Physics 100A – S 14 – Midterm 1 B 06/10/16

Name:

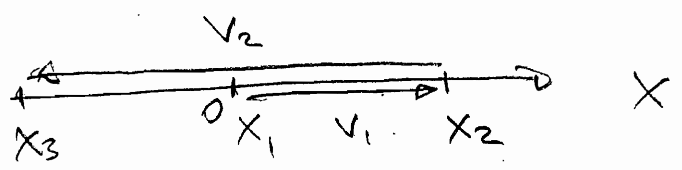
In order to get full credit for your work please show all your work, and explain reasoning clearly where necessary.

1. What is the speed in miles per hour of a beam of light traveling at 3.00×10^8 m / s? (1 mi = 1.609 km) (5.0 points)

$$C = 3{,}00\ 10^8\ \frac{m}{s}\ \frac{1\ mi}{1.609\ 10^3\ m}\ \frac{3.600\ 10^3\ s}{1\ h}$$

$$= 6.71\ 10^8\ \frac{mi}{h}$$

2. A finch rides on the back of a Galapagos tortoise, which walks at the stately pace of 0.80 m/s. After 1.2 minutes the finch tires of the tortoise's slow pace, and takes flight in the opposite direction for another 1.2 minutes at 8.0 m/s. What was the average velocity of the finch for this 2.4-minute interval? (5.0 points)



$$V_1 = 0.80\ \frac{m}{s}$$

$$\Delta t_1 = 1.2\ min = 72\ s$$

$$V_2 = -8{,}00\ \frac{m}{s}$$

$$\Delta t_2 = 72\ s$$

$$V_{av} = \frac{\Delta X_{TOT}}{\Delta t}$$

$$V_{av} = \frac{(X_3 - X_2) + (X_2 - X_1)}{t_1 + t_2}$$

$$(X_2 - X_1) = V_1 \Delta t_1 = 0.80\ 72 = 57{,}6\ m$$

$$(X_3 - X_2) = -V_2 \Delta t_1 = -8{,}00\ 72 = -576\ m$$

$$V_{av} = \frac{-576 + 57.6}{72 + 72} = -3{,}6\ \frac{m}{s}$$

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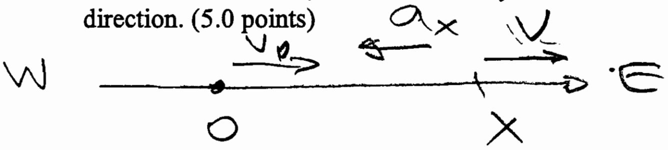
3. Coasting due east on your bicycle at 9.4 m/s, you encounter a sandy patch of road 8.4 m across. When you leave the sandy patch your speed has been reduced by 3.0 m/s to 6.4 m/s. Assuming the sand causes a constant acceleration, what was the bicycle's acceleration in the sandy patch? Give both magnitude and direction. (5.0 points)



$x = 8.4$ m $\quad x_0 = 0$

$v_0 = 9.4$ m/s

$v = 6.4$ m/s

$$v^2 = v_0^2 - 2a_x(x-0)$$

$$a_x = \frac{v^2 - v_0^2}{2x} = \frac{6.4^2 - 9.4^2}{2\ 8.4} = -\frac{47.4}{16.8}$$

$$a_x = -2.8\ \frac{m}{s^2}\ (\text{WEST})$$

4. Two boys are pulling a box across a horizontal floor as shown in, Fig 1. If $F_1 = 75.0$ N and $F_2 = 150$ N, find the resultant (or sum) force by the component method. (5.0 points)

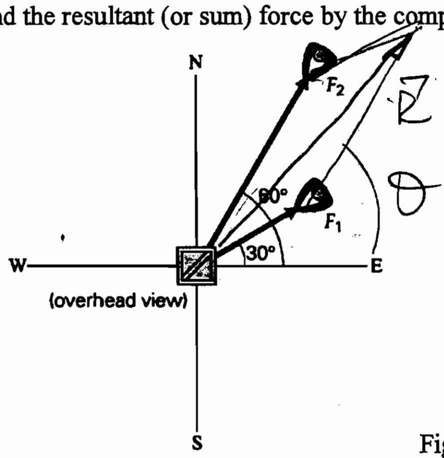


Fig 1

$F_{1x} = F_1 \cos 30° = 75.0 \cos 30° = 64.9$ N

$F_{1y} = F_1 \sin 30° = 75.0 \sin 30° = 37.5$ N

$F_{2x} = 150 \cos 60° = 75.0$ N

$F_{2y} = 150 \sin 60° = 129.9$ N

$R_x = F_{1x} + F_{2x} = 64.9 + 75.0 = 140$ N

$R_y = F_{1y} + F_{2y} = 37.5 + 129.9 = 167$ N $= 170$ N

$\vec{R} = 140\text{ N}\ \hat{x} + 170\text{ N}\ \hat{y}$

OR $R = \sqrt{R_x^2 + R_y^2} = \sqrt{140^2 + 167^2} = 218$ N $\simeq 220$ N

$$\theta = \tan^{-1}\frac{R_y}{R_x} = \tan^{-1}\frac{167}{140} = 50°$$

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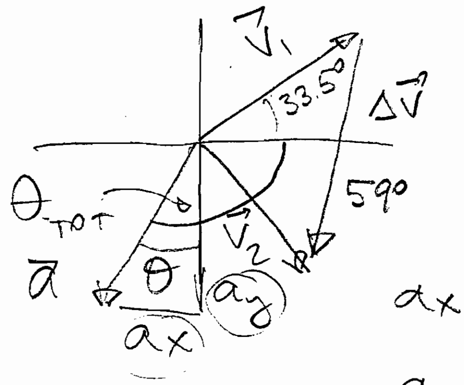
5. Initially, a particle is moving at 4.10 m/s at an angle of 33.5° above the horizontal. Two seconds later, its velocity is 6.05 m/s at an angle of 59.0° below the horizontall. What was the particle's average acceleration during these 2.00 seconds? (5.0 poinst)



$V_{1x} = 4.10 \cos 33.5° = 3.419 \frac{m}{s}$ $\Delta t = 2.00 s$

$V_{1y} = 4.10 \sin 33.5° = 2.26 \frac{m}{s}$

$V_{2x} = 6.05 \cos 59.0° = 3.116 \, m/s$

$V_{2y} = -6.05 \sin 59.0° = -5.186 \, m/s$

$a_x = \frac{V_{2x} - V_{1x}}{\Delta t} = \frac{3.116 - 3.419}{2.00} = -0.152 \frac{m}{s^2}$

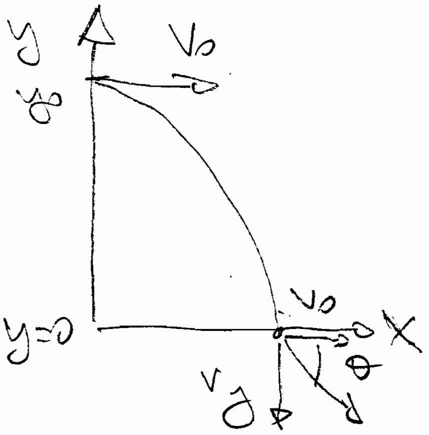
$a_y = \frac{V_{2y} - V_{1y}}{\Delta t} = \frac{-5.186 - 2.26}{2.00} = -3.72 \frac{m}{s}$

$\vec{a}_{av} = (-0.152 \hat{x} - 3.72 \hat{y}) \frac{m}{s^2}$ OR

$a_{av} = \sqrt{a_x^2 + a_y} = \sqrt{(-0.152)^2 + (-3.72)^2} = 3.73 \frac{m}{s^2}$

$\theta = \tan^{-1} \frac{a_x}{a_y} = \tan^{-1} \frac{-0.152}{-3.72} = 2.34°$ & $\theta_{TOT} = -92.3°$

6. On August 25, 1894, Chicago catcher William Schriver caught a baseball thrown from the top of the Washington Monument (555 ft, 898 steps). If the ball was thrown horizontally with a speed of 5.55 m/s, what were the ball's speed and direction of motion when caught? (1 m = 3.281 ft) (5.0 points)



$y_0 = 555 \, ft \frac{1 \, m}{3.281 \, ft} = 169.1 \, m$

$V_{0x} = 5.55 \frac{m}{s}$ $V_{0y} = 0$

$V_x = V_{0x} = 5.55 \, m/s$

$V_y^2 = V_{0y}^2 - 2g(y - y_0) =$

$V_y^2 = 0 - 2\, 9.81 (0 - 169.1) = 3314.$

$V_y = -\sqrt{3314} = -57.6 \, m/s$

$V = \sqrt{V_x^2 + V_y^2} = \sqrt{(-57.6)^2 + (5.55)^2} = 57.9 \, m/s$

$\theta = \tan^{-1} \frac{-57.6}{5.55} = -84.5°$ OR

84.5° BELOW THE +X-AXIS

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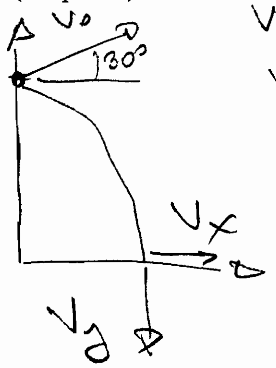
7. A stone is thrown upward from the top of a building at an angle of 30.0 ° to the horizontal and with an initial speed of 20.0 m/s. The point of release is 45.0 m above the ground. Find the stone's speed at impact. (5.0 points)



$V_0 = 20.0\ m/s \quad \theta_0 = 30.0 \quad y_0 = 45.0\ m$

$y = 0$

$V_{0x} = 20.0 \cos 30.0° = 17.32\ m/s$

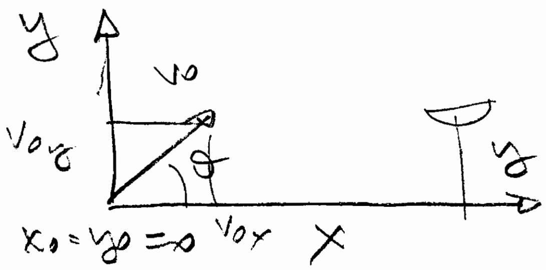
$V_{0y} = 20.0 \sin 30.0° = 10.0\ m/s$

$V_y^2 = V_{0y}^2 - 2\ 9.81\ (y - y_0)$

$V_y = \sqrt{100 + 882.9} = -31.35\ m/s$

$V = \sqrt{V_x^2 + V_y^2} = \sqrt{17.32^2 + 31.35^2} = 35.8\ \frac{m}{s}$

8. A daredevil is shot out of a canon at 45 ° to the horizontal with an initial speed of 20 m/s. A net is located at a horizontal distance of 40 m from the canon. At what height above the canon should the net be placed in order to catch the daredevil? (5.0 points)



$x = 40\ m \quad x_0 = y_0 = 0$

$V_0 = 20\ m/s \quad \theta = 45°$

$V_{0x} = 20 \cos 45° = 14.14\ m/s$

$V_{0y} = 20 \sin 45° = 14.14\ m/s$

$x = V_{0x} t \quad t = \frac{x}{V_{0x}} = \frac{40}{14.14} = 2.83\ s$

$y = y_0 + V_{0y} t - \frac{1}{2} g t^2 = 14.14\ 2.83 - \frac{9.81}{2} (2.83)^2$

$y = 0.73\ m$