HW 2 Solutions

1. You are standing at the top of a 10m cliff (as shown), throwing stones over the edge.

   You throw a 0.2 kg stone at an angle of 30 degrees above the horizontal with a speed of $10m/s$.

   (a) What is the x-component of the stone's velocity immediately after it leaves your hand?
   $v_{x0} = v_0 cos(\theta) = 5\sqrt{3}m/s$

   (b) What is the y-component of the stone's velocity immediately after it leaves your hand?
   $v_{y0} = v_0 sin(\theta) = 5m/s$

   (c) How long after you throw it does it reach it's maximum height?
   $v_y = v_{y0} - gt$, v_y is zero at the max $\Rightarrow t = \frac{v_{y0}}{g} = 0.5s$

   (d) How long after you throw the stone does it take to hit the ground?
   $y = h + v_{y0}t - \frac{g}{2}t^2$, y is zero when it hits the ground $\Rightarrow t = -1s, 2s$. -1s is an unphysical answer, so $t = 2s$

   (e) How far from the edge of the cliff does the rock hit?
   $x = v_{x0}t = 10\sqrt{3}m/s$

2. Consider the earth ($m = 6 \times 10^{24}kg$) traveling around the sun ($M = 2 \times 10^{30}kg$) with an orbital radius of $1.5 \times 10^{11}m$.

   For each part, please compute. Do not simply look up the answer. I'm aware that this internet that I've been hearing so much about could probably give you the answer, but that's not what we're looking for right now.

   (a) What is the gravitational force between the two?
   $F = \frac{GM_{\odot}m_{\oplus}}{r_{12}^2} = -3.56 \times 10^{22}N$

   (b) What is the centripetal acceleration on the earth?
   $a_c = \frac{F}{m_{\oplus}} = -0.0059m/s^2$

   (c) What is the circular velocity of the earth?
   $v_c = \sqrt{R|a_c|} = 29,822m/s$

   (d) What is the magnitude of the momentum of the earth?
   $|\vec{p}| = m_{\oplus}v_c = 1.79 \times 10^{29}kgm/s$

3. What is the charge number (Q), Baryon number, (B – how many baryons), and lepton number (L) of the following:

   (a) e (electron)
   $Q = -1, B = 0, L = 1$

   (b) p (proton)
   $Q = 1, B = 1, L = 0$

   (c) e^+ (positron)
   $Q = 1, B = 0, L = -1$

(d) γ (photon)
$Q = 0, B = 0, L = 0$

(e) $\overline{\nu}$ (anti-neutrino)
$Q = 0, B = 0, L = -1$

(f) He (Helium nucleus)
$Q = 2, B = 4, L = 0$

4. 2.P.26

a) $\vec{p}_{avg} = m\frac{\Delta x}{\Delta t} = (0.011, -0.0054, -0.0027)kgm/s$

b) $\vec{p}_{avg} = m\frac{\Delta x}{\Delta t} = (0.027, -0.0486, -0.0027)kgm/s$

c) $\vec{F}_{net} = \frac{\Delta\vec{p}}{\Delta t} = (-0.0041, -0.022, 0)N$

5. 2.P.38

This is a closed system $\Rightarrow$ total momentum ($\vec{P}$) is constant.

$\Delta\vec{P} = 0 \Rightarrow \vec{P}_i = \vec{P}_f \Rightarrow \vec{p}_{Big\ rock\ final} = \vec{P}_i - \vec{p}_{small\ rock\ final} = (0, 9000, 0)kgm/s - (0, -7500, 0)kgm/s = (0, 16500, 0)kgm/s$

6. 3.P.34

$F_g = \frac{Gm^2}{r^2} = \frac{-(6.67\times10^{-11}\frac{Nm^2}{kg^2})(1.7\times10^-22kg)^2}{(1\times10^{-10})^2m} = -1.92\times10^{-44}N$

$F_e = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} = (9\times10^9\frac{Nm^2}{C^2})(\frac{1.6\times10^{-19}C}{1\times10^{-10}m})^2 = 2.3\times10^{-8}N$

$\Rightarrow$ The electric repulsion is much larger then the gravitational attraction.

7. 3.P.37

$F_{avg}T = F\Delta t = \Delta p$, since the ball goes from heading down to heading up $\Delta p = 2p$.

$p = mv$, $v = -gt$, to find the time we use the projectile motion equation:

$0 = h - \frac{gt}{2} \Rightarrow t = \sqrt{\frac{2h}{g}} \Rightarrow \Delta p = 2m\sqrt{2gh}$. T is the time between bounces, this is just

$2t = 2\sqrt{\frac{2h}{g}} \Longrightarrow F_{avg} = \frac{2m\sqrt{2gh}}{2\sqrt{2h/g}} = mg$. This is the same as if it was just sitting at rest on the scale.