Department of Physics
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Physics 121 Fall 2002
Homework Assignment # 4

Problem Solutions

4) Here we are given the data $m = 5.0\ kg$, $v_0 = 0$, $v_f = 4.0 \times 10^3\ \frac{m}{s}$ and $\left|\vec{F}\right| = 4.9 \times 10^5\ N$. From Newton's 2-nd law we see

$$m\left|\vec{a}\right| = \left|\vec{F}\right| \rightarrow \left|\vec{a}\right| = \frac{\left|\vec{F}\right|}{m}$$
$$\rightarrow \left|\vec{a}\right| = \frac{4.9 \times 10^5}{5}\frac{m}{s^2} = 9.8 \times 10^4\frac{m}{s^2}$$

and one of the kinematic equations is

$$v_f = v_0 + a\,t \rightarrow t = \left(\frac{v_f - v_0}{a}\right)$$
$$t = \left(\frac{4.0 \times 10^3\ \frac{m}{s} - 0}{9.8 \times 10^4\ \frac{m}{s^2}}\right) = 4.08 \times 10^{-2}\ s$$

11) From the diagram we can make the follow table

Vector	x-component	y-component
$\vec{F}_1$	$40.0\,N$	0
$\vec{F}_2$	0	$60.0\,N$
$\vec{F}_1 + \vec{F}_2$	$40.0\,N$	$60.0\,N$

so that the mass must satisfy

$$(4.00\,kg)\,a_x = 40.0\,N \rightarrow a_x = 10\,\frac{m}{s^2}$$
$$(4.00\,kg)\,a_x = 60.0\,N \rightarrow a_y = 15\,\frac{m}{s^2}$$

so that

$$\left|\vec{a}\right| = \sqrt{(10\,\frac{m}{s^2})^2 + (15\,\frac{m}{s^2})^2} = 5\,\sqrt{4 + 9}\,\frac{m}{s^2}$$
$$\left|\vec{a}\right| = 5\,\sqrt{13}\,\frac{m}{s^2} = 18.03\,\frac{m}{s^2}$$

and this acceleration is at an angle of

$$tan\theta \;=\; \frac{15}{10} \;=\; \frac{3}{2} \;=\; 1.5 \;\;\longrightarrow\;\; \theta \;=\; tan^{-1}(1.5) \;=\; 56.31^o$$

above the x-axis.

24) The magnitude of the force between the sun and the moon is given by

$$F_{SM} = \;(6.67 \,\times\, 10^{-11}\,\frac{N\,\cdot\,m^2}{(kg)^2})\,\frac{(7.35\,\times\,10^{22}\,kg)\,(1.99\,\times\,10^{30}\,kg)}{(1.50\,\times\,10^{11}\,m)^2}$$

$$= \;\frac{(6.67)\,(7.35)\,(1.99)}{2.25}\,\times\,10^{19}\,N \;=\; 4.34\times\,10^{20}\,N$$

and the magnitude of the force between the sun and the moon is given by

$$F_{EM} = \;(6.67 \,\times\, 10^{-11}\,\frac{N\,\cdot\,m^2}{(kg)^2})\,\frac{(7.35\,\times\,10^{22}\,kg)\,(5.98\,\times\,10^{24}\,kg)}{(3.85\,\times\,10^{8}\,m)^2}$$

$$= \;\frac{(6.67)\,(7.35)\,(5.98)}{14.82}\,\times\,10^{19}\,N \;=\; 1.98\times\,10^{20}\,N \quad .$$

These forces can be used to write a table for the components

Vector	x-component	y-component
$\vec{F}_{SM}$	$-\,4.34\times\,10^{20}\,N$	0
$\vec{F}_{EM}$	0	$-\,1.98\times\,10^{20}\,N$
$\vec{F}_{SM}\,+\,\vec{F}_{EM}$	$-\,4.34\times\,10^{20}\,N$	$-\,1.98\times\,10^{20}\,N$

Now the magnitude can be easily found.

$$\left|\,\vec{F}_{SM}\,+\,\vec{F}_{EM}\right| = \;\left[\,\sqrt{(4.34)^2\;+\;(1.98)^2}\,\right]\,\times\,10^{20}\,N$$

$$= \;\left[\,\sqrt{18.84\;+\;3.92}\,\right]\,\times\,10^{20}\,N$$

$$= \;\left[\,\sqrt{22.76}\,\right]\,\times\,10^{20}\,N \;=\; 4.77\,\times\,10^{20}\,N$$

28) Since it is an equilateral triangle, the angle between each side is 60^0. The two masses of 2.80 kg can be drawn on the x-axis. So the third mass can be positioned on the y-axis, with y coordinate must be given by $y = 1.2\;\; sin(60^o)\,m = 1.04\;m$. The magnitude of the force between the third mass m_3 and either of the two others is given by

$$F = \;(6.67\,\times\,10^{-11}\,\frac{N\,\cdot\,m^2}{(kg)^2})\,\frac{(m_3)\,(2.80\,\times\,kg)}{(1.2\,m)^2}$$

$$= \;(6.67\,\times\,10^{-11}\,\frac{N}{(kg)})\,\frac{(m_3)\,(2.80\,)}{1.44}$$

$$= \;m_3\,(12.97\,\times\,10^{-11})\,\frac{m}{s^2}$$

Now we find the components of the vectors for the forces between m_1 and m_3 and well as between m_2 and m_3

Force	x-component	y-component
$\vec{F}_{1,3}$	$-m_3(12.97)\times 10^{-11}cos(60^o)\frac{m}{s^2}$	$-m_3(12.97)\times 10^{-11}sin(60^o)\frac{m}{s^2}$
$\vec{F}_{2,3}$	$m_3(12.97)\times 10^{-11}cos(60^o)\,\frac{m}{s^2}$	$-m_3(12.97)\times 10^{-11}sin(60^o)\frac{m}{s^2}$
$\vec{F}_{1,3}+\vec{F}_{2,3}$	0	$-2m_3(12.97)\times 10^{-11}sin(60^o)\frac{m}{s^2}$

So Newton's Second Law takes the form

$$\begin{aligned} m_3\,a_x &= 0 \quad , \quad m_3\,a_y = -\,2m_3(12.97)\times 10^{-11}sin(60^o)\frac{m}{s^2} \\ a_x &= 0 \quad , \quad a_y = -\,2\,(12.97)\times 10^{-11}sin(60^o)\frac{m}{s^2} \\ a_x &= 0 \quad , \quad a_y = -\,22.46\,\times 10^{-10}\,\frac{m}{s^2} \\ \left|\vec{a}\right| &= \sqrt{(a_x)^2\,+\,(a_y)^2} \;=\; 22.46\,\times 10^{-10}\,\frac{m}{s^2} \end{aligned}$$

38) By drawing a force diagram the following equation is found to be valid

$$\mu\,N_f \;=\; m\,a$$

but the normal force is given by $N_f = m\,g$ with $g = 9.8\,\frac{m}{s^2}$. After substituting into the above

$$a \;=\; \mu\,(9.8)\frac{m}{s^2} \;=\; \frac{3}{10}\,(9.8)\frac{m}{s^2} \;=\; 2.94\,\frac{m}{s^2}$$

39) After drawing a force diagram, then Newton's Second law implies

$$F \;=\; \mu\,(60\,kg)\,(9.8\,\frac{m}{s^2})$$

(a.) we have

$$F \;=\; 0.760\,(60\,kg)\,(9.8\,\frac{m}{s^2}) \;=\; 446.88\,N$$

(b.) we have

$$F \;=\; 0.410\,(60\,kg)\,(9.8\,\frac{m}{s^2}) \;=\; 241.08\,N$$

40) (a.) The frictional force is given by $F = \mu\;(92.0\;kg)\;9.8\;\frac{m}{s^2} = 0.61\;(92.0\;kg)\;9.8\;\frac{m}{s^2} = 549.98\;N$

(b.) The acceleration due to the friction is just given by

$$a_f \;=\; -\,0.61(9.8\frac{m}{s^2}) \;=\; -\,5.98\,\frac{m}{s^2}$$

and one of the kinematic equations is of the form

$$v_f \;=\; v_0 \;+\; a\,t$$

The player come to rest means $v_f = 0$ for $t = 1.2\ s$. So

$$\begin{aligned} 0 \;&=\; v_0 \;-\; 5.98\,\frac{m}{s^2}\,(1.2\,s) \\ \rightarrow \quad v_0 \;&=\; 5.98\,\frac{m}{s^2}\,(1.2\,s) \;=\; 7.18\,\frac{m}{s} \end{aligned}$$

49) There are two normal forces in this problem. We will call them N_1 and N_2. After drawing a force diagram, the components for each normal can be shown in the following table.

Force	x-component	y-component
$\vec{N}_1$	$-N_1\,cos(45^o)$	$N_1\,sin(45^o)$
$\vec{N}_2$	$N_2\,cos(45^o)$	$N_2\,sin(45^o)$
$\vec{N}_1\;+\;\vec{N}_1$	$(-N_1+N_2)\,cos(45^o)$	$(N_1+N_2)\,sin(45^o)$

The only other force acting is the force of gravity pulling downward. So Newton's Second Law takes the form

$$\begin{aligned} m\,a_x &= \;(-N_1+N_2)\,cos(45^o) \\ m\,a_y &= \;-\;m\,g\;+\;(N_1+N_2)\,sin(45^o) \end{aligned}$$

The bottle does not move so both acceleration components are zero.

$$\begin{aligned} 0 &= \;(-N_1+N_2)\,cos(45^o) \\ 0 &= \;-\;m\,g\;+\;(N_1+N_2)\,sin(45^o) \end{aligned}$$

The first of these clearly implies that $N_1 = N_2$. Finally, the numerical data can be substituted into the second equation.

$$\begin{aligned} 1.4\,(9.8\frac{m}{s^2}) \;&=\; \sqrt{2}\,N_1 \\ 13.72\,N \;&=\; \sqrt{2}\,N_1 \\ N_1 \;&=\; \Big(\frac{13.72\,N}{\sqrt{2}}\Big) \;=\; \Big(\frac{13.72\,N}{1.41}\Big) \;=\; 9.73\,N \quad . \end{aligned}$$

54) Due to the fact of the third law, since the clown pulls on the rope with a force T, this means that the rope pulls upward on the clown with the same force T. In turn this mean that the force diagram for the clown

has the force of gravity acting downward, the force T from the rope pulling upward and the normal force acting upward in the y-direction. Along the x-direction the rope pulls in the negative x-direction with force T and the frictional force is acting in the positive x-direction. So Newton's Second law takes the form

$$m\,a_x = \; - T \; + \; \mu\,N$$
$$m\,a_y = \; - m\,g \; + \; N \; + \; T$$

Just before the clown's feet begin to move, both a_x and a_y are equal zero, so

$$0 = \; - T \; + \; \mu\,N$$
$$0 = \; - m\,g \; + \; N \; + \; T \quad \rightarrow \quad N \; = \; m\,g \; - \; T$$

This second equation for N can be "plugged" into the first

$$0 \; = \; - T \; + \; \mu\,(m\,g \; - \; T) \quad \rightarrow$$
$$(1 \; + \; \mu)\,T \; = \; \mu\,m\,g \quad \rightarrow$$
$$T \; = \; \left[\frac{\mu\,m\,g}{1 \; + \; \mu}\right]$$

Now we just substitute the numerical values.

$$T \; = \; \left[\frac{0.53\,(890\,N)}{1 \; + \; 0.53}\right] \; = \; \left[\frac{0.53}{1.53}\right](890\,N) \; = \; 308.3\,N$$

67) After drawing two force diagram, we find two equations

$$-\left[\left(\frac{422}{9.8}\right)kg\right]a \; = \; T \;\; , \;\; \left[\left(\frac{185}{9.8}\right)kg\right]a \; = \; T \; - \; (185\,N)$$
$$-\left[\left(43.06\right)kg\right]a \; = \; T \;\; , \;\; \left[\left(18.88\right)kg\right]a \; = \; T \; - \; (185\,N)$$

(a.) If the first of these is substituted into the second, it gives

$$\left[\left(18.88\right)kg\right]a \; = \; -\left[\left(43.06\right)kg\right]a \; - \; (185\,N)$$
$$(185\,N) \; = \; \left[\left(43.06\right)kg\right]a \; + \; \left[\left(18.88\right)kg\right]a$$
$$(185\,N) \; = \; 61.94\,kg\;a$$
$$a \; = \; \left(\frac{185}{61.94}\right)\frac{m}{s^2} \; = \; 2.99\,\frac{m}{s^2}$$

(b.) This value of the acceleration can be used in the in the first equation above.

$$T \; = \; \left[\left(43.06\right)kg\right]2.99\,\frac{m}{s^2} \; = \; 128.6\,N$$

77) Here the acceleration is just given by

$$a \; = \; 0.40\,(9.8\,\frac{m}{s^2}) \; = \; 3.92\,\frac{m}{s^2}$$