Projectile Motion

Vector Quantities

A quantity such as force, that has both magnitude and direction.

<u>Examples:</u>

Velocity, Acceleration

Scalar Quantities

A quantity such as mass, volume, and time, which can be completely specified by it's magnitude, and has *no* direction.

Vector

A quantity that has magnitude and direction

Usually represented by an arrow whose length represents the magnitude and direction represents the direction

Vector scaled 1 cm = 20 m/s

This vector represents 60 m/s to the right.

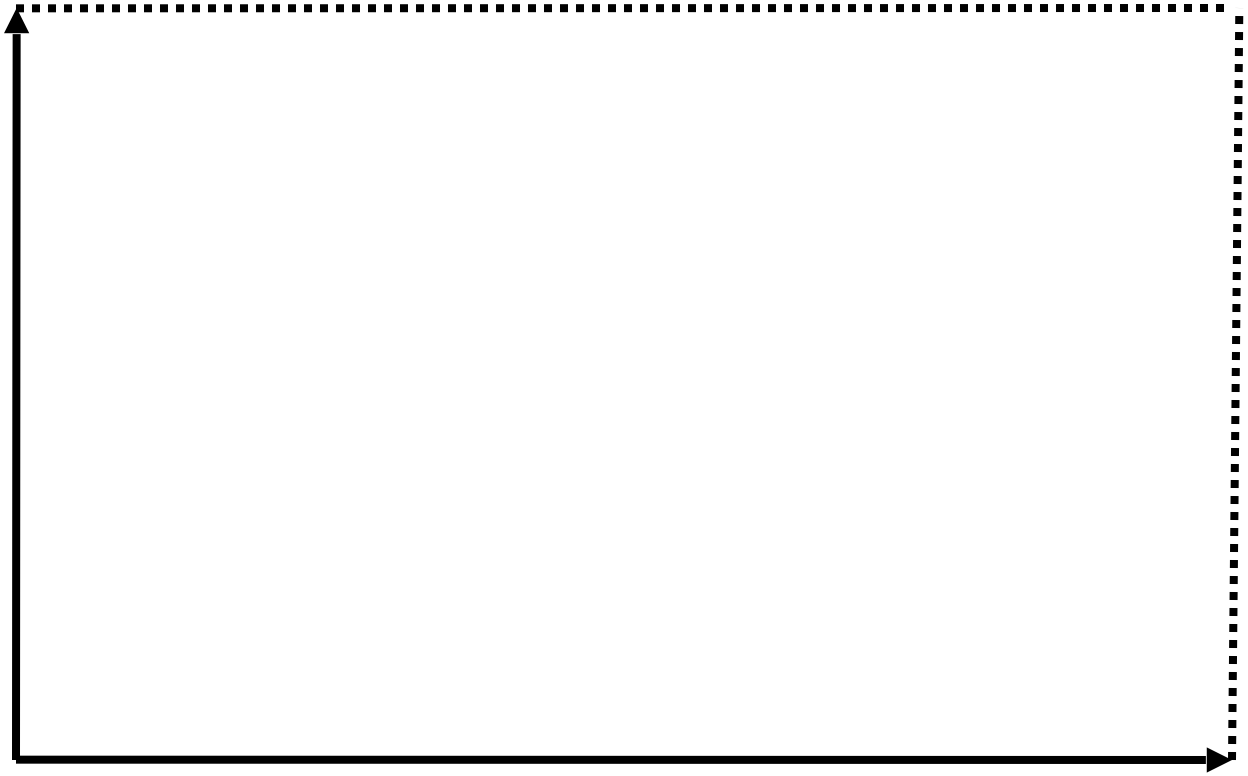
Resultant

The vector sum of the two or more component vectors

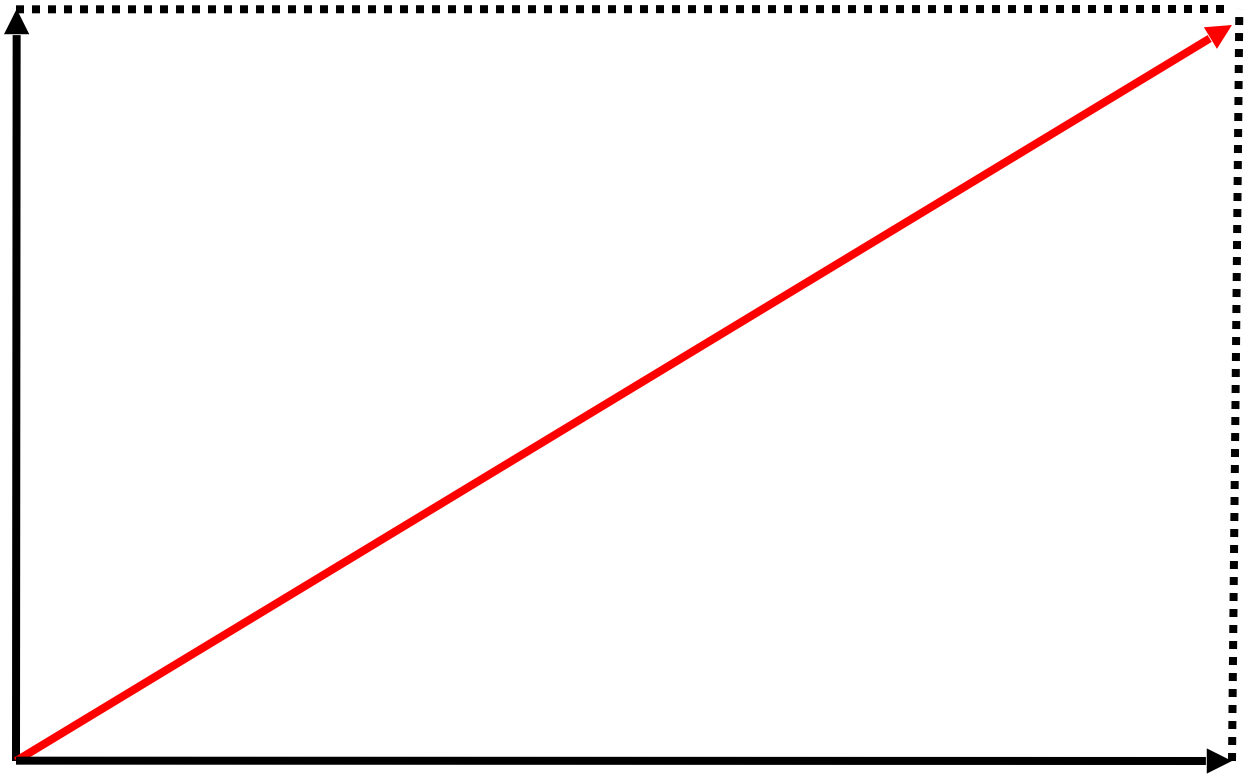
3 Step Technique

1) Draw the two vectors with their tails touching

2) Draw a parallel projection of each vector with dashed lines to form a rectangle.



3) Draw the diagonal from the point where the two tails are touching.

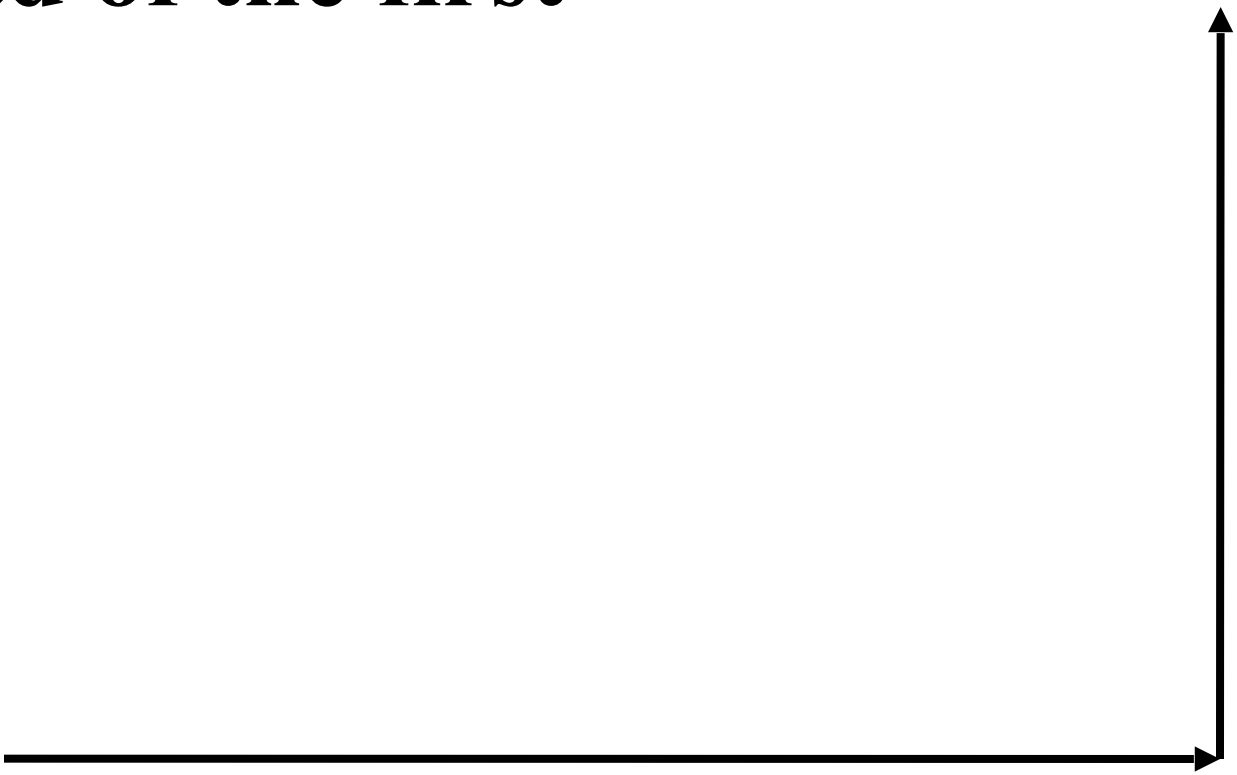


OR

1. Connect Draw the first vector

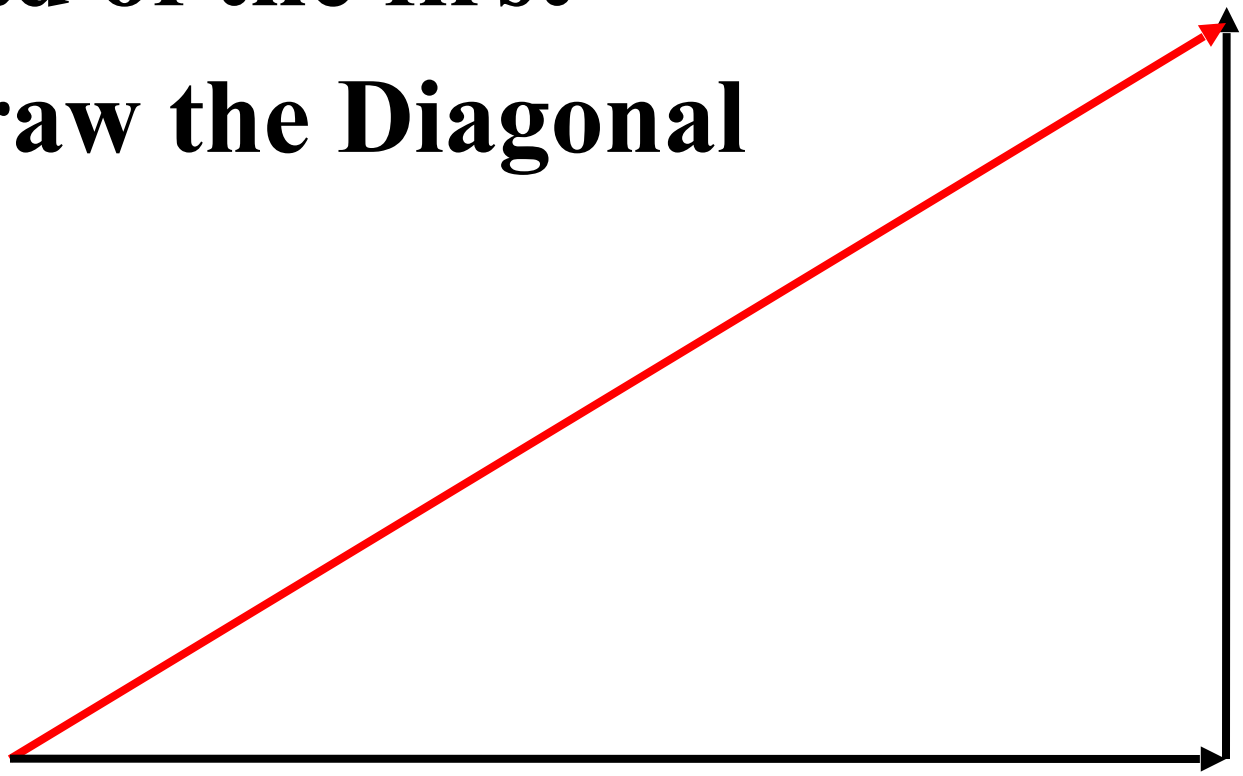
OR

1. Connect Draw the first vector
2. Connect the tail of the second to the head of the first



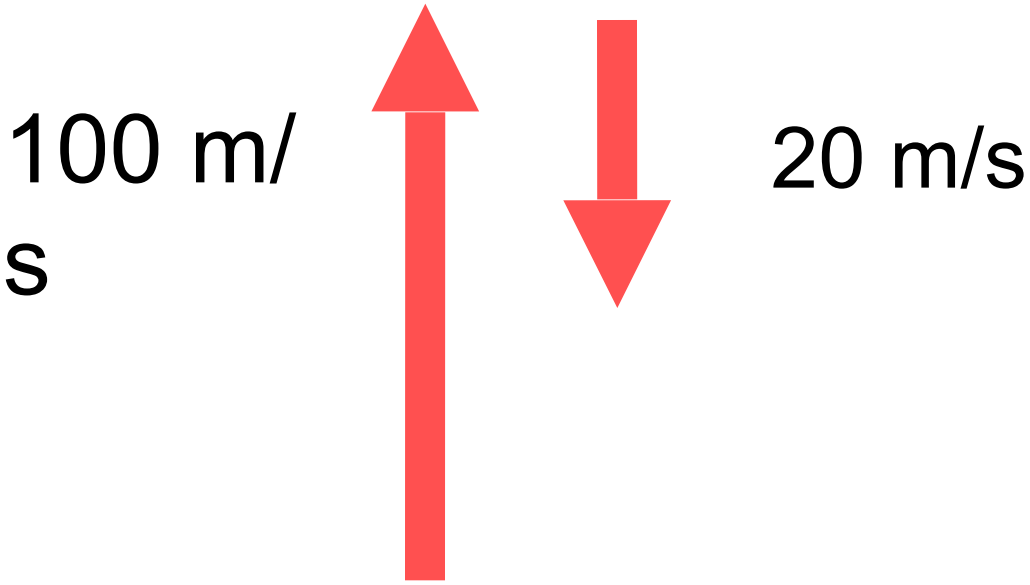
OR

1. Connect Draw the first vector
2. Connect the tail of the second to the head of the first
3. Draw the Diagonal



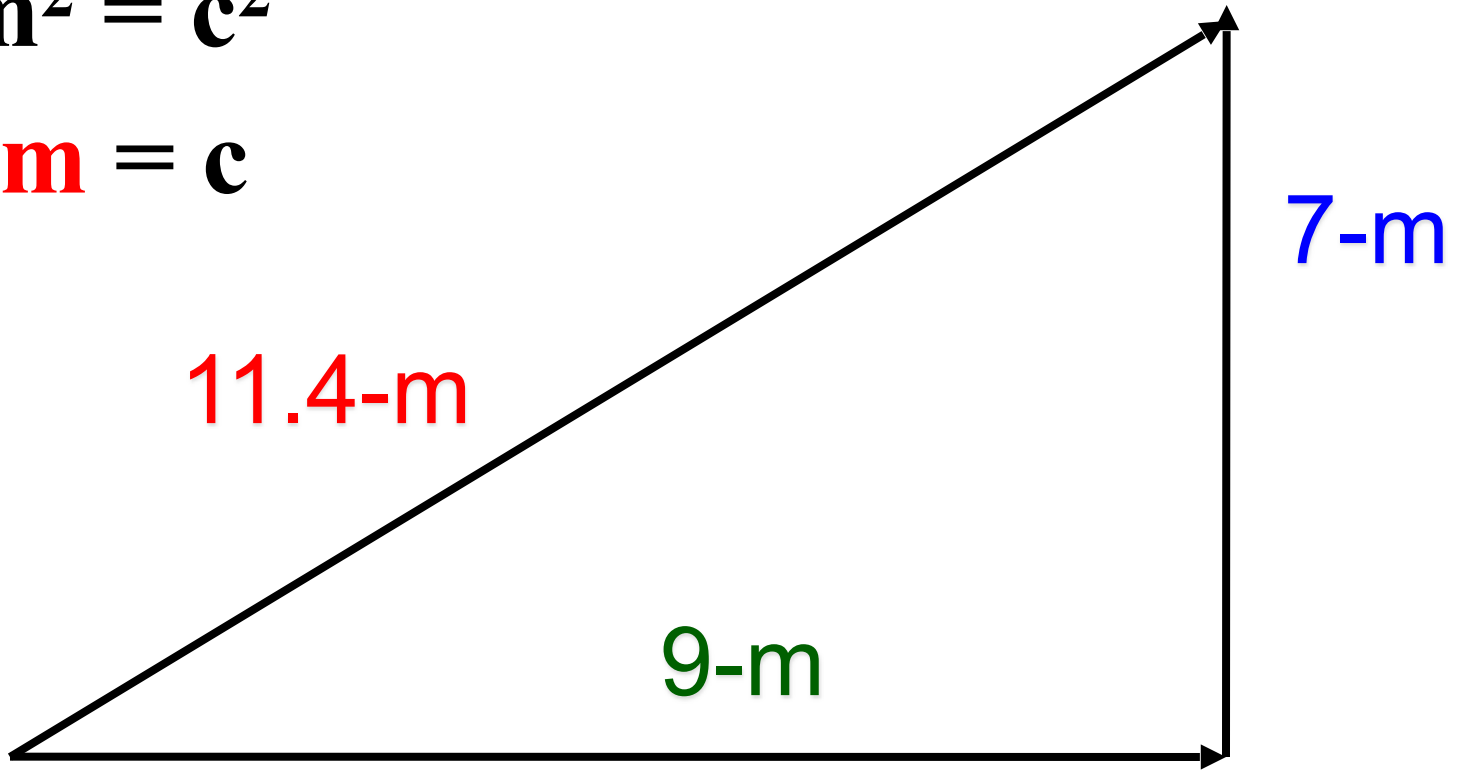
Sample Question

If a plane heads north at 100m/s and the wind is traveling south at 20m/s. What is the resulting velocity?



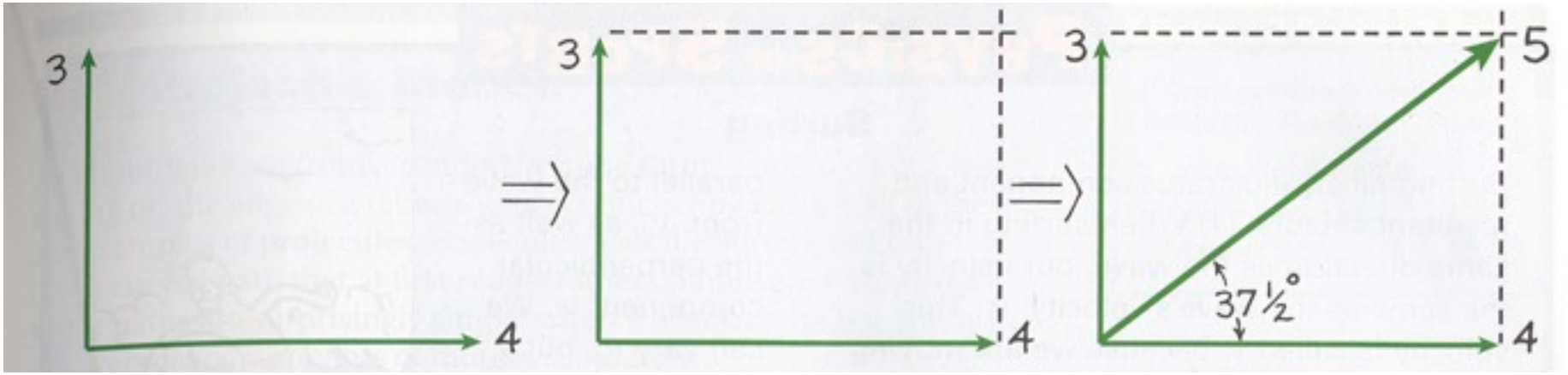
Finding the magnitude of the sides

1. Use the Pythagorean Theorem
2. $(7\text{-m})^2 + (9\text{-m})^2 = c^2$
3. $130\text{-m}^2 = c^2$
4. $11.4\text{-m} = c$



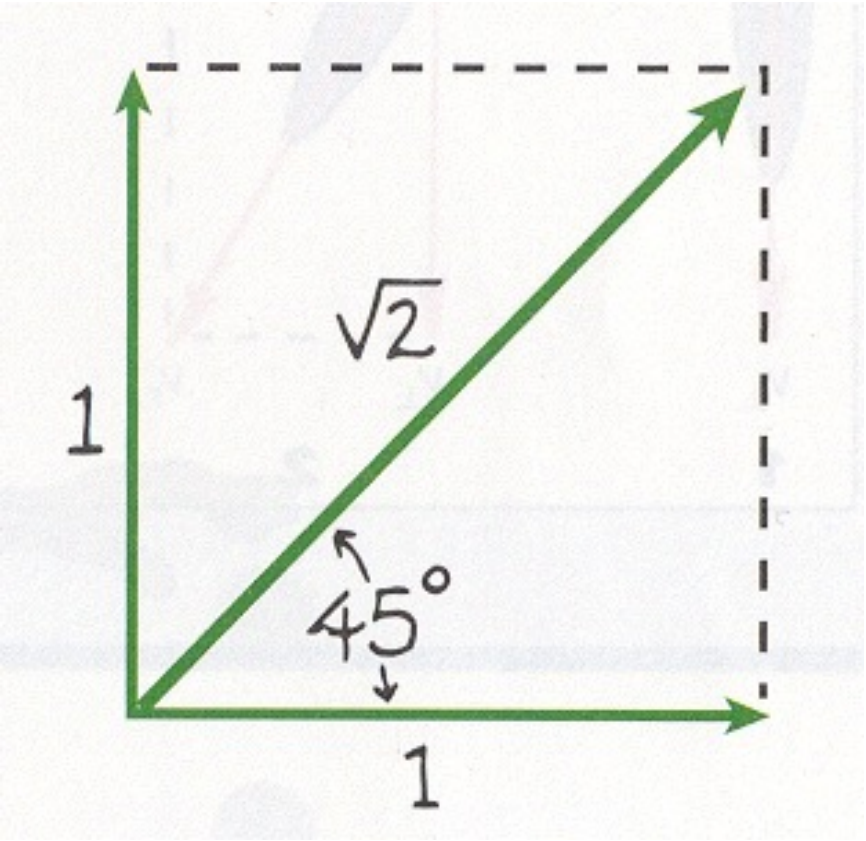
Vectors

The 3-unit and 4-unit vectors add to produce a resultant vector of 5 units, at 37.5 degrees from the horizontal



Vectors

The diagonal of a square is $\sqrt{2}$, times the length of one of its sides.



Hansel and Gretel walked straight north for 6-km from their home and then headed east for 12- km. What is their displacement from home?

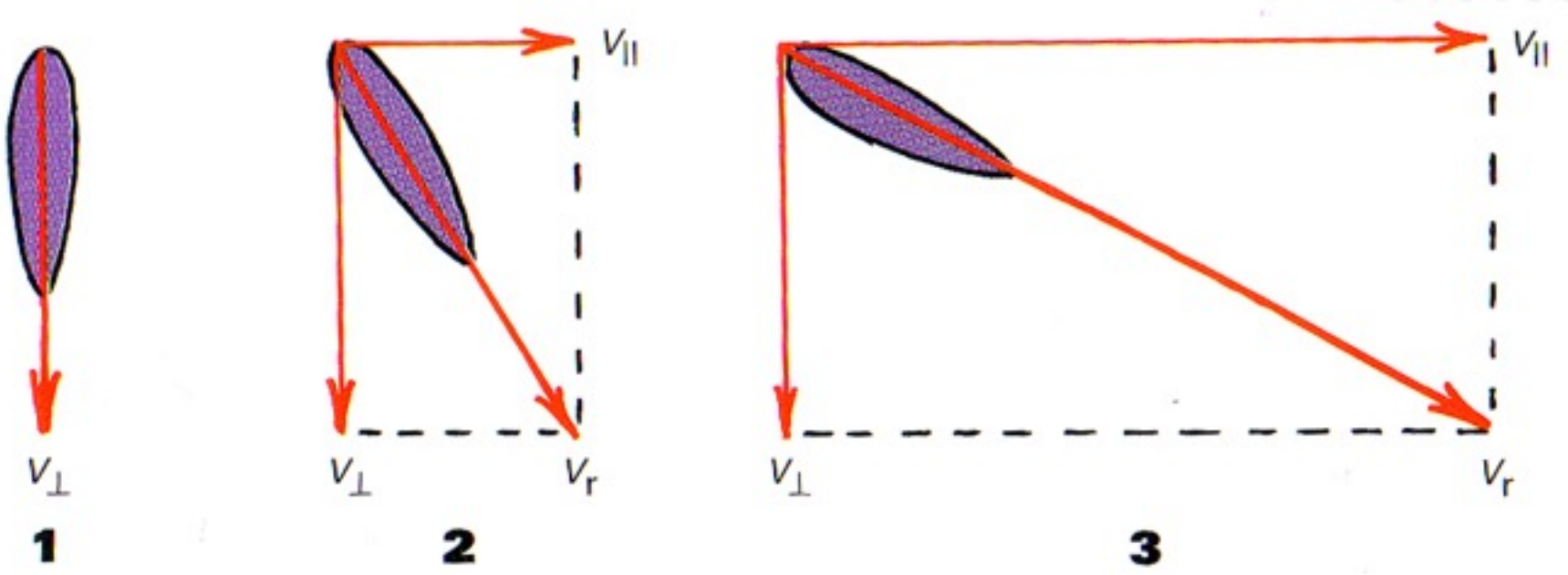
13.4-km

They then walked south for 20-km. What is their current displacement from home?

18.4-km

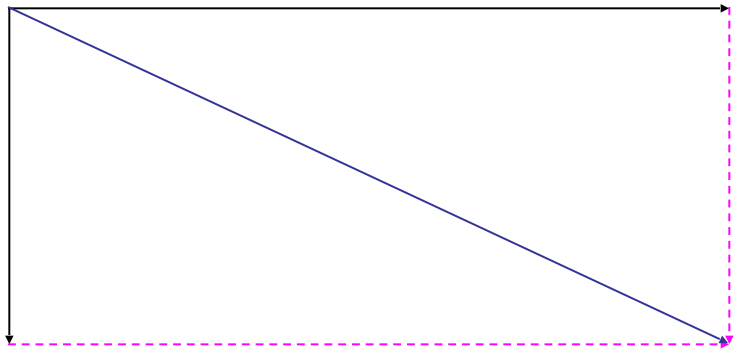
Components of Vectors

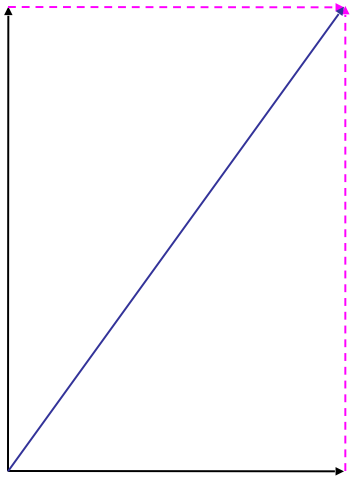
<u>Resolution</u>- the process of solving a vector into components



Components of Vectors

Any vector drawn can be resolved into vertical and horizontal components





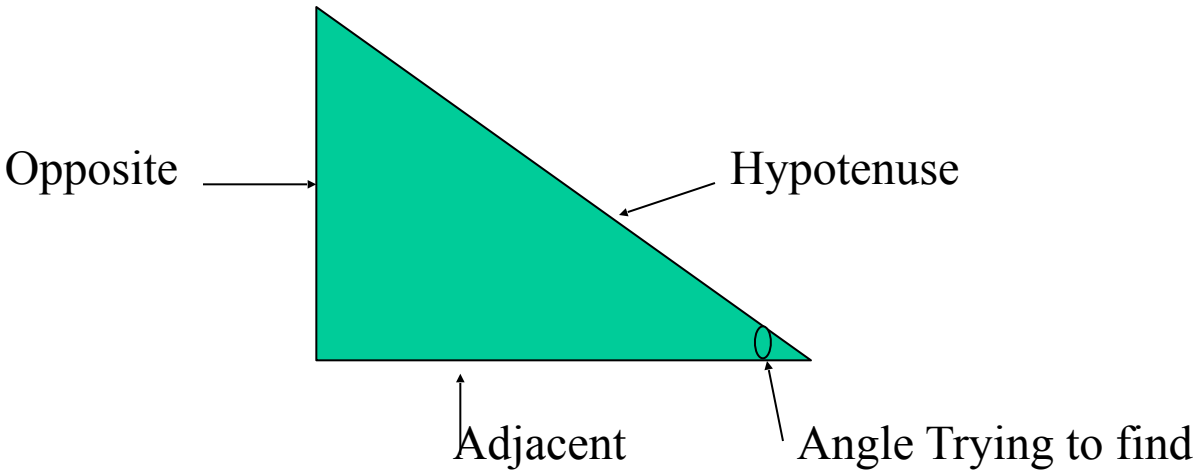
Finding the Angle from the Origin

When dealing with right triangles there are 3 trigonometric functions

SOH- Sine= Opposite/Hypotenuse

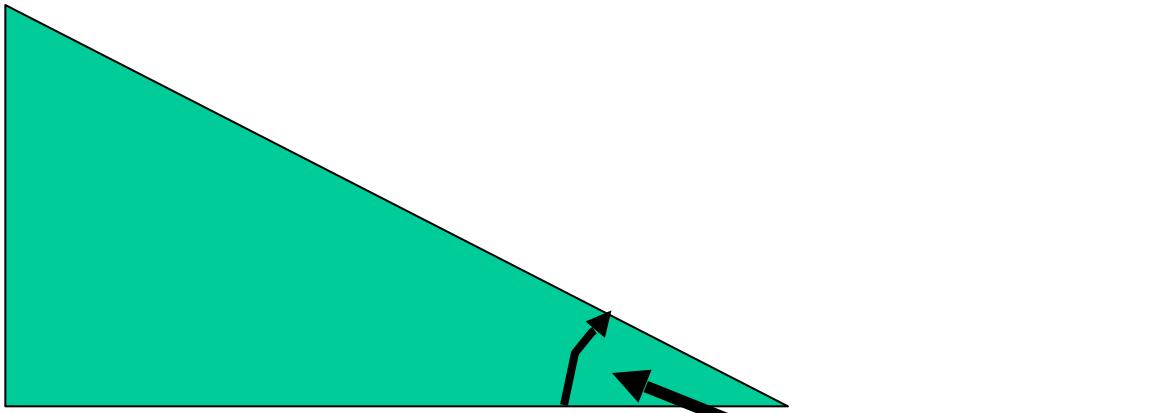
CAH- Cosine= Adjacent/Hypotenuse

TOA- Tangent= Opposite/Adjacent



Find Angle using Tangent

Tangent= Opposite/Adjacent



$\tan(\theta) = 12/5$

$\tan(\theta) = 2.4$

$\theta = \tan^{-1}(2.4)$

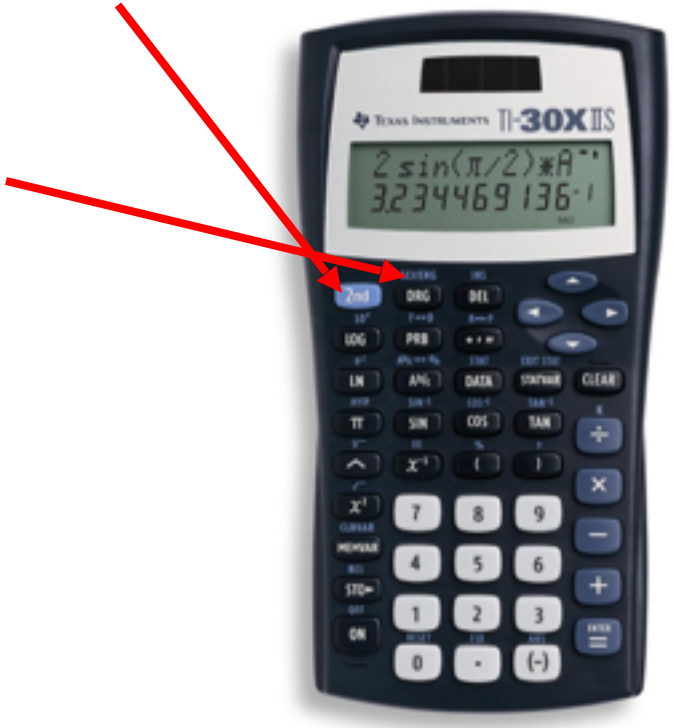
How is this done on our calculators?

Calculator

1.Make sure calculator is in **DEGREES**

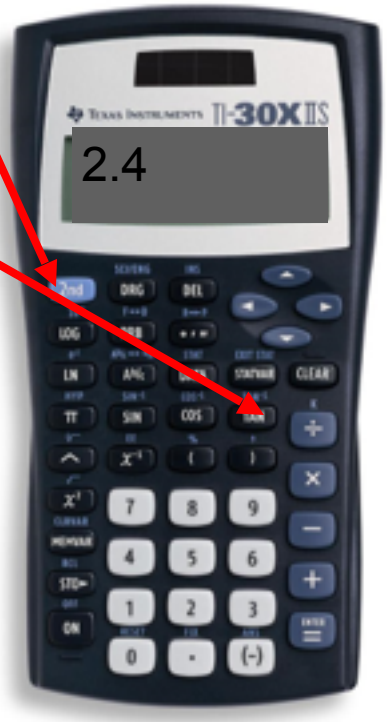
2.2nd function

3. DRG



Calculator

1. Find Inverse Tangent of 2.4
2. 2nd function
3. $\tan^{-1}$
4. Enter 2.4
5. Press =
6. 67.4º



A Football field has a total length off 120-meters and is 50 – meters wide. What is the length of the diagonal?

What angle does it make if the end-zone is the base?

Suppose that a river was moving with a velocity of 3 m/s N and the boat was moving at 4 m/s E. What would be the resultant speed (m/s)?

Suppose that a river was moving with a velocity of 3 m/s N and the boat was moving at 4 m/s E. What would be the resultant angle of the boat?

Hansel and Gretel walked straight north for 6-km from their home and then headed east for 12- km. What is their angle or direction from home?

63^{o} East of North

They then walked south for 20 miles. What is their current angle or direction from home?

49^{o} South of East or 139^{o}


N
E
S
W
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
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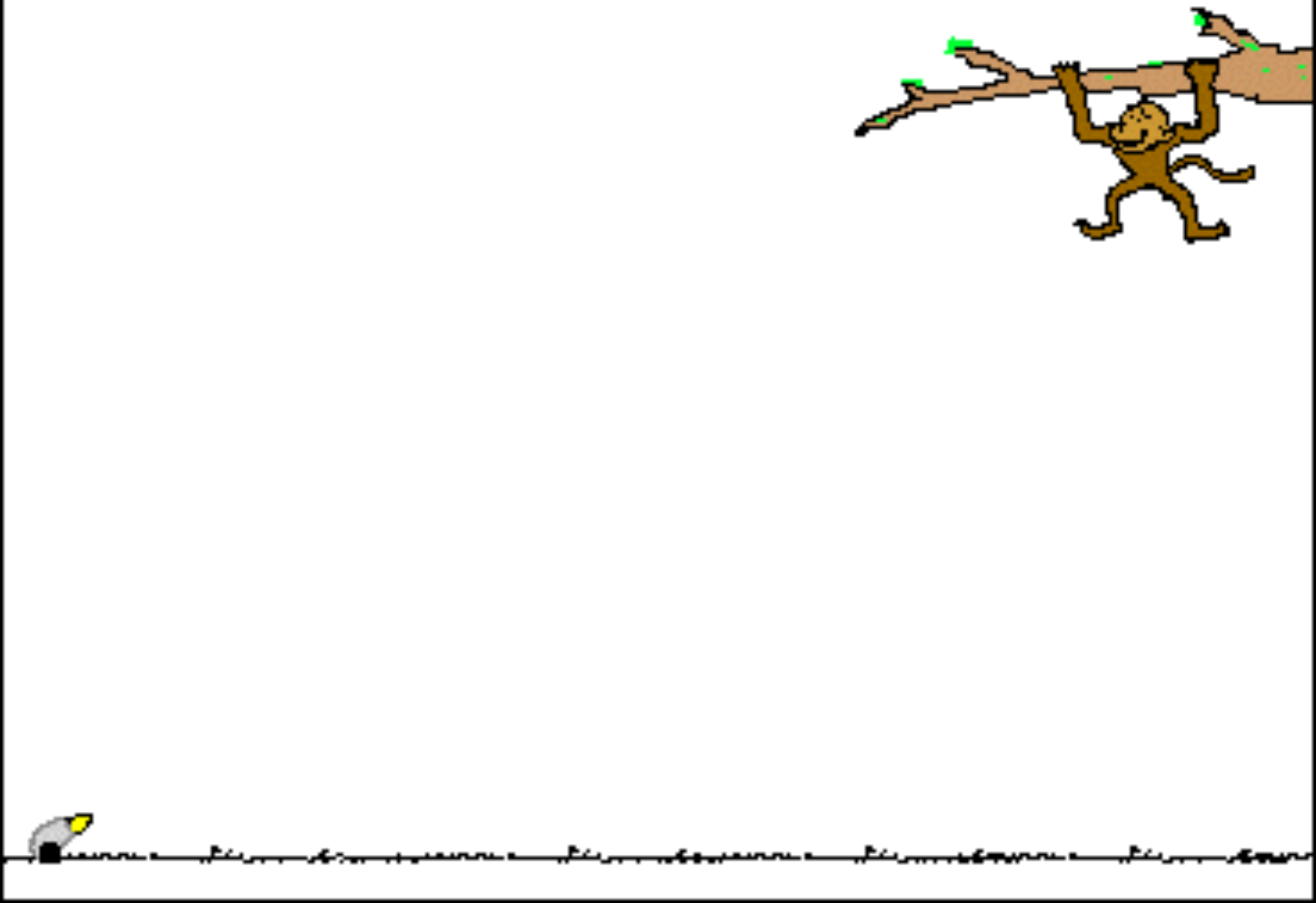
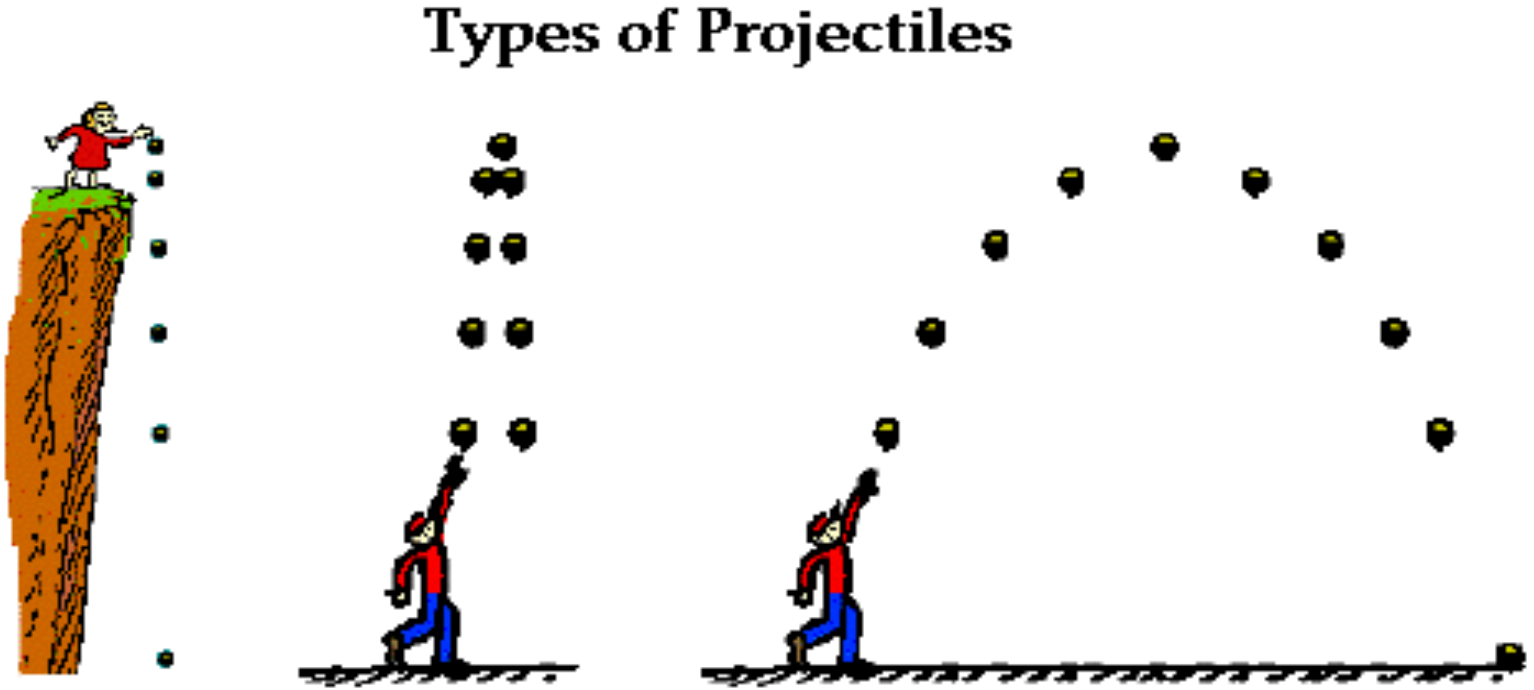
260
270
280
290
300
310
320
330
340
350



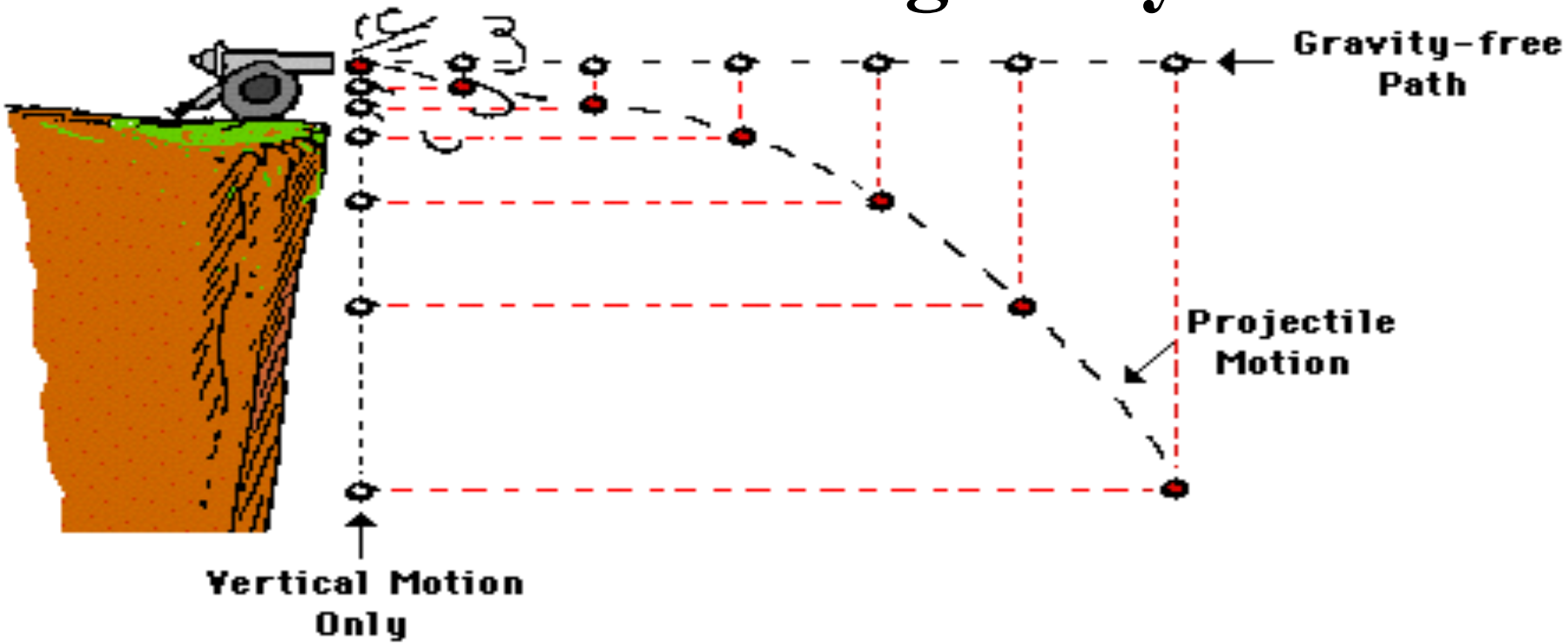
Projectile Motion

<u>Projectile</u>- any object that moves through air or through space, acted on only by gravity



Projectile Motion

Projectiles near the surface of the Earth follow a curved path, due to the force of gravity.



Projectile Motion

<u>Horizontal component</u>- when no horizontal force acts on a projectile, horizontal velocity is constant

Sample Question

At the instant a horizontally pointed cannon is fired, a cannonball held at the canon's side is released and drops to the ground. Which cannonball strikes the ground first, the one fired from the cannon or the one dropped?

Projectiles

The path traced by a projectile accelerating only in the Vertical direction while moving at a constant horizontal velocity is a *parabola*.

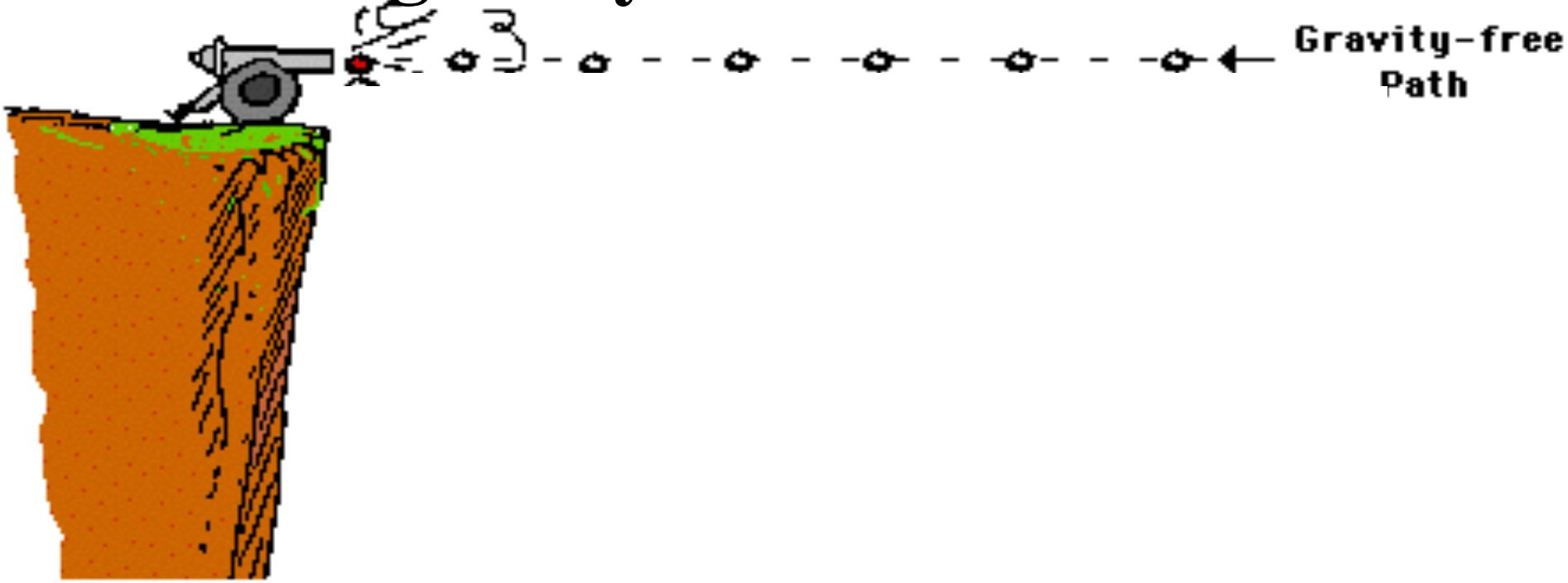
Air Resistance

When air resistance is small enough to neglect, usually for slow moving or very heavy projectiles, the curved paths are parabolic.

Air Resistance is TOO complex for our *Introduction to Physics Class*

Projectile Motion

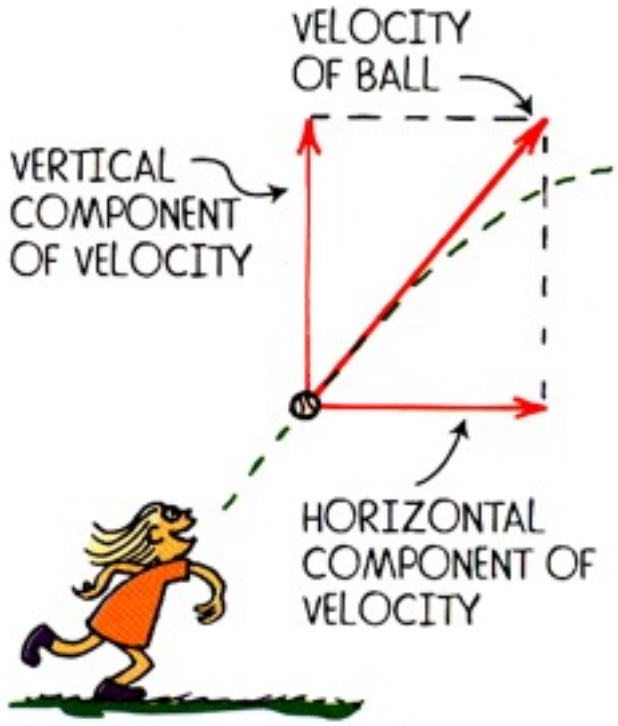
<u>Vertical component</u>- response to the force of gravity



Projectile Motion

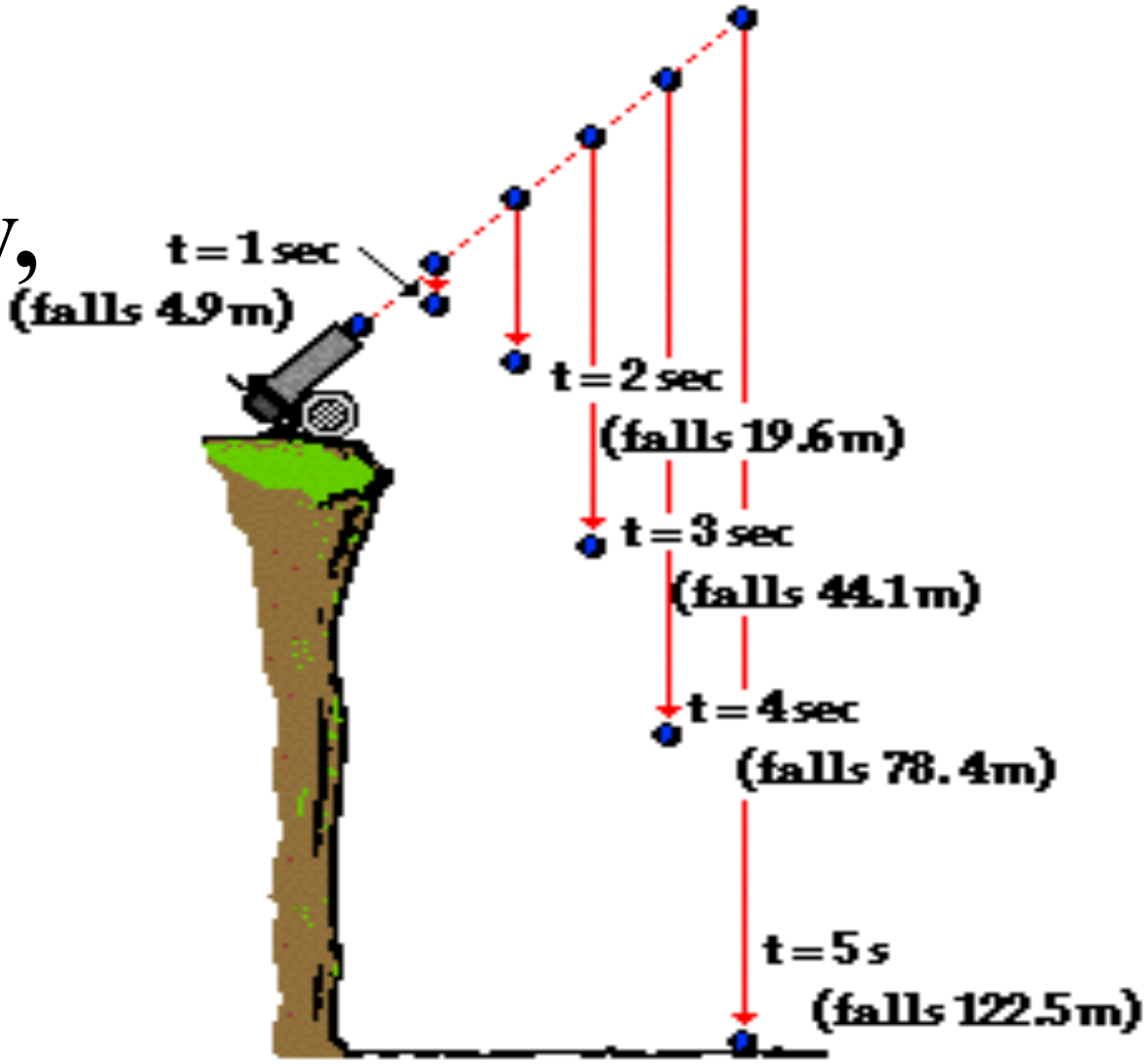
IMPORTANT:

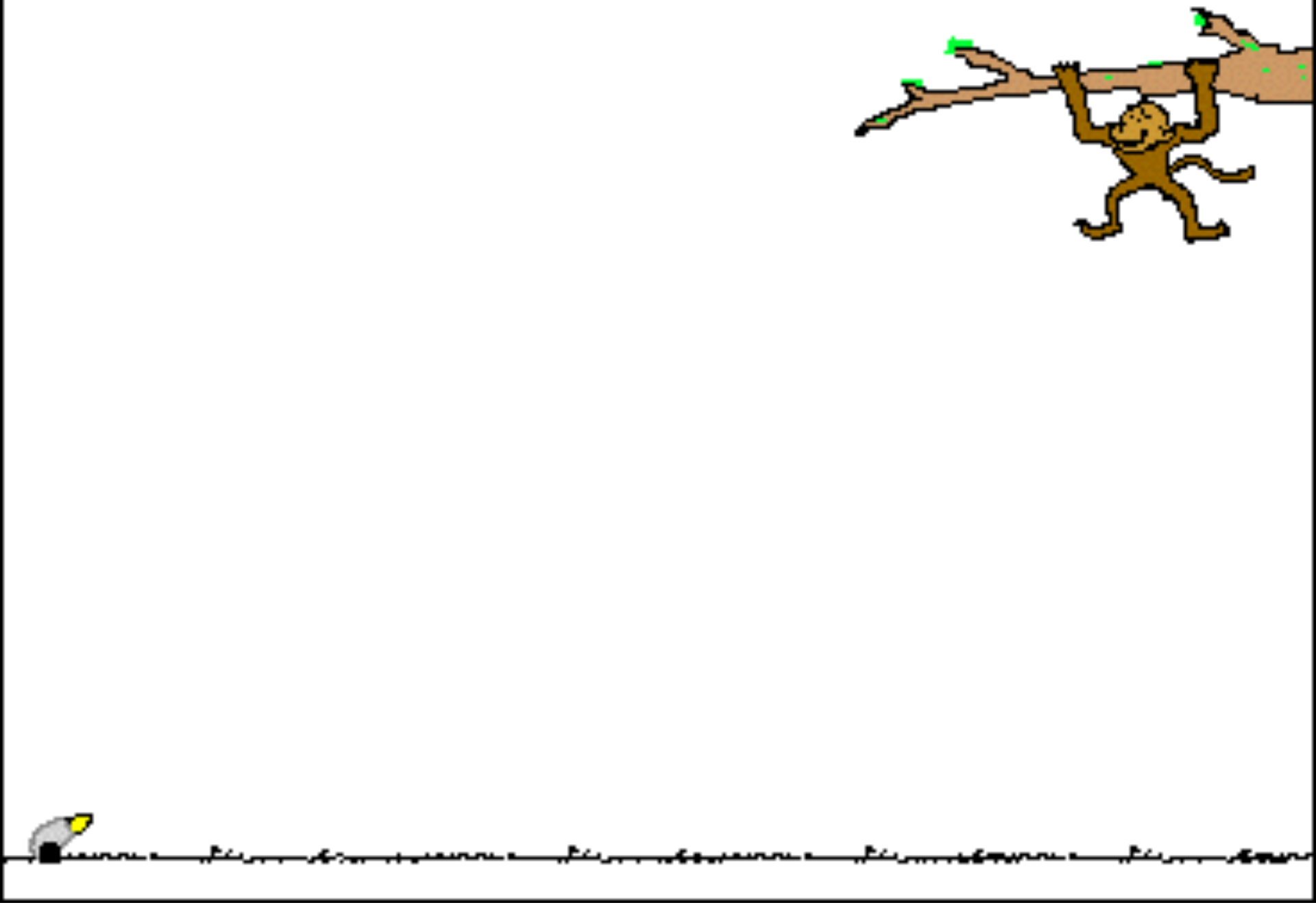
The horizontal component of motion for a projectile is completely independent of the vertical component of motion.



Upwardly Launched Projectiles

With no gravity, the projectile will follow a straight-line path.



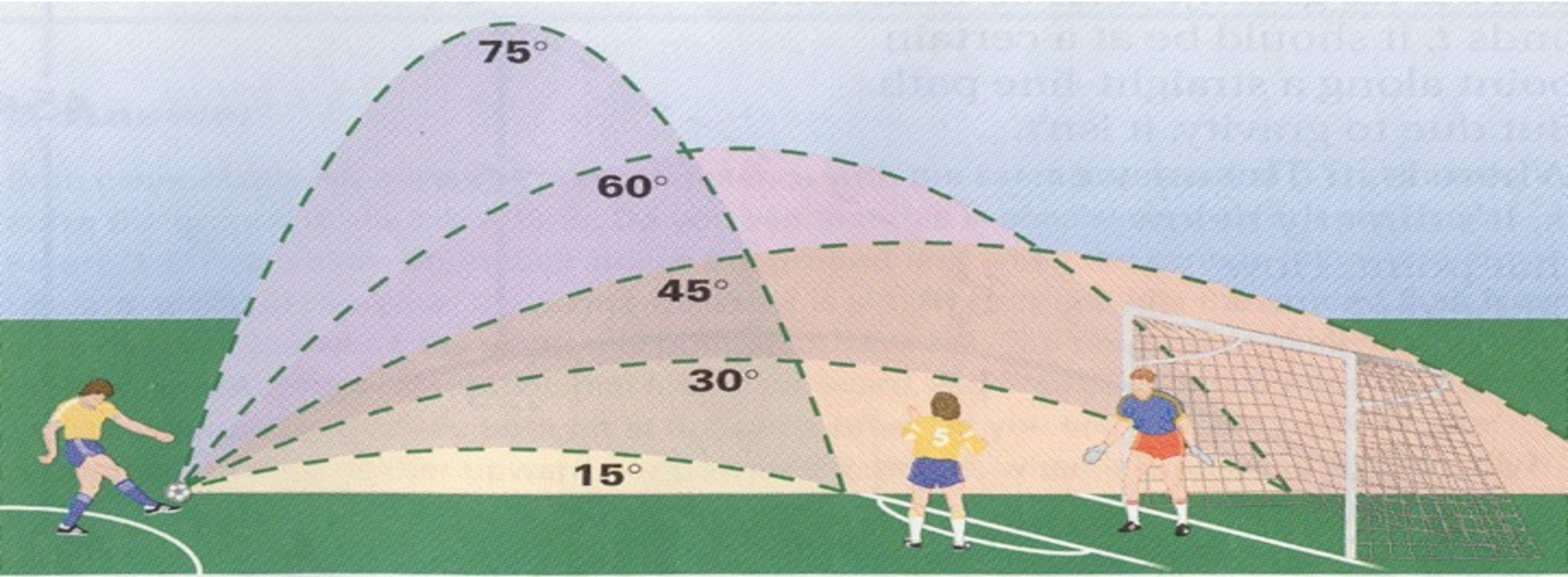


Upwardly Launched Projectiles

- **The horizontal range of a projectile depends on the angle of launched.**
- **The greater the launch angle, the higher the projectile will go, but…**

Upwardly Launched Projectiles

Complimentary launch angles will travel the same horizontal distance!!!



For a projectile, the only force acting upon it is:

A) **MOMENTUM**

B) **FORCE**

C) **GRAVITY**

D) **INERTIA**

A projectile is launched at an angle into the air. Neglecting air resistance, what is its vertical and horizontal acceleration?

A) V: 10 m/s^2 up, H: 0 m/s^2

B) V: 0 m/s^2 up, H: 10 m/s^2

C) V: 10 m/s^2 down, H: 0 m/s^2

D) V: 10 m/s^2 down, H: 10 m/s^2

At what point in its path does a projectile have minimum speed?

A) **at the beginning**

B) **at the top**

C) **when it is about to land**

In the absence of gravity, any launched projectile will travel what type of path?

A) **parabolic**

B) **straight**

C) **vertical**

D) **horizonal**

At the instant a horizontally pointed cannon is fired, a cannonball held at the canon's side is released and drops to the ground. Which cannonball strikes the ground first, the one fired from the cannon or the one dropped?

A) **The one from the cannon**
B) **The one dropped**
C) **Both hit the ground at the same time**
D) **Neither, they fly randomly off into Psychology class**

Calculations for Cliff

1. **Find the time to hit the ground.**
   a. **Measure height (y)**
   b. **Use $y = \frac{1}{2} a t_v^2$ or [$t_v = (2y/a)^{1/2}$]**

Calculations for Cliff

1. Find the time to hit the ground.
   a. Measure height (y)
   b. Use $y = \frac{1}{2} a t_v^2$ or $[t_v = (2y/a)^{1/2}]$

2. Find the horizontal velocity (v_h)

a. Find the time (t_h) to go horizontal (x)

b. $v_h = x/t_h$

Calculations for Cliff

1. Find the time to hit the ground.
   a. Measure height (y)
   b. Use $y = \frac{1}{2} a t_v^2$ or [$\mathbf{t_v = (2y/a)^{1/2}}$]
2. Find the horizontal velocity (v_h)

a. Find the time (t_h) to go horizontal (x)

b. $\mathbf{v_h = x/t_h}$

3. Find horizontal distance traveled from base of cliff

a. Distance = v_h t_v

A student standing on the roof of a 50.0-meter-high building kicks a stone at a horizontal speed of 4.00 meters per second. How much time will it take the stone to hit the ground?

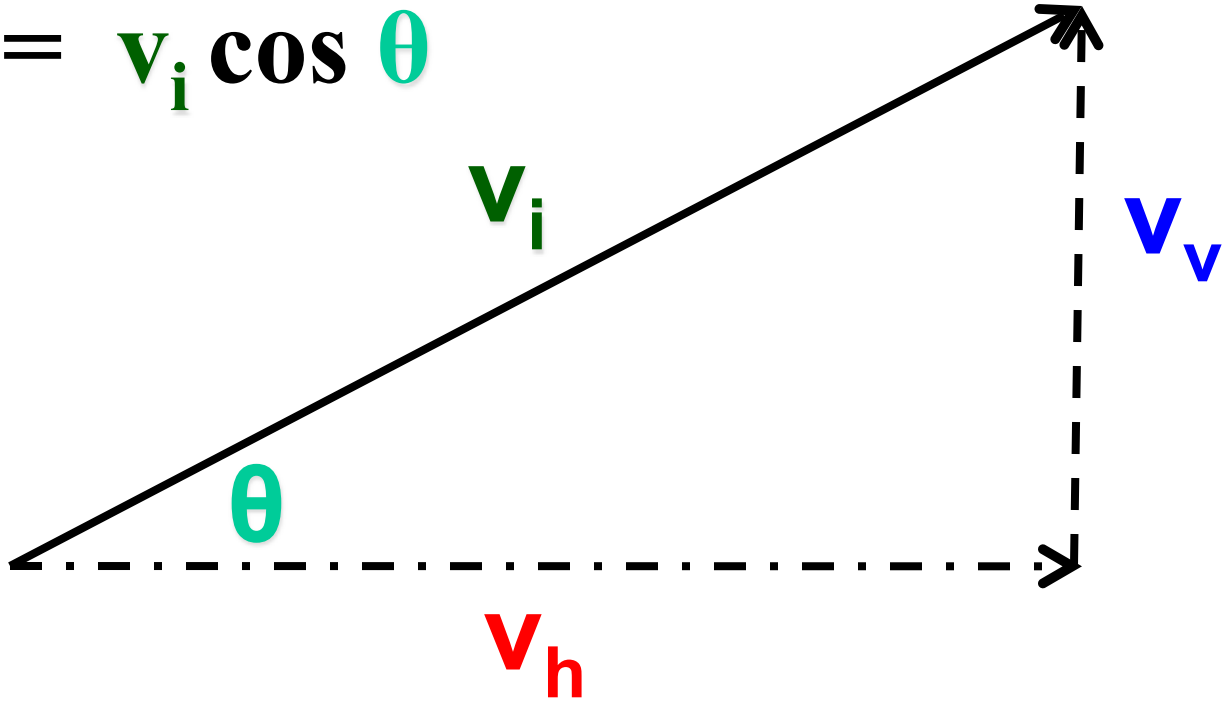
A student standing on the roof of a 50.0-meter-high building kicks a stone at a horizontal speed of 4.00 meters per second. How far from the base of the building will the stone hit?

Calculations for Launch

Given the initial Velocity v_i and Angle θ

A. Find Components of Velocity

1. $v_v = v_i \sin \theta$
2. $v_h = v_i \cos \theta$



Calculations for Launch

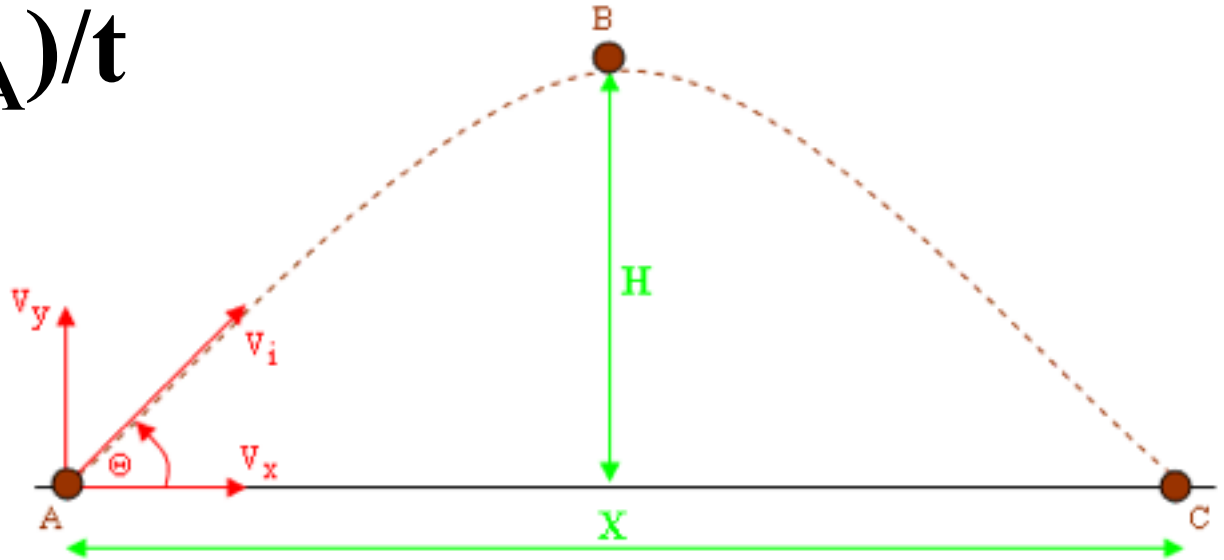
Given the initial Velocity v_i and Angle θ

A. Find Components of Velocity

1. $v_v = v_i \sin \theta$
2. $v_h = v_i \cos \theta$

B. Find time to get to top of path (B)

1. $a = (v_B - v_A)/t$
2. $v_B = 0$
3. $t = - v_A/a$



Calculations for Launch

Given the initial Velocity v_i and Angle θ

A. Find Components of Velocity

1. $v_v = v_i \sin \theta$
2. $v_h = v_i \cos \theta$

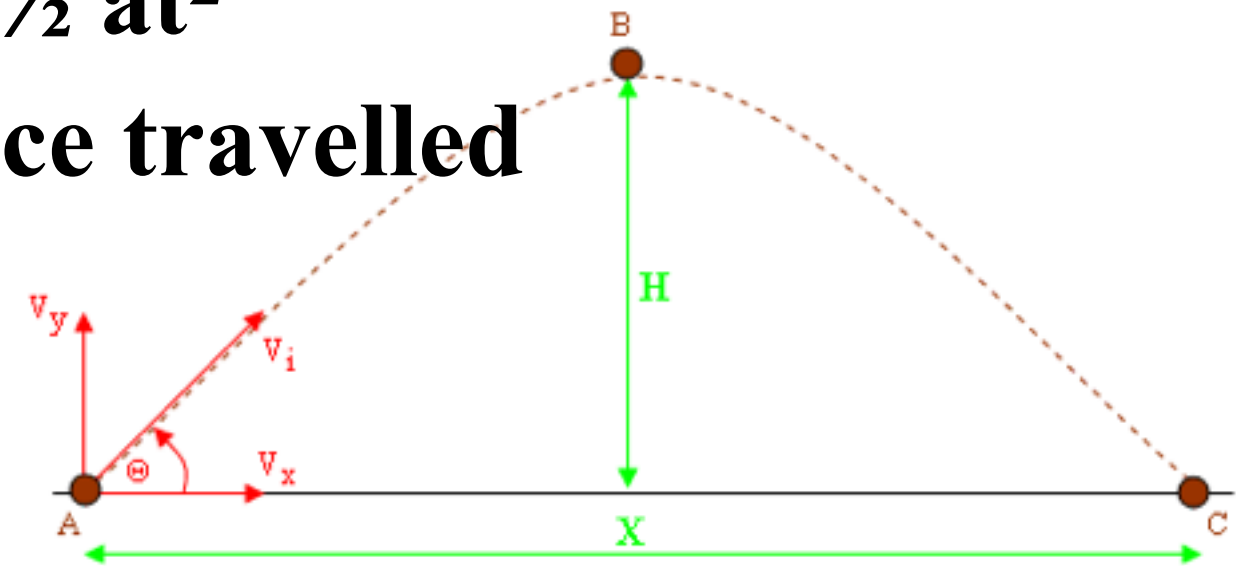
B. Find time to get to top of path (B)

1. $a = (v_{TOP} - v_v)/t$
2. $v_{TOP} = 0$
3. $t = - v_v/a$

C. Height $y = \frac{1}{2} at^2$

D. Total distance travelled

$x = v_h(2t)$



An athlete kicks a ball at a 30^{o} angle at 56 m/s. What is the vertical velocity in m/s?

56 m/s sin (30^{o}) = 28 m/s

What is the horizontal velocity in m/s?

56 m/s cos (30^{o}) = 48 m/s

An athlete kicks a ball at a 30^o angle at 56 m/s.

v_v = 28 m/s v_h =48 m/s

How much time until it reaches maximum height?

t = (28 m/s)/(10 m/s^2) = 2.8 s

An athlete kicks a ball at a 30^o angle at 56 m/s.

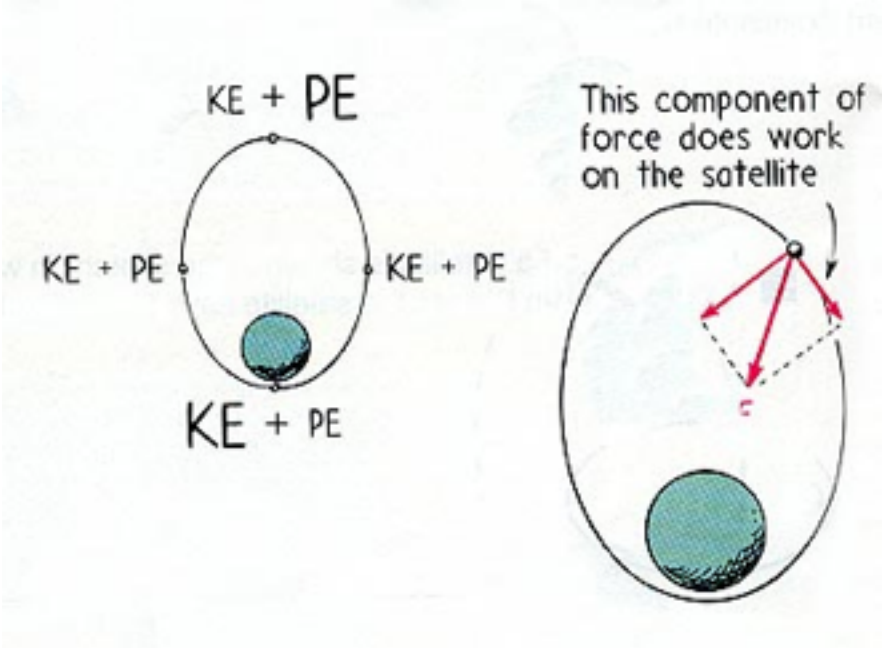
v_v = 28 m/s v_h =48 m/s t = 2.8 s

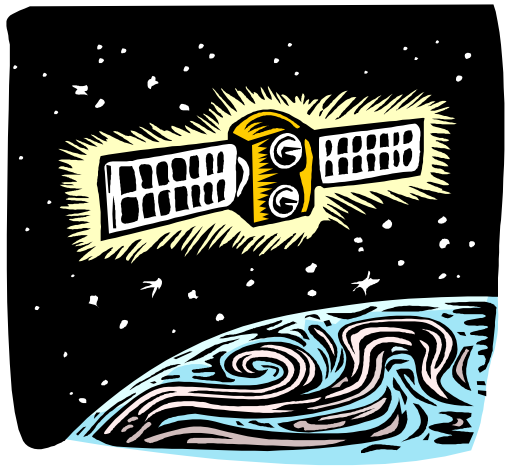
How far down field does the ball land?

x = 48 m/s (2 x 2.8 s) = 269 m

Fast-Moving Projectiles

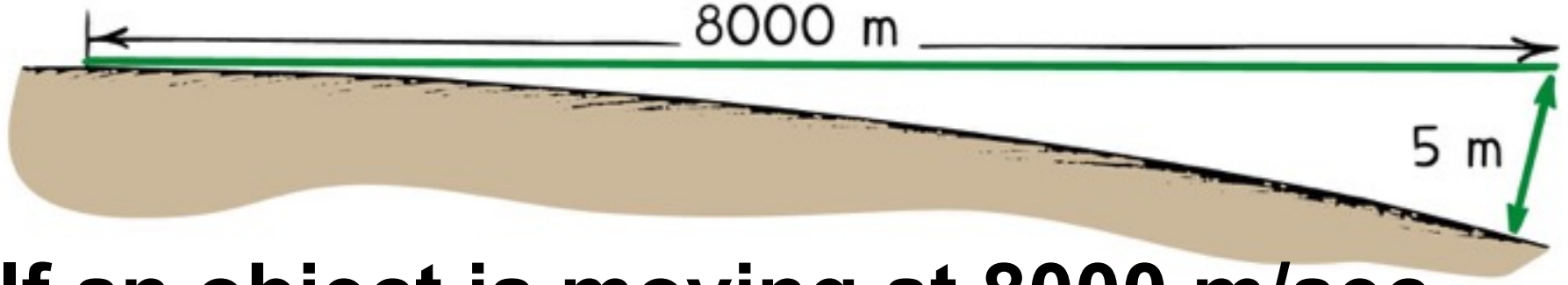
<u>Satellite</u> – an object that falls around the Earth or some other body rather than into it





Satellites

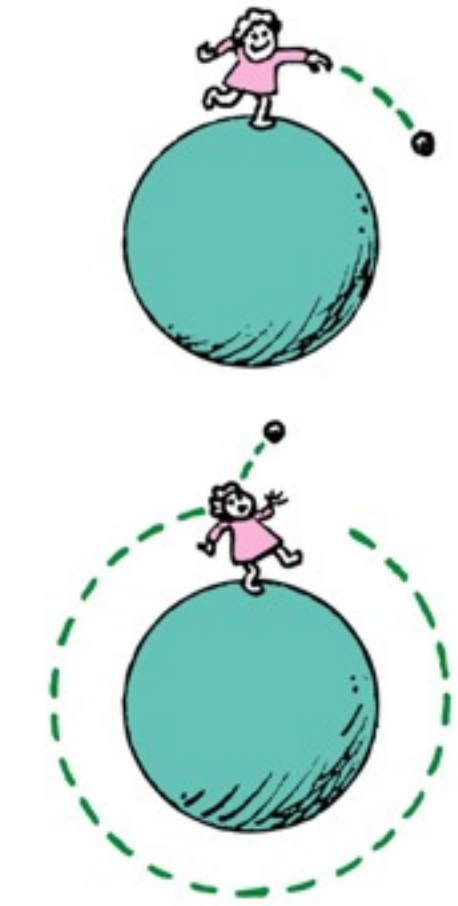
Curvature of the earth enters into our calculations



If an object is moving at 8000 m/sec AND it starts falling from 5 m above the surface

It will be 5 m above the ground after 1-s

Satellites



Throw at 8000 m/sec

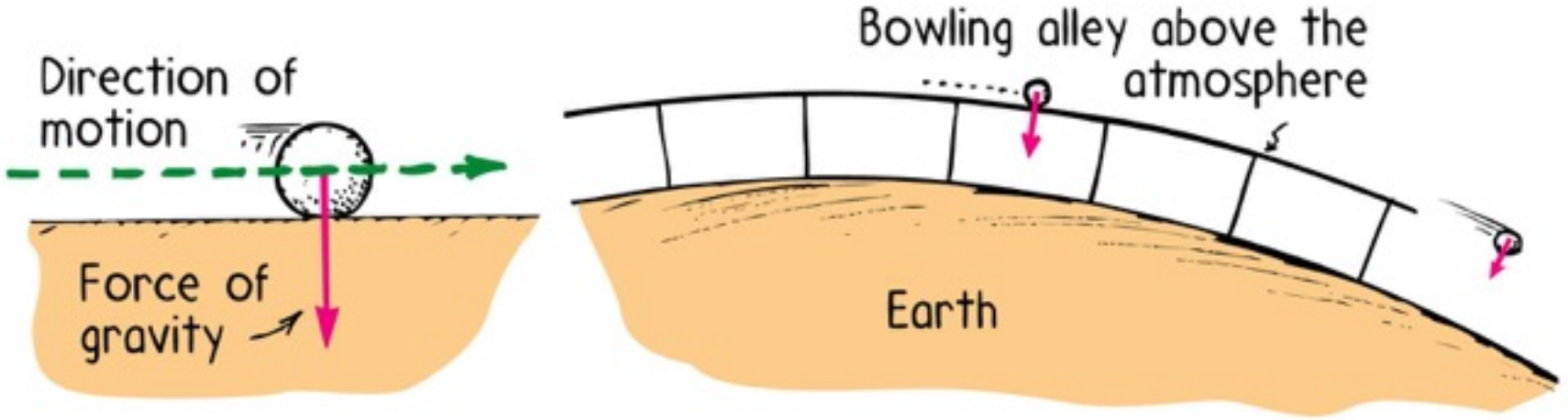
This is about 18,000 mph

Earth circumference is 25,000 miles

Takes 25000/18000 = 1.4 hours = 84 minutes

Higher altitude longer

Satellites



Force of gravity on bowling ball is at 90° to velocity, so it doesn't change the velocity!!!

If no air resistance, gravity doesn't change speed of satellite, only direction!!!

WHAT DO WE CALL A PROJECTILE THAT CONTINUALLY FALLS AROUND EARTH?

A) A ROTATING PROJECTILE

B) A SATELLITE

C) AN ORBITING OBJECT

D) A PLANET

What will happen if a satellite is launched with more velocity than is needed to stay in orbit?

A) **IT WILL EXIT THE EARTH'S GRAVATIONAL INFLUENCES AND CONTINUE IN MOTION WITHOUT ACUTALLY ORBITING EARTH.**

B) **IT WILL EXIT THE EARTH'S GRAVATIONAL INFLUENCES AND CATCH ON FIRE WHILE ORBITING THE EARTH**

C) **IT WILL LEAVE THE SOLAR SYSTEM AND BECOME IT'S OWN PLANET**

D) **THE GOVERNMENT WILL USE IT TO SPY ON OTHER COUNTRIES.**