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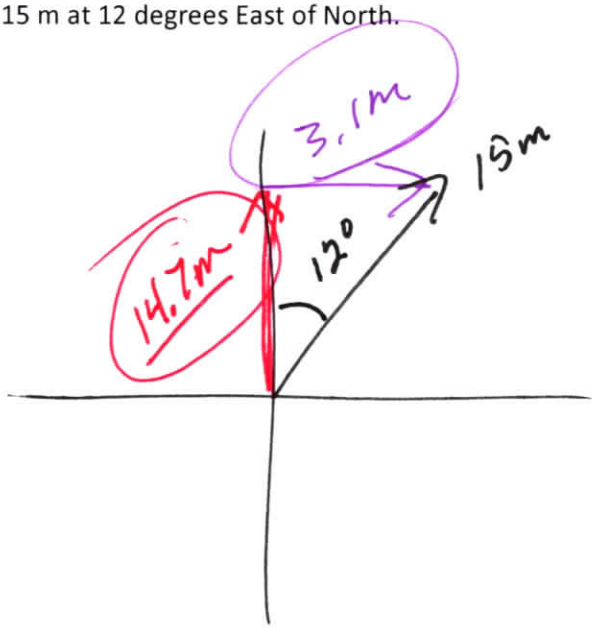
KEY

Kinematics & Vector Test

AT kinematics and Vector (21 S2)

Directions: Solve the following problems. Your work will be graded, not just the answer. This test is worth 50 points.

1) Resolve the following vector: 15 m at 12 degrees East of North.



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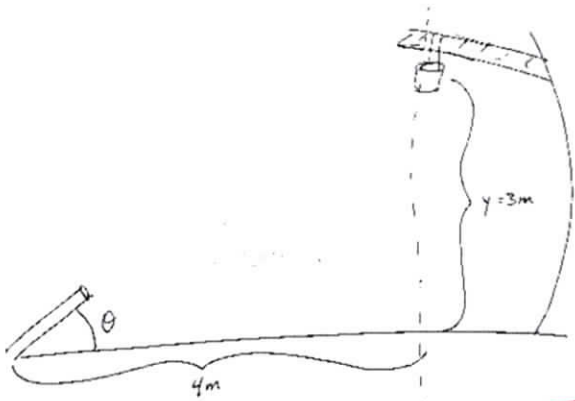
2) There is a "can" hanging from a tree that will fall at the same moment the gun is fired. The can is initially 3m above the ground, and the gun is 4 m from the line of fall of the can, as is shown in the diagram. Determine the angle of the gun so that the ball fired from the gun hits the can on its way down to the ground. Assume the speed of the ball will be such that it gets to the can before it hits the ground. (*note* this is a CLASSIC demo! It's possible that you may be familiar with the "Monkey & Hunter." If you are not, search it on YouTube {recommend Physics Force of the School of Physics and Astronomy, University of Minnesota.} when you are finished with the test. Rare is the mathematical justification, which is why we ask it here...)



"The Gun"

x

$x = 4m$

$v_x = v_0 \cos\theta$

$a = \text{zero}$

$x = v_0 \cos\theta\, t$

y

$v_y = v_0 \sin\theta$

$a = -9.8 m/s^2$

$y_0 = \text{zero}$

$y = v_0 \sin\theta\, t + \frac{1}{2}at^2$

"The Can"

$y = y_0 + v_0 t + \frac{1}{2}at^2$

$v_0 = 0 m/s$

$y_0 = 3m$

$a = -9.8 m/s^2$

$y = y_0 + \frac{1}{2}at^2$

The "y" Value For The Can & The Gun Will Be The Same When The Collide.

$y = y$

$y_0 + \frac{1}{2}at^2 = v_0 \sin\theta\, t + \frac{1}{2}at^2$

... Simplify ...

$y_0 = v_0 \sin\theta\, t$

... The Above Is Interesting...
Keep In Mind... It Is When $y = y$...
It Is A Unique time....
.. Now, Bring In The "x" of The Gun

$x = v_0 \cos\theta\, t$ ... Solve For time...

$\frac{x}{v_0 \cos\theta} = t$ ... Sub Into $y_0 = v_0 \sin\theta\, t$

$y_0 = v_0 \sin\theta \left(\frac{x}{v_0 \cos\theta}\right)$

$y_{0(can)} = \frac{v_0 \sin\theta\, x}{v_0 \cos\theta}$

$y_{0(can)} = \frac{\sin\theta\, x}{\cos\theta}$

$\frac{y_{0(can)}}{x} = \tan\theta$; $\theta = 37°$; point It At The Can

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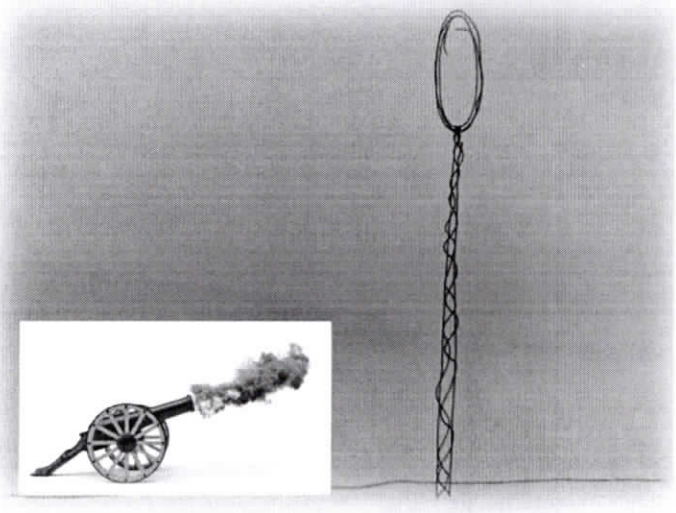
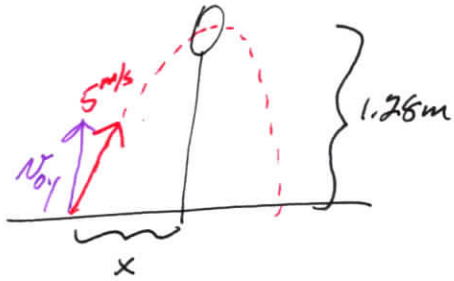
3) The cannon in the diagram below will fire the ball at 5m/s (Like the spring guns we used in the lab). The ring is ~~1.28m~~ 1.1m high. The cannon is to be fired such that the ball will go through the ring. Determine the greatest distance possible between the cannon and the bottom of the ring stand. Ignore the height of the cannon; assume the height is the distance above the end of the barrel.





#1

$v_{0,y} = (5\,m/s)\sin\theta$

$y = 1.28m$

$v_y = 0$ @ highest point

$a = -9.8\,m/s^2$

$v_y^2 = v_{0y}^2 + 2ay$

$\sqrt{2ay} = v_{0y}$

$\sqrt{2ay} = (5\,m/s)\sin\theta$

$\sin^{-1}\left[\frac{\sqrt{2ay}}{5\,m/s}\right] = \theta$

$\sin^{-1}\left[\frac{\sqrt{(2)(+9.8\,m/s^2)(1.1m)}}{5\,m/s}\right] = \theta$

$66^\circ = \theta$

#2

$v_{0x} = v_0\cos\theta$

$1.85\,m/s = (5\,m/s)\cos 66^\circ = v_{0x}$

time To highest Point

$v_{0y} = 4.6\,m/s$

$v_f = 0$

$t = ?$

$a = -9.8\,m/s^2$

$v = v_0 + at$

$\frac{-v_0}{a} = t = \frac{-4.6\,m/s}{-9.8\,m/s^2} = .469s$

$x = v_x t$

$x = (1.85\,m/s)(.469s)$

$x = .87m$

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4) While traveling south on I-83 while doing 65 mi/hr (29m/s) you spot an interesting truck-trailer combination driving northbound. It takes 3 seconds from the time you spot them until they drive past you. Assuming they are also traveling at 65 mi/hr, how far away were they from you when you first spotted them? (Feel free to solve in any reasonable unit)

Speed Relative 140mi/hr

$$(3s)\left(\frac{130mi}{hr}\right)\left(\frac{1hr}{3600s}\right) = .108m = 174m$$

Ugh... Basic Math...

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5) A cliff is 12 m above the water. The top surface of the cliff is flat and level allowing you to run at a full speed across the top of about 8.5 m/s. How long does it take you to hit the water?

$y = -12m$

$a = -9.8 m/s^2$

$t =$

$v_{0y} = ?$

$y = v_0 t + \frac{1}{2} a t^2$

$\sqrt{\frac{2y}{a}} = t = \sqrt{\frac{(2)(-12m)}{-9.8 \frac{m}{s^2}}} = 1.56s$

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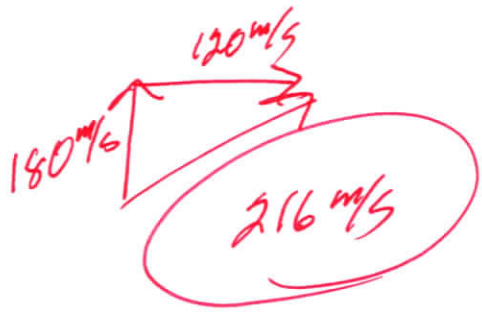
6) A space craft is flying through frictionless and gravity free space at 120 m/s. A thruster is fired that will impart an acceleration, perpendicular to the initial straight-line path of travel of the rocket, of 6 m/s^2. Determine the speed of the space craft when the thruster shuts off after 30 seconds.

$v = v_0 + at$

$v = \left(6 \frac{m}{s^2}\right)(30s)$

$v = 180 m/s$



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7) While driving on the interstate, you know your friends are in another car driving at a constant 65mi/hr and initially 1.5 miles ahead of you. If you are doing 70 mi/hr, how far will you drive until you have caught them?

$\frac{1.5\text{mi}}{5\text{mi/hr}} = .3\text{hr}$

$(70\text{mi/hr})(.3\text{hr}) = 21\text{mi}$

77, 69 M

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8) While watching a soccer practice, you notice a player is putting a boot on the ball, sending it upward initially with an approximate angle of 25 degrees, and landing about 45 yards (41.1m) away. How fast was the ball going when it left the player's foot?

$$x = \frac{v_0^2 \sin(2\theta)}{g}$$

$$\sqrt{\frac{xg}{\sin(2\theta)}} = v_0$$

$$\sqrt{\frac{(41.1m)(9.8m/s^2)}{\sin(50°)}} = 23\ m/s$$

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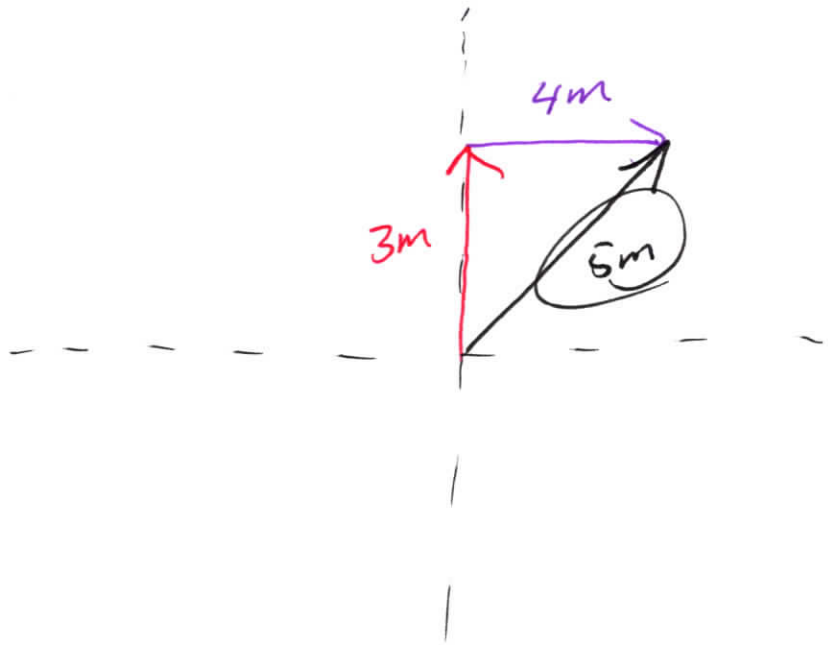
9) Make an APPROX sketch (A ruler and protractor are not needed) of the addition of the following vectors:
   a. 3 m north
   b. 4 m east



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10) Washington DC is about 114 miles south of here. During the trip, the cruise control is set to 62mph, except for 14 miles, when it is set to 73mph. How much time was saved by doing the stint of 73mph vs. doing 62 mph the entire time?

$\frac{114mi}{62 mi/hr} = 1.84hr$

$\frac{14mi}{73 \frac{mi}{hr}} = .192hr$

$\frac{100mi}{62 mi/hr} = 1.613$

$.192hr + 1.613hr = 1.805hr$

$1.84hr - 1.805hr = .0338hr = 2min$