PHY101 HW3 Solutions

Chapter 5 Problems

4) Using the definition of impulse, $F\Delta t = m\Delta v$, we are given the mass m, the change in velocity Δv, and the Δt - the time over which the force is exerted. So isolate for F and plug in the givens to arrive at

$$F = \frac{m\Delta v}{\Delta t} = \frac{(75\,kg)(25\,m/s)}{0.1\,sec} = 18{,}750\,N$$

9) By conservation of momentum, $\vec{P}_{\substack{before\\ initial}} = \vec{P}_{\substack{after\\ final}}$. Since the initial $\vec{p}$ is zero, the final $\vec{p}$ must also be zero. In other words,

$$0 = \vec{P}_{final} = M_s V_s + M_A V_A = 0,$$

where A = asteroid and S = superman. Now, solve for V_s and plug in the givens: $V_A = 800\,m/s$, $M_A = 1000\,M_s$. So

$$V_s = -\frac{M_A V_A}{M_s} = -\frac{(1000\,\cancel{M_s})(800\,m/s)}{\cancel{M_s}} = -80{,}000\,m/s.$$

12) As was done in class, using the work-energy theorem, $W_{tot} = \Delta KE$,

$$W_{friction} = \tfrac{1}{2}m(v_f^2 - v_i^2) = -F_{fric}\,d$$ (negative since friction

force opposes displacement). We know $d = 15\,m$ and $v_i = 50\,\frac{km}{hr}\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,hr}{3600\,sec}\right) = 13.9\,m/s$.

When the car skids a distance d_2 starting at a speed of $150\,\frac{km}{hr}\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,hr}{3600\,sec}\right) = 41.7\,m/s$, again, $-F_{fric}\,d_2 = -\frac{1}{2}m(41.7\,m/s)^2$ using $v_f = 0$. As in class, we can divide one equation by the other s.t. the F_{fric} and m cancel to arrive at

$$\frac{15\,m}{d_2} = \frac{(13.9\,m/s)^2}{(41.7\,m/s)^2} \Rightarrow d_2 = 15\,m\left(\frac{41.7\,m/s}{13.9\,m/s}\right)^2 = 135\,m.$$

18) We have a collision problem, a completely inelastic one, w/ $\vec{P}_{before} = \vec{P}_{after} =$

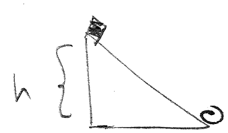
$$M\,V_{skateboard} = (M+m)\,V_{final} \Rightarrow V_{final} = \frac{M\,V_{skateboard}}{(M+m)} = \frac{(8\,kg)(4\,m/s)}{(10\,kg)} = 3.2\,m/s$$

24) Using conservation of energy $\Delta GPE + \Delta KE = 0 \Rightarrow GPE_{initial} + KE_{initial} = GPE_{final} + KE_{final}$

Since $GPE_{final} = KE_{initial} = 0$, $mgh = \frac{1}{2}mv_f^2 = KE_{final}$. The final form of the answer in the book has time in it though. To incorporate time, think back to motion of a object undergoing constant acceleration and $y_f = -\frac{1}{2}gt^2 + y_i$, or $0 = -\frac{1}{2}gt^2 + h \Rightarrow h = \frac{1}{2}gt^2$. Substituting this into the above expression yields the result $\frac{1}{2}mv_f^2 = mgh = mg\frac{1}{2}gt^2 = \frac{1}{2}mg^2t^2$.

For the givens, $KE_{final} = \frac{1}{2}(1.2\,kg)(9.8\,m/s^2)^2(2\,s)^2 = 230.5\,J$.

We can't find the force of impact because we do not know the impact time or duration.

25)  again using $\underline{GPE_i + \overset{0}{KE_i} = \overset{0}{GPE_f} + KE_f} \Rightarrow mgh_i = \frac{1}{2}mv_f^2$.

Solving for v_f yields $v_f = \sqrt{2gh}$. The mass cancels!

For a mass of 27 kg (which is not needed), $h = 1.5\,m$, $v_f = \sqrt{2(9.8\,m/s^2)(1.5\,m)}$

$= 5.4\,m/s$

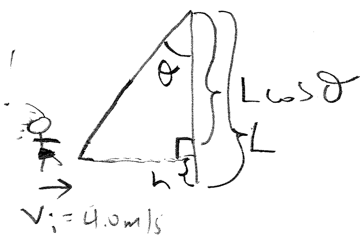
26) Power $P = \frac{W_{done}}{\Delta t}$. The work done here is the work against gravity so $W_{done} = (\underbrace{F_{pulling}}_{\text{equal and opposite to } F_{gravity} = mg})\overbrace{\Delta h}^{\text{displacement}} = mg\Delta h$.

So $P = \frac{mg\Delta h}{\Delta t} = mgv \Rightarrow v = \frac{P}{mg} = \frac{100{,}000\,W}{(900\,kg)(9.8\,m/s^2)} = 11.3\,m/s$.

$\frac{\Delta h}{\Delta t} = v$

Extra Credit

Start w/ a picture!



a) So, $h = L - L\cos\theta = L(1 - \cos(20°))$

b) At the lowest point in her swing, $GPE_f = 0$, so $GPE_i + KE_i = KE_f$, or

$$mgh + \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2.$$

Again, the masses cancel and $v_f = \sqrt{2gh + v_i^2} = \sqrt{2(9.8\,m/s^2)\,7.0m(1-\cos 20) + (4\,m/s)^2}$

$= 4.9$ m/s.

c) At the highest point, $KE_{f_2} = 0$ and $mgh + \frac{1}{2}mv_i^2 = mgh_{f_2}$, or

another final position

$$h_{f_2} = h + \frac{\frac{1}{2}v_i^2}{g} = h + \frac{\frac{1}{2}v_i^2}{g}$$

$$= 7m(1 - \cos(20)) + \frac{(4\,m/s)^2}{2(9.8\,m/s^2)} = 1.24m$$