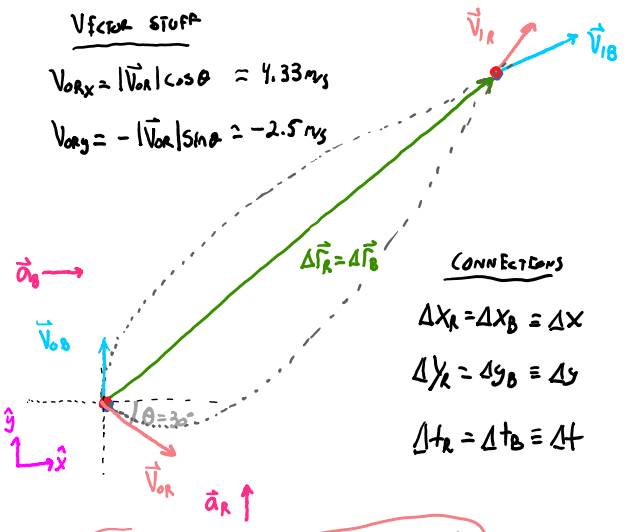
Week 4 Challenge Homework Solutions

At the Ice Capades two ice skaters pass right by each other while doing a routine where they are wearing directional jet packs. At this moment the skater in the red suit is traveling at a speed of 5 m/s in a direction 30° from the positive *x* axis towards the negative *y* axis and the skater in the blue suit is traveling at 4 m/s in the positive *y* direction. As they pass each other their jet packs turn on, shooting flames for effect and providing each of them a constant acceleration. The acceleration of the skater in the blue suit is in the positive *x* direction and has a magnitude of 4 m/s², while the acceleration of the skater in the red suit is in the positive *y* direction. With their jet packs turned on the entire time, they eventually meet again and pass right by each other.

(a) (a) How much time elapses between the two times they are side-by-side?
(b) (b) What was the magnitude of the acceleration of red skater to achieve this feat?
(c) (c) What is their change in position during this time?
(d) (d) What is the final velocity of each skater?
(e) (e) Use the *Order of Magnitude* sense-making technique to determine if your answers to part (d) seem safe.

Instructor Guide:

1. Drawing a physical representation is a very important first step. Starting to see a trend here in kinematics?
2. Encourage students to set up known and unknown lists. Here you can see the x-components looks like good places to start in math-land because there are more knowns compared to the y-components.
3. Encourage students explicitly write out the connections..



$$\Delta x = v_{ix}\Delta t + \frac{1}{2}a_x\Delta t^2$$

$$v_{fx} = v_{ix} + a_x\Delta t$$

$$v_{fx}^2 = v_{ix}^2 + 2a_x\Delta x$$

RED OBJECT USE SNAPSHOTS 0 AND 1

x: K	x: UK	y: K	y: UK
$v_{0Rx} = 4.33\ m/s$	$\Delta x_R \equiv \Delta x$	$v_{0Ry} = -2.5$	$\Delta y_R \equiv \Delta y$
	v_{fRx}		v_{fRy}
$a_{Rx} = 0$	$\Delta t_R \equiv \Delta t$		a_{Ry}
			$\Delta t_R \equiv \Delta t$

BLUE OBJECT USE SNAPSHOTS 0 AND 1

x: K	x: UK	y: K	y: UK
$v_{0xB} = 0$	$\Delta x_B \equiv \Delta x$	$v_{0yB} = 4\ m/s$	$\Delta y_B \equiv \Delta y$
	v_{fBx}		v_{fyB}
$a_{Bx} = 4\ m/s^2$	$\Delta t_B \equiv \Delta t$	$a_{yB} = 0$	$\Delta t_B \equiv \Delta t$

(a)

$$\Delta x_R = v_{0Rx}\Delta t_R + \frac{1}{2}a_{xR}\Delta t_R^2 \qquad \Delta x_B = v_{0Bx}\Delta t_B + \frac{1}{2}a_{xB}\Delta t_B^2$$

$$\Delta x = v_{0Rx}\Delta t \qquad \Delta x = \frac{1}{2}a_{xB}\Delta t^2$$

$$v_{0Rx}\Delta t = \frac{1}{2}a_{xB}\Delta t^2$$

$$\Delta t = \frac{2v_{0Rx}}{a_{xB}} = \frac{2(4.33)}{4} = 2.17\ sec$$

(b)

$\Delta y_A = v_{oAy}\Delta t_A + \frac{1}{2}a_{yA}\Delta t_A^2$ $\quad$ $\Delta y_B = v_{oyB}\Delta t_B + \frac{1}{2}a_{yB}\Delta t_B^2$

$\Delta y = v_{oAy}\Delta t + \frac{1}{2}a_{yA}\Delta t^2$ $\quad$ $\Delta y = v_{oyB}\Delta t$

$v_{oyB}\Delta t = v_{oAy}\Delta t + \frac{1}{2}a_{yA}\Delta t^2$

$v_{oyB} = v_{oAy} + \frac{1}{2}a_{yA}\Delta t$

$a_{yA} = \frac{2(v_{oyB} - v_{oAy})}{\Delta t} = \frac{2(4-(-2.5))}{2.17} = 5.99\ m/s^2$

(c)

$\Delta\vec{r} = \langle \Delta x, \Delta y \rangle$

From (a) ... $\Delta x = v_{oAx}\Delta t$ And $\Delta t = \frac{2v_{oAx}}{a_{Bx}}$

$\Delta\vec{r} = \langle 9.37, 8.66 \rangle m$

$\Delta x = \frac{2v_{oAx}^2}{a_{Bx}} = 9.37\ m$

From (b) ... $\Delta y = v_{oyB}\Delta t$

$\Delta y = \frac{2v_{oyB}v_{oAx}}{a_{Bx}} = 8.66\ m$

(d)

$|\vec{V}_{1R}| = \sqrt{V_{1Rx}^2 + V_{1Ry}^2}$

$|\vec{V}_{1B}| = \sqrt{V_{1Bx}^2 + V_{1By}^2}$

$\because a_{xR} = 0$ $\quad V_{yR} = V_{oyR} + a_{yR}\Delta t_R$

$V_{1Rx} = V_{oRx}$ $\quad V_{yR} = (-2.5) + (5.99)(2.17)$

$V_{1Rx} = 4.33\ m/s$ $\quad V_{yR} = 10.5\ m/s$

$|\vec{V}_{1R}| = \sqrt{4.33^2 + 10.5^2}$

$\boxed{|\vec{V}_{1R}| \simeq 11.4\ m/s}$

≈ 25 MPH

$\because a_{By} = 0$ $\quad V_{1Bx} = V_{oBx} + a_{Bx}\Delta t_B$

$V_{1By} = V_{oBy}$ $\quad V_{1Bx} = 0 + 4(2.17)$

$V_{1By} = 4\ m/s$ $\quad V_{1Bx} = 8.68\ m/s$

$|\vec{V}_{1B}| = \sqrt{4^2 + 8.68^2}$

$\boxed{|\vec{V}_{1B}| \simeq 9.56\ m/s}$

≈ 21 MPH

(e) $|\vec{V}_{FR}| \sim |\vec{V}_{FB}| \sim 10^1$ MPH

EVER FALL OFF A BICYCLE AT 10^1 MPH (20 ISH MPH)? ...

.... OUCH!!