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 $3.00 \times 10^8$ m/s? (1 mi = 1.609 km) (5.0 points)

$$\frac{C}{1 \text{ m/s}} = \frac{3.600 \times 10^3 \text{ s}}{1.609 \times 10^2 \text{ m}} = 6.71 \times 10^8 \frac{\text{mi}}{\text{h}}$$

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)

$$\vec{v}_1 = 0.80 \frac{\text{m}}{\text{s}}$$
$$\Delta t_1 = 1.2 \text{ min} = 72 \text{ s}$$
$$\vec{v}_2 = -8.00 \frac{\text{m}}{\text{s}}$$
$$\Delta t_2 = 72 \text{ s}$$

$$\text{Var} = \frac{\Delta X_{\text{tor}}}{\Delta t}$$

$$\text{Var} = \frac{(X_3 - X_2) + (X_2 - X_1)}{t_1 + t_2}$$

$$(X_2 - X_1) = \vec{v}_1 \Delta t_1 = 0.80 \times 72 = 57.6 \text{ m}$$
$$(X_3 - X_2) = -\vec{v}_2 \Delta t_1 = -8.00 \times 72 = -576 \text{ m}$$

$$\text{Var} = \frac{-576 + 57.6}{72 + 72} = -3.6 \frac{\text{m}}{\text{s}}$$
Physics 100A – S 14 – Midterm 1

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)

\[ v^2 = v_0^2 - 2a_x (x - 0) \]

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

\[ a_x = -2.8 \text{ m/s}^2 \text{ (West)} \]

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

\[ F_{Rx} = F_1 \cos 30^\circ = 75.0 \cos 30^\circ = 64.9 \text{ N} \]

\[ F_{Ry} = F_1 \sin 30^\circ = 75.0 \sin 30^\circ = 37.5 \text{ N} \]

\[ F_2x = 150 \cos 60^\circ = 75.0 \text{ N} \]

\[ F_2y = 150 \sin 60^\circ = 129.9 \text{ N} \]

\[ E_x = F_{Rx} + F_2x = 64.9 + 75.0 = 140 \text{ N} \]

\[ E_y = F_{Ry} + F_2y = 37.5 + 129.9 = 167 \text{ N} \]

\[ E = 140 \text{ N} \hat{x} + 170 \text{ N} \hat{y} \]

\[ R = \sqrt{R_x^2 + R_y^2} = \sqrt{140^2 + 167^2} = 218 \text{ N} \]

\[ \theta = \tan^{-1} \frac{R_y}{R_x} = \tan^{-1} \frac{167}{140} = 50^\circ \]
In order to get full credit for your work please show all your work, and explain reasoning clearly where necessary.

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 horizontal. What was the particle’s average acceleration during these 2.00 seconds? (5.0 points)

\[ v_{1x} = 4.10 \cos 33.5° = 3.419 \text{ m/s} \]
\[ v_{1y} = 4.10 \sin 33.5° = 2.26 \text{ m/s} \]
\[ v_{2x} = 6.05 \cos 59.0° = 3.116 \text{ m/s} \]
\[ v_{2y} = -6.05 \sin 59.0° = -5.186 \text{ m/s} \]
\[ a_x = \frac{v_{2x} - v_{1x}}{\Delta t} = \frac{3.116 - 3.419}{2.00} = -0.152 \text{ m/s}^2 \]
\[ a_y = \frac{v_{2y} - v_{1y}}{\Delta t} = \frac{-5.186 - 2.26}{2.00} = -3.72 \text{ m/s}^2 \]
\[ a = \sqrt{a_x^2 + a_y^2} = \sqrt{(-0.152)^2 + (-3.72)^2} = 3.73 \text{ m/s}^2 \]
\[ \theta = \tan^{-1} \left( \frac{a_y}{a_x} \right) = \tan^{-1} \left( \frac{-3.72}{-0.152} \right) = 23.4° \text{ or } \theta_{tot} = -92.3° \]

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)

\[ y_0 = 555 \text{ ft} \times \frac{1 \text{ m}}{3.281 \text{ ft}} = 169.1 \text{ m} \]
\[ v_{0x} = 5.55 \text{ m/s} \quad v_{0y} = 0 \]
\[ v_x = v_{0x} = 5.55 \text{ m/s} \]
\[ v_0^2 = v_{0y}^2 - 2 \cdot 9.81 \cdot (y_0 - y) = v_{0y}^2 - 2 \cdot 9.81 \cdot (0 - 169.1) = 3314 \text{ m}^2/\text{s}^2 \]
\[ v_y = -\sqrt{3314} = -57.6 \text{ m/s} \]
\[ v = \sqrt{v_x^2 + v_y^2} = \sqrt{(5.55)^2 + (-57.6)^2} = 57.9 \text{ m/s} \]
\[ \theta = \tan^{-1} \left( \frac{-57.6}{5.55} \right) = -84.5° \text{ or } \theta \]
\[ 84.5° \text{ below the } +x \text{-axis} \]
7. A stone is thrown upward from the top of a building at an angle of $30.0^\circ$ 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)

\[ v_o = 20.0 \text{ m/s} \quad \theta_o = 30.0^\circ \quad y_o = 45.0 \text{ m} \]

\[ v_y = 0 \]

\[ v_{ox} = 20.0 \cos 30.0^\circ = 17.32 \text{ m/s} \]

\[ v_{oy} = 20.0 \sin 30.0^\circ = 10.0 \text{ m/s} \]

\[ v_y^2 = v_{oy}^2 - 2g(y - y_o) \]

\[ v_y = \sqrt{100 + 882.9} = -31.35 \text{ m/s} \]

\[ v = \sqrt{v_{ox}^2 + v_y^2} = \sqrt{17.32^2 + 31.35^2} = 35.8 \text{ m/s} \]

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

\[ v_o = 20 \text{ m/s} \quad \theta = 45^\circ \]

\[ v_{ox} = 20 \cos 45^\circ = 14.14 \text{ m/s} \]

\[ v_{oy} = 20 \sin 45^\circ = 14.14 \text{ m/s} \]

\[ x = v_{ox} t \quad t = \frac{x}{v_{ox}} = \frac{40}{14.14} = 2.83 \text{ s} \]

\[ y = y_o + v_{oy} t - \frac{1}{2} g t^2 = 14.14 \times 2.83 - \frac{9.81}{2} (2.83)^2 \]

\[ y = 0.73 \text{ m} \]