Homework VIII

Ch. 6 - 5, 15, 20, 21, 30, 32, 40, 47, 49.

Problem 5

The average force is just given by the change in the momentum divided by the time interval. That is,

$$\bar{F} = \frac{\Delta p}{\Delta t} = \frac{(55.0\ g)(61.0\ \frac{m}{s})}{0.0020\ s} = 1680\ N.$$

Problem 15

(a) The acceleration is just a = $\frac{v_0^2}{2d}$ = 260 $\frac{m}{s^2}$. Thus, the collision lasts t = $\frac{v_0}{a}$ = .096 s.

(b) The average force is once again just just given by the change in the momentum divided by the time interval. That is,

$$\bar{F} = \frac{\Delta p}{\Delta t} = \frac{(1400\ kg)(25.0\ \frac{m}{s})}{0.096\ s} = 3.6\ x\ 10^5\ N.$$

(c) As found in the part (a), the acceleration is a = 260 $\frac{m}{s^2}$ = 26.6g.

Problem 20

(a) This is just a problem in conservation of momentum. Equating the intial and final momenta, we have

$$\begin{aligned} p_i &= p_f, \\ 0 &= (5.0\ g)(300\ \frac{m}{s}) - (\frac{30.0\ N}{9.8\ \frac{m}{s^2}})(v_r), \\ v_r &= 0.49\ \frac{m}{s}. \end{aligned}$$

(b) Just replace 30.0 N above with 730.0 N to find v_r = .002 $\frac{m}{s}$.

Problem 21

(a) Again, this is just a problem in conservation of momentum.

$$
\begin{aligned}
p_i &= p_f, \\
0 &= (45.0\ kg)(1.50\ \frac{m}{s}) - (195.0\ kg)(v_p), \\
v_p &= 0.346\ \frac{m}{s}.
\end{aligned}
$$

Thus, the girl has a velocity 1.50 - 0.35 = 1.15 $\frac{m}{s}$ relative to the ice.

(b) From above, the velocity of the plank is 0.346 $\frac{m}{s}$ directed opposite to the girl's motion.

Problem 30

From basic kinematics, we find that it takes t = $\sqrt{\frac{2y}{g}}$ = 0.45 s for the block to reach the ground. With this time, the block must leave the table with a velocity v = $\frac{x}{t}$ = 4.43 $\frac{m}{s}$. Now, all we have to do is apply conservation of momentum to determine the inital speed of the bullet.

$$
\begin{aligned}
p_i &= p_f, \\
0 &= (8.00\ g)(v_b) - (258.0\ g)(4.43\ \frac{m}{s}), \\
v_b &= 143.0\ \frac{m}{s}.
\end{aligned}
$$

Problem 32

(a) Again, this is just conservation of momentum.

$$
\begin{aligned}
p_i &= p_f, \\
(1200\ kg)(25.0\ \frac{m}{s}) + (9000\ kg)(20.0\ \frac{m}{s}) &= (1200\ kg)(18.0\ \frac{m}{s}) + (9000\ kg)(v_t), \\
v_t &= 20.9\ \frac{m}{s}.
\end{aligned}
$$

(b) To determine the amount of mechanical energy lost in the collision, just calculate the change in kinetic energy.

$$
\begin{aligned}
\Delta K &= K_f - K_i, \\
&= \frac{1}{2}(1200\ kg)(18.0\ \frac{m}{s})^2 + \frac{1}{2}(9000\ kg)(20.9\ \frac{m}{s})^2 - \frac{1}{2}(1200\ kg)(25.0\ \frac{m}{s})^2 + \frac{1}{2}(9000\ kg)(20 \\
&= -1.50\ x\ 10^4\ J.
\end{aligned}
$$

The energy lost is dissipated through the sound and heat generated during the collision.

Problem 47

(a) A 3.0 N force gives a 0.50 kg object a 6 $\frac{m}{s^2}$ acceleration. If it acts for 1.5 s and starts at rest, its final velocity must be 9.0 $\frac{m}{s}$.

(b) This time the acceleration is -8 $\frac{m}{s^2}$. Acting for 3.0 s, the final velocity will be -15 $\frac{m}{s}$.

Problem 49

This again is just a conservation of momentum problem.

$$\begin{aligned}
p_i &= p_f, \\
-(800\ kg)(8.0\ \frac{m}{s}) + (4000\ kg)(8.0\ \frac{m}{s}) &= (4800\ kg)v, \\
v &= 5.33\ \frac{m}{s}.
\end{aligned}$$

Now, the change in momentum of each driver is given by

$$\begin{aligned}
\Delta p_{td} &= (80.0\ kg)(8.0 - 5.33\ \frac{m}{s}), \\
&= 213.3\ \frac{kg\ m}{s}, \\
\Delta p_{cd} &= (80.0\ kg)(8.0 + 5.33\ \frac{m}{s}), \\
&= 1066.7\ \frac{kg\ m}{s}.
\end{aligned}$$

Thus, the average force experienced by each driver is

$$\begin{aligned}
\bar{F}_{td} &= \frac{\Delta p_{td}}{\Delta t}, \\
&= 1780\ N, \\
\bar{F}_{cd} &= \frac{\Delta p_{cd}}{\Delta t}, \\
&= 8890\ N.
\end{aligned}$$

Ch. 8 - 46, 48.

Problem 46

This problem just involves conservation of angular momentum.

$$\begin{aligned}
L_p &= L_a, \\
mv_pr_p &= mv_ar_a, \\
v_a &= \frac{mv_pr_p}{mr_a}, \\
&= \frac{(54\ \frac{km}{s})(0.59\ A.U.)}{35\ A.U.}, \\
&= 0.91\ \frac{km}{s}.
\end{aligned}$$

Problem 48

Once again, this is just conservation of angular momentum.

$$\begin{aligned}
L_p &= L_a, \\
I_0\omega_0 &= I_f\omega_f, \\
(I+m)(\omega_0) &= (I+4m)(\omega_0), \\
\omega_f &= 11.2\ \frac{rev}{min}.
\end{aligned}$$

Evil Knieval starts with zero velocity at the top of a ramp 100m above the rim of the Grand Canyon. He coasts his motor cycle down the ramp and is hurled horizontally over the canyon. What is Evil's velocity at the end of the ramp? How far from the base of the Canyon wall does he hit the Colorado River 1 mile (1610m) below? What is his velocity when he hits the Colorado River?

To find his velocity at the bottom of the ramp (assumed frictionless) just apply conservation of energy.

$$\begin{aligned}
mgh &= \frac{1}{2}mv^2, \\
v &= \sqrt{2gh}, \\
&= 44.3\ \frac{m}{s}.
\end{aligned}$$

The time it takes Evil Knieval to fall to the bottom is simply given by

$$t = \sqrt{\frac{2y}{a}} = 18.1\ s.$$

Thus, given the velocity calculated above (and assuming he takes off in a manner parallel to the basin floor) he lands a distance

$$x = vt = 803\ m,$$

from the Canyon wall. His velocity when he hits the colorado river can be determined by calculating the final y-component of Knieval's velocity and then using this with the x-component calculated above to determine the final magnitude.

$$v_y = at = 177.6\ \frac{m}{s}.$$

Thus, his velocity when he hits the colorado river is

$$\|v\| = \sqrt{v_x^2 + v_y^2} = 183\ \frac{m}{s}.$$