~ The Big Ol' Duck ~

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I. Warm Ups

1) Romeo and Mercutio are running in a race. Romeo runs at a *constant* velocity of 3 meters/second. Mercutio comes from behind and passes him, running at a *constant* velocity of 5 meters/second. They continue at these constant velocities for the next several seconds.

Call the moment that Mercutio passes Romeo t = 0. In other words, at t = 0 the displacement between Mercutio and Romeo is 0 meters.

Call the direction the racers are running—i.e. towards the finish line—the ***positive*** direction.

a) How far ahead is Mercutio at t = 1 second?

b) How far ahead is Mercutio at t = 2 seconds?

c) How far ahead was Mercutio at t = -1 seconds?

d) How fast is the gap between Mercutio and Romeo increasing?

e) What is Mercutio's velocity relative to Romeo. In other words, at what velocity is Mercuito going from Romeo's point of view?

f) What is Romeo's velocity relative to Mercutio?

g) What is Romeo's speed relative to Mercutio?

2) A baseball rolls down a 6 foot slide. From rest, it accelerates at a constant rate and completes the slide in 2 seconds.

a) Determine the precise moment at which the baseball's instantaneous velocity is 3 ft/s.

b) Determine the displacement of the baseball at t = 1 second.

II. **EXTRA CREDIT: Turning Around**

A sub-atomic particle has recently been discovered. It is called a Caryon. (Although it has a tiny electric charge, it has an enormous charge account.)

At t=0 seconds, the Caryon is found at position x=0 angstroms. At that instant, the Caryon is observed to have an instantaneous velocity of 20 angstroms/sec. Responding to the magnetic field of some nearby magnetic strip, the Caryon accelerates at a constant rate. It accelerates all the way to x=100 angstroms, reverses direction and heads back to x=0.

The acceleration remains CONSTANT throughout the entire 1-dimensional round trip.

a) Compute the constant acceleration for the Caryon.

b) Place time on the x-axis and VELOCITY on the y-axis of some coordinate system. Graph v/t for the first 15 seconds of the Caryon's journey.

III. A Few Bolts.

Assume that, a free-falling object accelerates ***down*** at a constant rate.

Assume that this rate, ***a***, is approximately 10 meters/second^2.

One fine instant, you see a bolt known as Bolta get *dropped from rest* down an infinitely deep rabbit hole. 5 seconds later, you see a bolt known as Boltb get *thrust* from the same height--but with an initial downward velocity of 40 m/s!

a) How large (or small) is the gap (i.e. ***distance***) between the bolts at the instant 2 *more* seconds elapse?

b) Is this gap (distance) getting larger, getting smaller or staying the same size? Justify your answer *without* any quadratics.
HINT: we are asking about the ***distance*** between them, ***not*** the difference in their ***speeds***.

c) Sketch one neat, clear **velocity vs. time** graph which represents the motion of both bolts from the beginning of your observations (t=0) until t=7 seconds.

Now imagine that Boltb had instead been thrust *up* with an initial speed of 40 m/s from the same height and ***at the same time*** as Bolta.

d) Sketch one neat, clear **v vs. t** graph which represents the motion of both bolts from the beginning of your observations (t=0) until t=7 seconds.

e) Sketch a neat, clear **v vs. t** graph of the first 10 seconds of Bolta's motion--FROM Boltb's **frame of reference** (perspective)!

IV. A Velocity/Time Graph.

Place instantaneous velocity (m/s) on the y-axis and time (s) on the x-axis of a coordinate system. Draw a straight line of slope -4 m/s^2 and y-intercept of 12 m/s.

Let this graph represent the motion of some object known as "Edna the Object."

a) Determine the *displacement* of Edna for the first 3 seconds of her journey.
b) Determine the *displacement* of Edna for the first 6 seconds of her journey.
c) Determine the *instantaneous acceleration* of Edna at precisely t=3 seconds.
d) Is Edna ever speeding up? If so, when? If not, how do you know?
e) Complete the following table:

Time (s)	**Instantaneous Velocity (m/s)**	**Instantaneous Acceleration (m/s^2)**	**Total Displacement (m)**
0	12	-4	0
1			
2			
3			
4			
5			
6			
7			
8			
9			

f) Neatly sketch a **Position/Time** graph for the first 6 seconds of Edna's motion. What shape does this graph have?

V. Derivation of Equation #6.

From any of the DEFINITIONS we have thus far, and any equations we have derived or otherwise established as true, algebraically DERIVE an equation which expresses position as a function of acceleration, final (instantaneous) velocity and initial velocity. This equation, in other words, will be a short cut to be used when you neither know nor care about the time.

VI. The Big Ol' Duck.

A Big Ol' Duck flies in a straight line ***due south at a constant speed of 20 m/s***.

A Quiet Young Human stands ***40 meters below the passing duck***. She wishes to hit the duck when the duck is directly overhead.

Right at the moment she starts making plans to pursue this wish, however, the duck is not only ***above*** her, but also some noticeable (but ***unknown***) distance ***north*** of her. (SEE DIAGRAM! [also: see how vital diagrams are?])

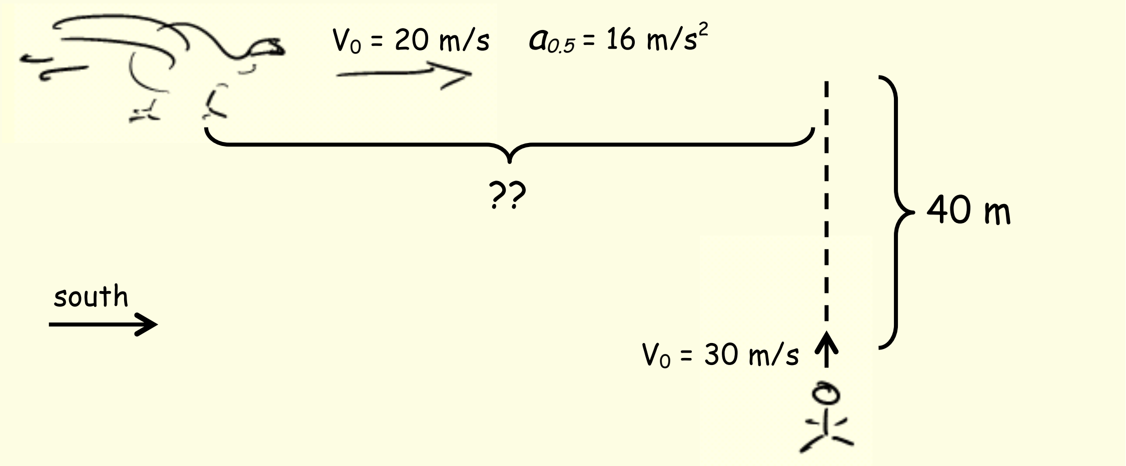
(And please note: ***NORTH*** is ***NOT*** the same as ***UP***.)

The Quiet Young Human fires a shot straight up with an ***initial velocity of 30 m/s up***.

Of course, after the shot is fired, it is in ***free fall***… which means constant _________.
(Fill in the blank in the line above using what you discovered in ***lab 2***.)

For this problem ***and for ALL future homework and exam problems***, you may assume that (near earth's surface), free fall ***acceleration is 10 m/s^2 downwards***.

Half a second after the shot is fired, The Big Ol' Duck instantly commences a ***constant acceleration of 16 meters/sec^2 forward (to the south)***.



a) How far North of the QYH should the Big Ol' Duck be at the moment the shot is fired, if the shot is to hit the Big Ol' Duck?

b) Why are there two mathematically possible answers to the above question (a)? Are both mathematical "roots" physically meaningful?

c) What if the Big Ol' Duck had accelerated at the same constant rate but toward the North? Can you find ***four*** mathematical "roots" to the problem? Are there four physically meaningful answers to the problem?