Department of Physics
University of Maryland

Physics 121 Fall 2002
Homework Assignment # 2

Problem Solutions

2) The problem tells us that the lake is circular with a radius of 1.50 km $= R$. 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 3/4 C so

$$D \;=\; \tfrac{3}{4}\,(2\,\pi)\,(1.50\,km) \;=\; 7.07\,km$$

(b.) Since they walked 3/4 of the way around the lake, they are standing due north of the center of the lake at the end of their walk. This immediately implies that their displacement vector makes an angle of 45^o north of the east direction and has a magnitude given by

$$\Big|\,displacement\,\Big| \;=\; \sqrt{R^2 \;+\; R^2} \;=\; \sqrt{2}\,R \;=\; 2.12\,km$$

8) During the first part of her fall we can find the average velocity

$$\overline{v}_1 \;=\; \frac{625\,m}{15\,s} \;=\; 41.67\,\frac{m}{s} \quad ,$$

and during the second part we find

$$\overline{v}_2 \;=\; \frac{356\,m}{142\,s} \;=\; 2.51\,\frac{m}{s} \quad .$$

We can average over the total fall to find

$$\begin{aligned}\overline{v}_3 &= \frac{625\,m \;+\; 356\,m}{15\,s \;+\; 142\,s} \;=\\ &= \;6.25\,\frac{m}{s}\end{aligned}$$

and the direction is downward toward the earth.

13) For the jogger we find

$$\overline{a}_J \;=\; \frac{3\,\frac{m}{s} \;-\; 0\,\frac{m}{s}}{2\,s} \;=\; 1.5\,\frac{m}{s^2} \quad ,$$

and for the car

$$\overline{a}_C \;=\; \frac{41\,\frac{m}{s} \;-\; 38\,\frac{m}{s}}{2\,s} \;=\; 1.5\,\frac{m}{s^2} \quad ,$$

Both have the same acceleration. But to find the distance travelled by the jogger we use,

$$\begin{aligned} x_{f,\,J} &= \; v_{0\,J}\,t \;+\; \frac{1}{2}\,\overline{a}_J\,t^2 \\ &= \; 0 \;+\; \frac{1}{2}\,(1.5\,\frac{m}{s^2})\,(2\,s)^2 \;=\; 3\,m \quad . \end{aligned}$$

and for the car we have

$$\begin{aligned} x_{f,\,C} &= \; v_{0\,C}\,t \;+\; \frac{1}{2}\,\overline{a}_C\,t^2 \\ &= \; (38.0\,\frac{m}{s})\,(2\,s) \;+\; \frac{1}{2}\,(1.5\,\frac{m}{s^2})\,(2\,s)^2 \;=\; 79\,m \quad . \end{aligned}$$

Yes, the car travels farther than the jogger by 76 m.

21) In the problem we have the following data

v_0 = Initial velocity	0
v_f = Final velocity	$6\,\frac{m}{s}$
t_0 = Initial time	0
t_f = Final time	$1.5\,s$

and one of the basic kinematic equations states

$$v_f \;=\; v_0 \;+\; a\,(\,t_f \;-\; t_0\,) \quad ,$$

which upon substitution of the numerical data gives

$$6\,\frac{m}{s} \;=\; 0 \;+\; a\,(\,1.5\,s \;-\; 0\,) \;\;\rightarrow\; a \;=\; \frac{6\,\frac{m}{s}}{1.5\,s} \;=\; 4\,\frac{m}{s^2}$$

The distance he travels is determined now by

$$\begin{aligned} x_f &= \; x_0 \;+\; v_0\,t \;+\; \frac{1}{2}\,a\,t^2 \\ &= \; 0 \;+\; 0\,(1.5\,s) \;+\; \frac{1}{2}\,(4\,\frac{m}{s^2})\,(1.5\,s)^2 \;=\; 4.5\,m \quad . \end{aligned}$$

24) The data for this problem are

v_0 = Initial velocity	0
v_f = Final velocity	$26\,\frac{cm}{s}$
x_0 = Initial position	0
x_f = Final position	$2\,cm$

The data can be substituted into the kinematical equation

$$(v_f)^2 \;=\; (v_0)^2 \;+\; 2\,a\,(\,x_f \;-\; x_0\,)$$

to yield

$$(26\frac{cm}{s})^2 = \;0\;+\;2\,a(\,2\,cm\;-\;0\,)$$

$$676\,(\frac{cm}{s})^2 = \;0\;+\;4\,a\,cm \quad\longrightarrow\quad a \;=\; \frac{676}{4}\frac{cm}{s^2} \;=\; 169\,\frac{cm}{s^2}$$

One other kinematical equation states

$$x_f = \;x_0\;+\;v_0\,t\;+\;\frac{1}{2}\,a\,t^2$$

$$2\,cm = \;0\;+\;0\;+\;\frac{1}{2}\,(`169\,\frac{cm}{s^2})\,t^2$$

where in the second line the data and the value of a are substituted. This last equation can be solved according to

$$t^2 \;=\; \frac{4\,cm}{169\,\frac{cm}{s^2}} \quad\longrightarrow\quad t \;=\; \frac{2}{13}\,s \;=\; 0.15\,s$$

31) In this problem there are two smaller problems. First during the accelarating part of the trip, the taxi travels some distance that can be call s_1. Then during the decelerating phase of the trip the taxi travels a distance that can be called s_2. The problem does not give a numerical value for the speed limit that can be denoted by V_{SL}.

During the accelarating part of the trip, one of the kinematic equations states

$$(V_{SL})^2 \;=\; 0\;+\;2\,a\,s_1$$

because the taxi starts from zero. During the decelerating part of the trip the kinematical equation takes the from

$$0 \;=\; (V_{SL})^2 \;+\; 2\,(-3\,a)\,s_2$$

because it has to slow down from the speed limit to zero to drop off the passenger. Note its deceleration is three times that of the first part. This second equation yields

$$(V_{SL})^2 \;=\; 2\,(3\,a)\,s_2 \;=\; 6\,a\,s_2$$

Since the speed limit is the same for both part, it follows

$$2\,a\,s_1 \;=\; 6\,a\,s_2 \quad\rightarrow\quad s_1 \;=\; 3\,s_2$$

The total distance travelled is 2 km so

$$s_1 \;+\; s_2 \;=\; 2\,km \qquad\rightarrow\qquad 4\,s_2 \;=\; 2\,km$$

So $s_1 = 1.5\ km$ and $s_2 = 0.5\ km$.

37) This problems gives the data as

v_0 = Initial velocity	0
v_f = Final velocity	$39\,\frac{m}{s}$
y_0 = Initial position	$99.4\,m$
y_f = Final position	0

If there were no air resistance then the following must be true,

$$\begin{aligned} y_f \;&=\; y_0 \;+\; v_0\,t \;+\; \tfrac{1}{2}\,a\,t^2 \\ 0 =&\;\; 99.4\,m \;+\; 0 \;+\; \tfrac{1}{2}(-9.8\frac{m}{s^2})\,t^2 \\ 99.4\,m =&\;\; \tfrac{1}{2}(9.8\frac{m}{s^2})\,t^2 \\ t =&\;\; \sqrt{\frac{2\,(99.4)}{9.8}}\;s \;=\; 4.50\,s \end{aligned}$$

If this time is multiplied by the acceleration of gravity this yields the speed he would have if there was no air resistance.

$$v_f \;=\; (9.8\frac{m}{s^2})\,4.50\,s \;=\; 44.14\,\frac{m}{s}$$

47) In the first part of this problem the data given is

v_0 = Initial velocity	??
v_f = Final velocity	0
y_0 = Initial position	0
y_f = Final position	$16\,m$

and using the kinematical equation involving the square of the velocities one finds

$$
\begin{aligned}
(v_f)^2 &= (v_0)^2 \ + \ 2\,a\,(\,y_f \ - \ y_0\,) \\
0 &= (v_0)^2 \ + \ 2\,(-\,9.8\,\frac{m}{s^2})\,(16\,m) \\
\rightarrow \quad v_0 \ &= \ \sqrt{2(9.8)(16)}\ \frac{m}{s} \ = \ \sqrt{313.6}\,\frac{m}{s} \ = \ 17.71\,\frac{m}{s}
\end{aligned}
$$

In the second part of this problem, we wish to know the height of the ball when its velocity is one-half of the initial value. So we use the same kinematic equation but with

$$
\begin{aligned}
(8.85\,\frac{m}{s})^2 &= (17.71\,\frac{m}{s})^2 \ + \ 2\,(-\,9.8\,\frac{m}{s^2})\,y_f \\
2\,(\,9.8\,\frac{m}{s^2})\,y_f &= (17.71\,\frac{m}{s})^2 \ - \ (8.85\,\frac{m}{s})^2 \\
2\,(\,9.8\,\frac{m}{s^2})\,y_f &= \frac{3}{4}\,(313.6)\,\frac{m^2}{s^2} \\
y_f &= \frac{3(313.6)}{8\,(9.8)}\,m \ = \ \frac{940.8}{78.4}\,m \\
y_f &= 12\,m \quad .
\end{aligned}
$$

61) By calculating the slope of the straight-line segments in the graph, three velocities can be found.

$$
\begin{aligned}
\overline{V}_1 &= \frac{24\,km}{1\,hr} \ = \ 24\,\frac{km}{hr} \\
\overline{V}_3 &= \frac{27\,km - 33\,km}{3.5\,hr - 2.2\,hr} \ = \ -\,5\,\frac{km}{hr}
\end{aligned}
$$

We next use this to define an average acceleration

$$
\overline{a} \ = \ \frac{-5\,\frac{km}{hr} - 24\,\frac{km}{hr}}{3.5\,hr - 0\,hr} \ = \ 8.33\,\frac{km}{hr^2} \quad .
$$