Department of Physics
University of Maryland

Physics 121 Fall 2002
Homework Assignment # 3

Problem Solutions

10) This problem starts by stating some displacement vectors. This information can be used to find the components of each. For vector $\vec{C}$ this means the usual use of trigonometry.

$$\begin{aligned} C_x &= -\,2.15\,cos(35^o)\,km \quad , \quad C_y = 2.15\,sin(35^o)\,km \quad , \\ &= -\,1.76\,km \quad , \quad\quad\quad\quad\quad = 0.48\,km \quad , \end{aligned}$$

Next the components can be added.

Vector	x-component	y-component
$\vec{A}$	$0.5\,km$	0
$\vec{B}$	0	$-\,0.75\,km$
$\vec{C}$	$-\,1.76\,km$	$0.48\,km$
$\vec{A} + \vec{B} + \vec{C}$	$-\,1.26\,km$	$0.48\,km$

(a.) This give a magnitude of

$$\begin{aligned} \left|\vec{A} + \vec{B} + \vec{C}\right| &= \sqrt{(-1.26)^2 + (0.48)^2}\;km \\ &= 1.35\,km \end{aligned}$$

and the vector points at angle of

$$tan\theta = \frac{0.48}{1.26} = 21^o \quad ,$$

north of due west.

(b.) The average velocity points in the same direction but yields a speed of

$$\left|\overline{v}\right| = \frac{1.35}{2.50}\,\frac{km}{hr} = 0.54\,\frac{km}{hr} \quad .$$

11) The problem tells us that the orbit is circular with a radius of $1.50 \times 10^{11}\, m = R$. The distance around the circle is the circumference C and is related to the radius via $C = 2\,\pi\,R$.

(a.) The distance travelled is (1/4) C so

$$D \;=\; \tfrac{1}{4}\,(2\,\pi)\,(1.50\;\times 10^{11}\,m) \;=\; 2.36\;\times 10^{11}\,m$$

and this occurs in a time of $7.89\;\times 10^{6}\,s$ and so this yields an average speed of

$$\overline{v} \;=\; \frac{2.36\;\times 10^{11}\,m}{7.89\;\times 10^{6}\,s} \;=\; \frac{2.33}{7.89}\times 10^{5}\,\frac{m}{s} \;=\; 2.99\;\times 10^{4}\,\frac{m}{s}$$

(b.) At the beginning of the period the earth is moving with the speed above along the x-axis. At the end of the three month period it is moving with this same speed but along the y-axis.

Vector	x-component	y-component
$\vec{v}_0$	$2.99\;\times 10^{5}\,\frac{m}{s}$	0
$\vec{v}_f$	0	$2.99\;\times 10^{5}\,\frac{m}{s}$

If a picture is drawn then it can be see that the magnitude of the displacement vector is just $\sqrt{2}$ time the radius of the orbit so

$$\overline{v} \;=\; \frac{\sqrt{2}(1.50\;\times 10^{11}\,m)}{7.89\;\times 10^{6}\,s} \;=\; 2.69\;\times 10^{4}\,\frac{m}{s}$$

13) This problem is really asking how long the ball stays in the air. Since the ball is kicked at an angle, the usual use of trigonometric function applies

$$V_{0,\,x} \;=\; 25\,cos(60^{o})\,\frac{m}{s} \quad , \quad V_{0,\,y} \;=\; 25\,sin(60^{o})\,\frac{m}{s} \quad ,$$
$$\;=\; 12.5\,\frac{m}{s} \quad , \quad \;=\; 21.65\,\frac{m}{s} \quad ,$$

and the component $V_{0,\,y}$ can be used to find out how long it takes for the ball to reach its highest point where its final y-component of velocity is zero.

$$0 \;=\; 21.65\,\frac{m}{s} \;-\; (9.8\frac{m}{s^2})\,t \quad\rightarrow\; t \;=\; \frac{21.65}{9.8}s \;=\; 2.2\,s.$$

This is just the time it takes to go up to the highest point. It must then fall down and this takes the same amount of time. So the total "hang time" is just

$$T_{total} \;=\; 2(2.2\,s) = 4.4\,s \quad .$$

20) It was noted in class that the x-component of an object that flies through the air is always the same. So if the fielder catches the ball 115 ft from home plate and throws it with a speed of 41 $\frac{m}{s}$, then we have

$$115\,m \;=\; 41\,\frac{m}{s}\,t \quad \rightarrow \quad t \;=\; \frac{115\,m}{41\,s} \;=\; 2.8\,s$$

Since the runner takes 3.50 s to reach home, the ball beats him there by 0.7 s and he is out.

26) If Jordan were really able to take two second from the time he left the ground until he landed, then it would take him one second to reach the maximum height of his leap. This can be used to find out what would be his velocity when leaving the ground.

$$0 \;=\; v_0 \;-\; (9.8\,\frac{m}{s^2})\,(1\,s) \;\; to \;\; v_0 \;=\; 9.8\,\frac{m}{s}$$

In turn this can be used to deduce his final y-position

$$\begin{aligned} y_f &= (9.8\,\frac{m}{s})\,(1\,s) \;-\; \tfrac{1}{2}\,(9.8\,\frac{m}{s^2})\,(1\,s)^2 \\ &= 9.8\,m \;-\; \tfrac{1}{2}\,(9.8\,m) \;=\; \tfrac{1}{2}\,(9.8\,m) \\ &= 4.9\,m \end{aligned}$$

Since Jordan's leap is only 1 m, the fans are merely being hysterical.

34) The tomato begin with the x-component and y-component of velocity given by

$$V_x \;=\; 25\,\frac{m}{s} \quad , \quad V_y \;=\; 11\,\frac{m}{s}$$

Once again the y-component can be used to deduce how long it takes to travel to the highest point

$$0 \;=\; 11\,\frac{m}{s} \;-\; (9.8\,\frac{m}{s})\,t \quad \rightarrow \quad t \;=\; \frac{11}{9.8}\,s \;=\; 1.12\,s$$

The total time the tomato is in the air is twice this time, $T_{total} = 2.24\ s$ and the car has continued to move in the x-direction along with the tomato, so the distance travelled eastward is

$$x_f \;=\; 25\,\frac{m}{s}\,(2.24\,s) \;=\; 56\,m$$

39) Since no numbers are given in this problem, it is purely an algebraic problem. Let the height of the first building be written as H_1 and the height of the second building be written as H_2. Next the times t_1 and t_2 it takes

for the stones thrown from each building to hit the ground can be found (with $g = 9.8\ \frac{m}{s^2}$)

$$H_1 \;=\; \frac{1}{2}\, g\, (t_1)^2 \quad \rightarrow \quad t_1 \;=\; \sqrt{\frac{2H_1}{g}}$$

$$H_2 \;=\; \frac{1}{2}\, g\, (t_2)^2 \quad \rightarrow \quad t_2 \;=\; \sqrt{\frac{2H_2}{g}}$$

Since both stones are thrown horizontally with the same initial velocity, the distance in the x-direction that each travels is given by, respectively

$$x_{f,1} \;=\; V_0\, t_1 \;=\; V_0 \sqrt{\frac{2H_1}{g}}$$

$$x_{f,2} \;=\; V_0\, t_1 \;=\; V_0 \sqrt{\frac{2H_2}{g}}$$

The problem states that one of these distances is twice the other so that $x_{f,1} \;=\; 2x_{f,2}$ which implies

$$V_0 \sqrt{\frac{2H_1}{g}} \;=\; 2\, V_0 \sqrt{\frac{2H_2}{g}} \quad \rightarrow \quad (V_0)^2\, \frac{2H_1}{g} \;=\; 4\, (V_0)^2\, \frac{2H_2}{g}$$

$$\rightarrow \quad H_1 \;=\; 4H_2 \quad \rightarrow \frac{H_1}{H_2} = 4$$