Homework #10

1. The orbital speed at the distance of r from an object of mass M can be found through the equation: $v = \sqrt{\frac{GM}{r}}$, where G is the gravitational constant.

a). Your orbital speed around the black hole is:
$v = \sqrt{\frac{GM_{BH}}{r}} = \sqrt{\frac{5GM_{\odot}}{r}}\sqrt{\frac{5\times 6.67\times 10^{-11}(Nm^2kg^{-2})\times 2\times 10^{30}(kg)}{750{,}000(m)}} \approx 2.98\times 10^{7}(m\cdot s^{-1})$

b). The gravitaional force can be calculated from the formula $F = \frac{GMm}{r^2}$. Assuming the weight is $m = 80\ kg$.
The force on feet is:
$F_{feet} = \frac{GM_{BH}0.5m}{r^2_{feet}} = \frac{6.67\times 10^{-11}(Nm^2kg^{-2})\times 5\times 2\times 10^{30}(kg)\times 40(kg)}{(749{,}999(m))^2} = 4.743124\times 10^{10}(N)$.
The force on head is:
$F_{head} = \frac{GM_{BH}0.5m}{r^2_{head}} = \frac{6.67\times 10^{-11}(Nm^2kg^{-2})\times 5\times 2\times 10^{30}(kg)\times 40(kg)}{(750{,}001(m))^2} = 4.743111\times 10^{10}(N)$.

c). The tidal force is:
$F_{tide} = (4.743124 - 4.743111)\times 10^{10}\ (N) = 130,000\ (N) \approx 286,600\ (pounds)$.
Nobody wants to do that, the hugh tidal force will pull the body apart.

2. a). With a constant acceleration a, starting from the zero speed, an object will reach a speed $v = at$ after time t, so it will take:
$t = \frac{c}{1g} = \frac{3\times 10^8(m\ s^{-1})}{9.8(m\ s^{-2})} = 30,612,245\ (s) = 0.97(yrs)$
to accelerate up to the speed of light.

b). The distance from us to the center of the Milky Way is $8kpc$ (pp607). We can convert that into value in the unit of lightyear (ly), remember that $1ly$ is the distance you can travel in one year with the speed of light. $8kpc = 8,000\times 3.3(ly) = 26,400(ly)$, which means it will take 26,400 years to travel this far at the speed of light. Now we are travelling at the speed $0.99c$, 1% slower, so we need a little more time, that's $\frac{100}{99}\times 26,400 = 26,666.7(yrs)$.

c). The slowing factor is:
$\gamma = [1 - \frac{v^2}{c^2}]^{-1/2} = \sqrt{[1 - \frac{v^2}{c^2}]^{-1}} = \sqrt{[1 - \frac{(0.99c)^2}{c^2}]^{-1}} = \sqrt{[1 - 0.99^2]^{-1}} = 7.09$.
So the trip will still last about $26,666.7/7.09 = 3,761.8(yrs)$, we definitely don't want to try it.