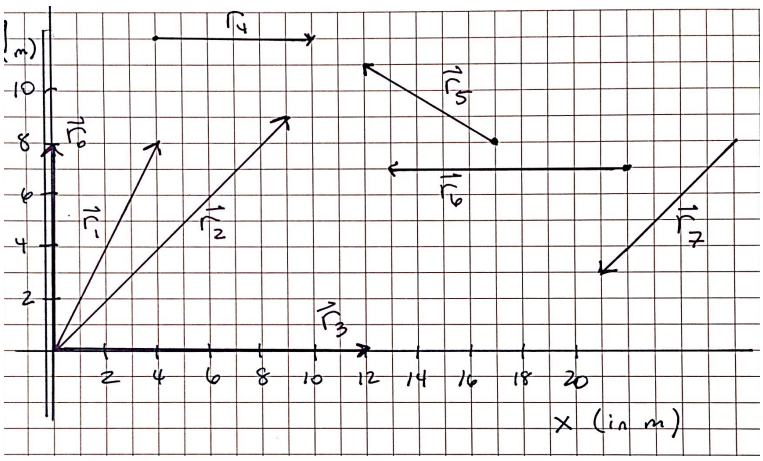
9/11 In Class Group Board 2 – Vector practice and Motion in 2D

For today, working on the board in groups, I will ask you to use column vectors. You may also use another method if you like, but I want everyone to get a chance to try using column vectors. In the future, you can use the method that works best for you.

1. Using the figure shown below, write vectors $\vec{r}_0$ through $\vec{r}_7$ as column vectors.



2. Using the results of the previous problem, evaluate the following: (please leave your answers as column vectors!)

   (a) $\vec{d}_1 = \vec{r}_0 + \vec{r}_3$
   (b) $\vec{d}_2 = \vec{r}_0 + \vec{r}_3 + \vec{r}_5$
   (c) $\vec{d}_3 = \vec{r}_2 + \vec{r}_5$
   (d) $\vec{d}_4 = \vec{r}_2 - \vec{r}_5$
   (e) $\vec{d}_5 = 3\vec{r}_0 + 2\vec{r}_5$

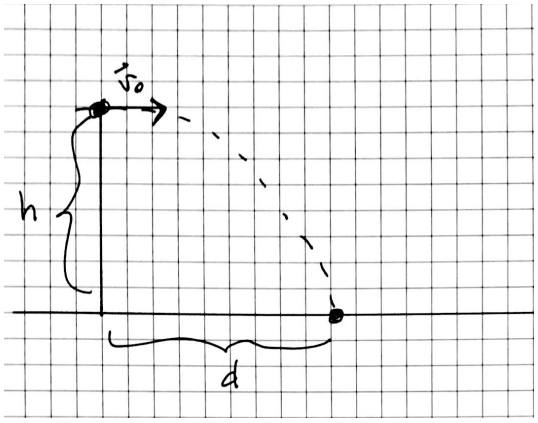
3. An object moves with an initial position given by $\vec{r}_0 = \begin{bmatrix} 15 \\ 8 \end{bmatrix}$ m and an initial velocity of $\vec{v}_0 = \begin{bmatrix} 0 \\ 24 \end{bmatrix}$ m/s. The object undergoes a constant acceleration of $\vec{a} = \begin{bmatrix} 3 \\ -2 \end{bmatrix}$ m/s^2.

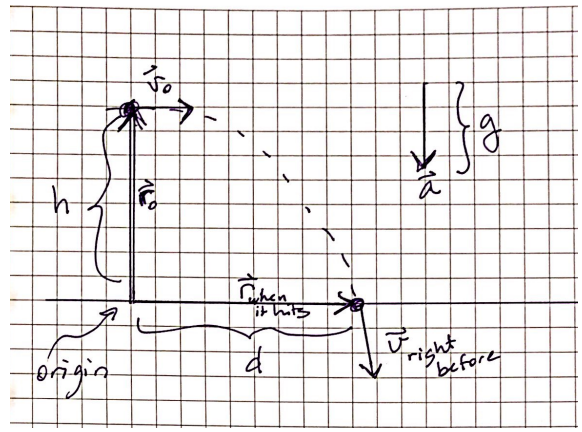
   (a) Write an expression for the velocity of the object as a function of time, using column vectors.
   (b) What is the object's velocity 2.0 seconds after the start?
   (c) Write an expression for the position as a function of time, using column vectors.
   (d) What is the position of the object 2.0s after the start?

4. An object has a velocity of 1.5 m/s at an angle of 20° above the horizontal. Write the velocity as a column vector.

5. Last time in class, we did a demo with a ball fired horizontally with an initial velocity of $\vec{v}_0$ from a height h. (The demo included the ball dropped straight down, but we won't analyze that here.) We can ask: how far did the ball go horizontally from the a point right under its starting position, d, and what was the ball's velocity right before it hit the ground $\vec{v}$. I would

draw a picture that looks like the first one: Then I would think about all the vectors I need to solve the kinematic equations, and I'd add them to my picture. (The second one.)





(a) Using the magnitudes h, d, v_0, g, write $\vec{r}_0$, $\vec{r}$, $\vec{v}_0$, and $\vec{a}$ as column vectors.

(b) Now write both kinematic equations in their vector form. Then substitute in the vectors you wrote above.

(c) Given $v_0 = 5.0\text{m/s}$ and $h = 2.0\text{m}$, find the time it takes the ball to land

(d) Given $v_0 = 5.0\text{m/s}$ and $h = 2.0\text{m}$, find the horizontal distance traveled d.

(e) Given $v_0 = 5.0\text{m/s}$ and $h = 2.0\text{m}$, find the velocity of the ball just before it hits the ground.

6. A ball is thrown from a height of 12m with an initial velocity of 3.0m/s at an angle of 30° upward from horizontal.

(a) Draw a picture and label vectors $\vec{r}_0$ and $\vec{v}_0$. You can't draw $\vec{r}$ until you know what time, or where, you will be asked about.

(b) How long does it take the ball to get to the top of its trajectory? How high above the ground is the top of the trajectory?

i. Now you can draw the $\vec{r}$ that you would use to answer both of those questions. (You won't know the x-comp, but you won't need it. You can just call it x.)

ii. Draw the velocity vector, $\vec{v}$ at the top. (Which is at the same time as the $\vec{r}$ you just drew.)

iii. Write the kinematic equations. Write the vectors you will use to substitute into the kinematic equations. Practice using symbols till the very end. Plug in things like h and no numbers yet. (Except for zeros. Plug in the zeros!)

iv. Solve for the time to top and the height at the top.

(c) Using the same procedure, find the time it takes the ball to land.

(d) Find the horizontal distance the ball traveled (from the start).

(e) Find the ball's velocity just before it hits the ground.