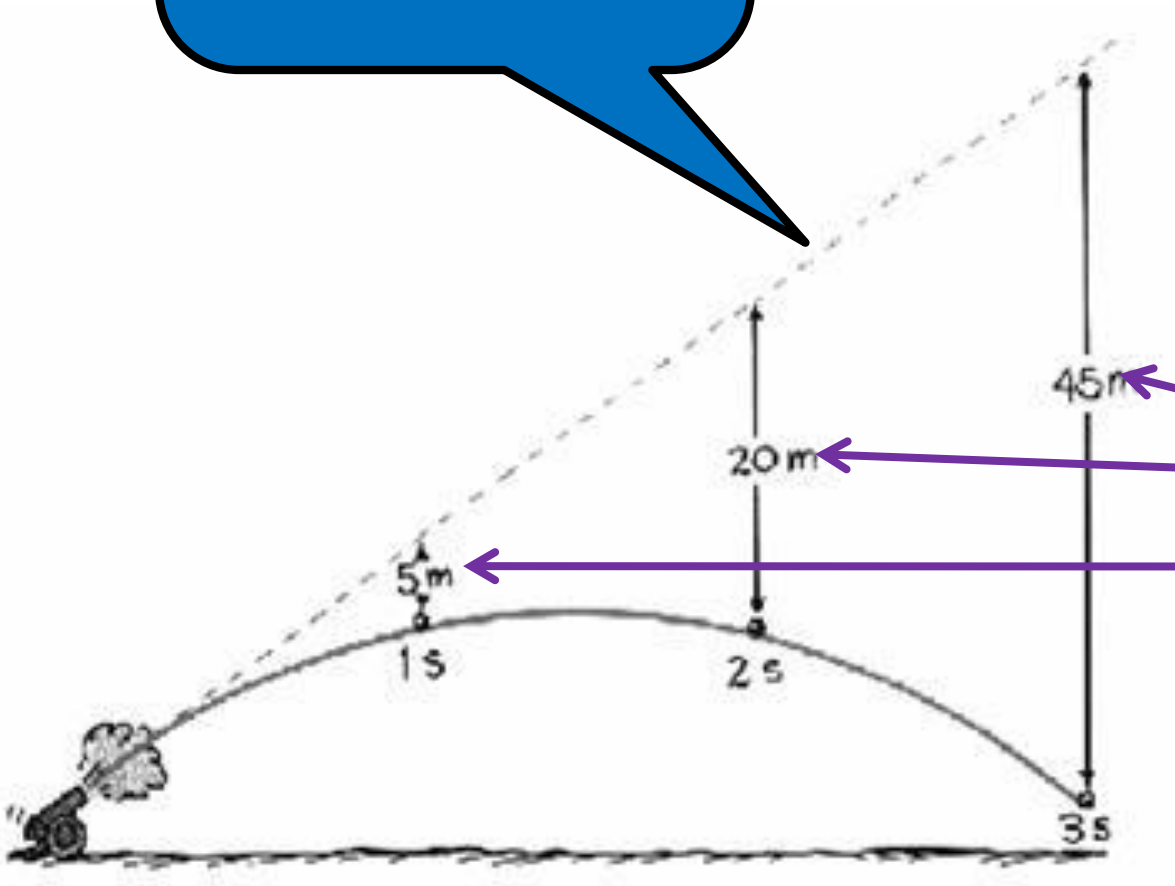





A projectile which is launched at a nearly 45 degree angle will travel more than twice as far as the same projectile launched with the same power but at an extreme angle such as 10 degrees or 80 degrees.

- Objects launched at complimentary angles will produce equal ranges
  - 80º and 10º (as seen above) are complimentary angles
  - http://www.ngsir.netfirms.com/englishhtm/ThrowABall.htm

Hypothetical straight line path cannonball would follow if there was no Gravity



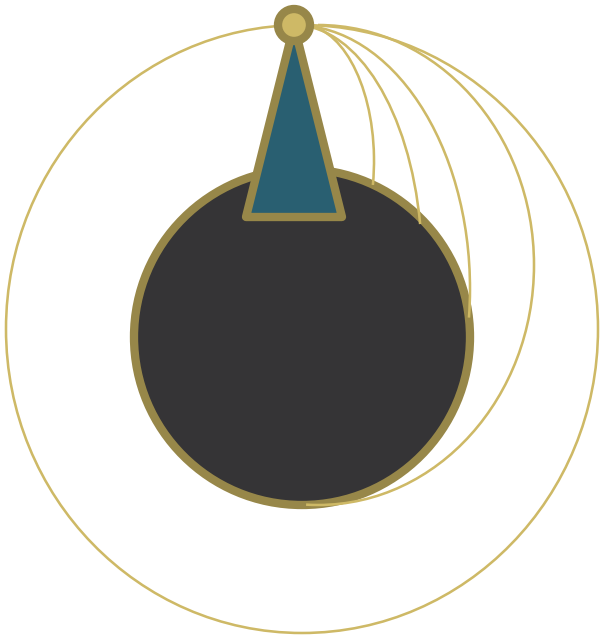

Distances below hypothetical straight line path object is at 1s, 2s, and 3 sec.

***Same distances as if ball was launched horizontally **

# SATELLITES

- Satellites--- objects that orbit another object
- Moon orbits Earth
- Earth and other planets orbit Sun
- These are all essentially just projectiles
- If objects fall because of gravity, how come satellits stay orbiting forever?? Or do they? Are they getting closer?? Are they falling??
- How???

# Projectile being thrown a different speeds, from the top of a mountain above the atmosphere



- Satellites are moving so fast that the rate at which they are **falling** matches the rate at which the center object curves away from it

- So yes they are falling, but *falling around Earth not into it* and no if they are orbiting properly they will not be getting closer