General Physics I
Homework Chapter 9

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Homework: Chapter 9

Problem (1)

A 0.091 sl ball drops vertically onto a floor, hitting with a speed of 23 ft/s. It rebounds with an initial speed of 17 ft/s.

Question (a)

What impulse acts on the ball during the contact?
R:

$$\begin{aligned} I &= \Delta p = p_f - p_i \\ &= mv_f - mv_i \\ &= (0.091\ sl)(23\ ft/s) - (0.091\ sl)(0\ ft/s) \\ &= 2.093\ sl \times ft/s \end{aligned} \tag{1}$$

Question (b)

If the ball is in contact with the floor for 0.016 s, what is the average force on the ball from the floor?
R:

$$
\begin{aligned}
I &= F_{ave}\Delta t \\
F_{ave} &= \frac{I}{\Delta t} \\
&= \frac{2.093\ sl \times ft/s}{0.016\ s} \\
&= 130.8125\ lb
\end{aligned} \tag{2}
$$

Problem (2)

A 2.5 kg toy car can move along an x axis; the figure gives F_x of the force acting on the car, which begins at rest at time $t = 0$. The scale on the F_x axis is such that the point $F_{xs} = 20.0\ N$.

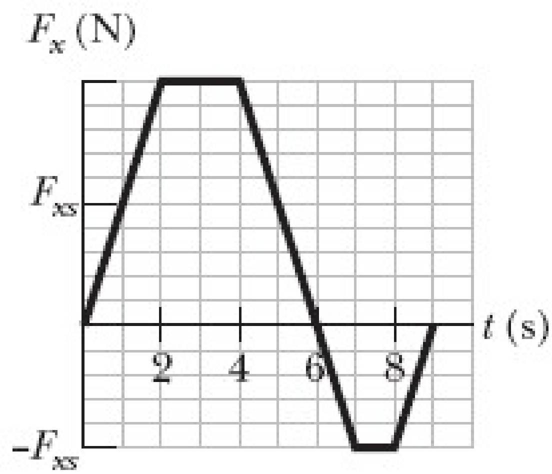

Figure 1: Illustration of Problem 2

Question (a)

What is p at $t = 1.0\ s$?

R:

$$
\begin{aligned}
p_i &= (2.5\ kg)(0\ m/s) = 0 \\
p_f &= I = F_{ave}\Delta t \\
p_{1.0\ s} &= \left(\frac{F_{xs}}{2}\right)(1\ s) \\
&= 10.0\ N \times s
\end{aligned} \tag{3}
$$

Question (b)

What is p at $t = 2.0\ s$?

R:

$$
\begin{aligned}
p_{2.0\ s} &= \left(\frac{F_{xs} + 2F_{xs}}{3}\right)(2\ s) \\
&= (20.0\ N)(2\ s) \\
&= 40.0\ N \times s
\end{aligned} \tag{4}
$$

Question (c)

What is v at $t = 5.0\ s$?

R:

$$
\begin{aligned}
p_{5.0\ s} &= \left(\frac{F_{xs} + 2F_{xs} + 2F_{xs} + 2F_{xs} + F_{xs}}{6}\right)(5\ s) \\
&= (26.\bar{6}\ N)(5\ s) \\
&= 133.\bar{3}\ N \times s \\
v_{5.0\ s} &= \frac{p_{5.0\ s}}{m} \\
&= \frac{133.\bar{3}\ N \times s}{2.5\ kg} \\
&= 53.\bar{3}\ m/s
\end{aligned} \tag{5}
$$

Problem (3)

The fig. 2 shows an approximate plot of force magnitude F versus time t during the collision of a 42 g Superball with a wall. The initial velocity of the ball is 35 m/s perpendicular to the wall; It rebounds directly back with approximately the same speed, also perpendicular to the wall. What is F_{max}, the maximum magnitude of the force on the ball from the wall during the collision?

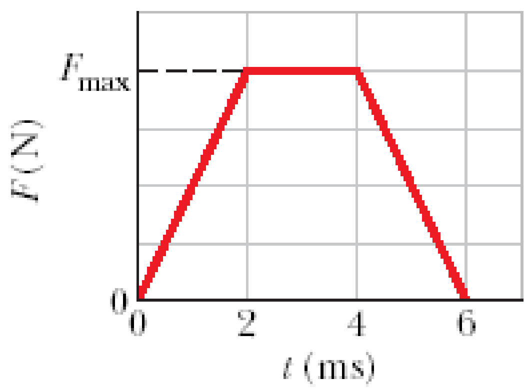

Figure 2: Illustration of Problem 3

R:

$$
\begin{aligned}
m &= 42\ g \times \left(\frac{1\ kg}{1000\ g}\right) = 0.042\ kg \\
p_i &= (0.042\ kg)(35\ m/s) \\
&= 1.47\ N \times s \\
p_f &\approx (0.042\ kg)(-35\ m/s) \\
&= -1.47\ N \times s
\end{aligned}
$$

$$\begin{aligned}
I = \Delta p &= (-1.47\ N \times s) - (1.47\ N \times s) \\
&= -2.94\ N \times s \\
I &= F_{ave} \Delta t \\
(-2.94\ N \times s) &= F_{max}[(4\ ms) - (2\ ms)] \\
F_{max} &= \frac{|-2.94\ N \times s|}{0.002\ s} \\
&= 1470\ N
\end{aligned} \tag{6}$$

Problem (4)

A 150 lb man lying on a surface of negligible friction shoves a 9.0 lb stone away from himself, giving it a speed of 6.5 ft/s. What speed does the man acquire as a result?

R:

$$\begin{aligned}
m_m &= \frac{150\ lb}{32.2\ ft/s^2} = 4.6584\ sl \\
m_s &= \frac{9\ lb}{32.2\ ft/s^2} = 0.2795\ sl \\
\Delta p &= 0 \\
p_i &= p_f \\
MV_i &= m_m v_{mf} + m_s v_{sf} \\
[(4.6584\ sl) + (0.2795\ sl)](0\ ft/s) &= (4.6584\ sl)v_{mf} + (0.2795\ sl)(6.5\ ft/s) \\
v_{mf} &= \frac{(0.2795\ sl)(6.5\ ft/s)}{4.6584\ sl} \\
&= 0.39\ ft/s
\end{aligned} \tag{7}$$

Problem (5)

A 9.7 kg sled is coasting across frictionless ice at a speed of 2.3 m/s when a 19.1 kg package is dropped into it from above. What is the new speed of the sled?

R:

$$\begin{aligned}
\Delta p &= 0 \\
p_i &= p_f \\
m_s v_{si} &= (m_s + m_p) V_f \\
V_f &= \frac{m_s v_{si}}{m_s + m_p} \\
&= \frac{(9.7\ kg)(2.3\ m/s)}{(9.7\ kg) + (19.1\ kg)} \\
&= 0.775\ m/s
\end{aligned} \tag{8}$$

Problem (6)

In the fig. 3, block A (mass 1.5 sl) slides into block B (mass 2.5 sl), along a frictionless surface. The directions of velocities before and after the collision are indicated; the corresponding speeds are $v_{Ai} =$ 4.0 ft/s, $v_{Bi} =$ 2.4 ft/s, and $v_{Bf} =$ 3.2 ft/s. What is velocity v_{Af} (including sign, where positive denotes motion to the right)?

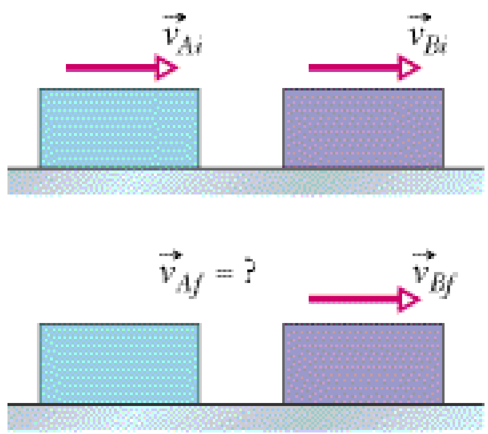

Figure 3: Illustration of Problem 6

R:

$$\begin{aligned}
\Delta p &= 0 \\
p_i &= p_f \\
m_A\vec{v}_{Ai} + m_B\vec{v}_{Bi} &= m_A\vec{v}_{Af} + m_B\vec{v}_{Bf} \\
\vec{v}_{Af} &= \frac{m_A\vec{v}_{Ai} + m_B\vec{v}_{Bi} - m_B\vec{v}_{Bf}}{m_A} \\
&= \vec{v}_{Ai} + \frac{m_B(\vec{v}_{Bi} - \vec{v}_{Bf})}{m_A} \\
&= (4.0\ ft/s) + \frac{(2.5\ sl)[(2.4\ ft/s) - (3.2\ ft/s)]}{1.5\ sl} \\
&= (4.0\ ft/s) + (1.\bar{6})(-0.8\ ft/s) \\
&= (4.0\ ft/s) - (1.\bar{3}\ ft/s) \\
&= +2.\bar{6}\ ft/s
\end{aligned} \tag{9}$$

Problem (7)

Two 3.0 kg bodies, A and B, collide. The velocities before the collision are $\vec{v}_A = (35\hat{i} + 22\hat{j})\ m/s$ and $\vec{v}_B = (-12\hat{i} + 11\hat{j})\ m/s$. After the collision, $\vec{v'}_A = (18\hat{i} + 16\hat{j})\ m/s$.

Question (a)

What is the x-component of the final velocity of B?

R: Assuming $\Delta p = 0$

$$\begin{aligned}
m_A &= m_B = m \\
p_i &= p_f \\
m\vec{v}_A + m\vec{v}_B &= m\vec{v'}_A + m\vec{v'}_B \\
\vec{v}_A + \vec{v}_B &= \vec{v'}_A + \vec{v'}_B \\
\vec{v'}_B &= \vec{v}_A + \vec{v}_B - \vec{v'}_A \\
v'_{Bx} &= v_{Ax} + v_{Bx} - v'_{Ax} \\
&= (35\ m/s) + (-12\ m/s) - (18\ m/s) \\
&= 5\ m/s
\end{aligned} \tag{10}$$

Question (b)

What is the y-component of the final velocity of B?

R:

$$\begin{aligned} v'_{By} &= v_{Ay} + v_{By} - v'_{Ay} \\ &= (22\ m/s) + (11\ m/s) - (16\ m/s) \\ &= 17\ m/s \end{aligned} \tag{11}$$

Question (c)

What is the change in the total kinetic energy (including sign)?

R:

$$\begin{aligned} \vec{V}_i &= \vec{v}_A + \vec{v}_B \\ &= (35\hat{\imath} + 22\hat{\jmath})\ m/s + (-12\hat{\imath} + 11\hat{\jmath})\ m/s \\ &= (23\hat{\imath} + 33\hat{\jmath}) m/s \\ V_i &= \sqrt{23^2 + 33^2}\ m/s \\ &= \sqrt{529 + 1089}\ m/s = 40.224\ m/s \\ \vec{V}_f &= \vec{v'}_A + \vec{v'}_B \\ &= (18\hat{\imath} + 16\hat{\jmath})\ m/s + (5\hat{\imath} + 17\hat{\jmath})\ m/s \\ &= (23\hat{\imath} + 33\hat{\jmath}) m/s \\ V_i &= \sqrt{23^2 + 33^2}\ m/s \\ &= \sqrt{529 + 1089}\ m/s = 40.224\ m/s \\ V_f &= V_i = V \\ \Delta K &= K_f - K_i \\ &= \frac{1}{2}MV^2 - \frac{1}{2}MV^2 \\ &= 0 \end{aligned} \tag{12}$$

Problem (8)

The fig. 4 shows a three-particle-system, with masses $m_1 = 2.8\ kg$, $m_2 = 4.0\ kg$, and $m_3 = 9.6\ kg$.

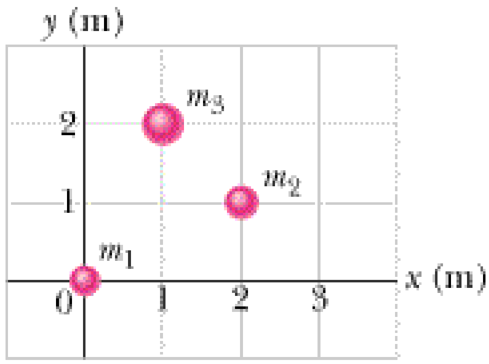

Figure 4: Illustration of Problem 8

Question (a)

What is the x coordinate of the system's center of mass?

R:

$$\begin{aligned}
X_{CM} =& \frac{\sum_{i=1}^{3} m_i x_i}{\sum_{i=1}^{3} m_i} \\
=& \frac{(2.8\ kg)(0) + (4.0\ kg)(2\ m) + (9.6\ kg)(1\ m)}{(2.8\ kg) + (4.0\ kg) + (9.6\ kg)} \\
=& \frac{17.6\ kg \times m}{16.4\ kg} \\
=& 1.\overline{0731}\ m
\end{aligned} \tag{13}$$

Question (b)

What is the y coordinate of the system's center of mass?

R:

$$
\begin{aligned}
Y_{CM} =& \frac{\sum_{i=1}^{3} m_i y_i}{\sum_{i=1}^{3} m_i} \\
=& \frac{(2.8\ kg)(0) + (4.0\ kg)(1\ m) + (9.6\ kg)(2\ m)}{16.4\ kg} \\
=& \frac{23.2\ kg \times m}{16.4\ kg} \\
=& 1.\overline{41463}\ m
\end{aligned} \tag{14}
$$

Problem (9)

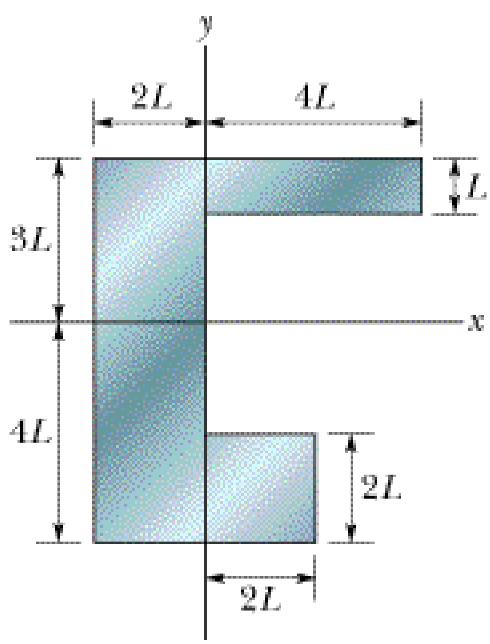

Figure 5: Illustration of Problem 9

Question (a)

What is the x coordinate of the center of mass for the uniform plate shown in the figure if $L =\ 5.0\ inches$?

R:

$$\begin{aligned}
m_1 &= 6L^2\\
x_1 &= -1L\\
m_2 &= 4L^2\\
x_2 &= 2L\\
m_3 &= 4L^2\\
x_3 &= 1L\\
m_4 &= 8L^2\\
x_4 &= -1L\\
X_{cm} &= \frac{(6L^2)(-1L)+(4L^2)(2L)+(4L^2)(1L)+(8L^2)(-1L)}{6L^2+4L^2+4L^2+8L^2}\\
&= \frac{-2L^3}{22L^2} = \frac{-1}{11}L = \frac{-5\ in}{11}\\
&= -0.\overline{45}\ in
\end{aligned} \tag{15}$$

Question (a)

What is the y coordinate of the center of mass for the uniform plate shown in the figure if $L =\ 5.0\ inches$?

R:

$$
\begin{aligned}
y_1 &= 1.5L \\
y_2 &= 2.5L \\
y_3 &= -3L \\
y_4 &= -2L \\
Y_{cm} &= \frac{(6L^2)(1.5L) + (4L^2)(2.5L) + (4L^2)(-3L) + (8L^2)(-2L)}{22L^2} \\
&= \frac{-9L^3}{22L^2} = \frac{-9}{22}L = \frac{-45\ in}{22} \\
&= -2.0\overline{45}\ in
\end{aligned} \tag{16}
$$