1 Selected Ch 6 Problems

1. Once, while skiing, I fell because I was so tired that I couldn't really stand anymore. I was on a part of the slope that was similar to a bowl, and we can assume I underwent circular motion. Assuming I mass 90kg, and that my legs can support three times my own body weight, what was the radius of curvature for the bowl if I was moving at 30m/s?

Drawing a free body diagram shows that the only forces acting on me are the normal force, and the force due to gravity. The centripetal acceleration is added in as the acceleration acting on the body instead of . These are all acting in the vertical (y) direction. Therefore, the sum of forces will be $\Sigma F = N - F_g = ma_c$. The normal force my legs can provide is three times my weight, therefore, if $F_g = mg = 90kg * 9.8m/s^2 = 882N$ then $N = 3F_g = 2650N$. We also know that centripetal acceleration is given by $a_c = v^2/r$. Therefore, we have $2650 - 882 = 90kg * (30m/s)^2/r$. Solving for r gives r=46m.

2. What is the Mercury's tangential velocity as it goes around the sun, assuming the orbit to be circular?
Ans) The only force acting on Mercury is the force due to gravity from the sun. The acceleration is centripetal again, therefore our equation is $G\frac{m_{mercury}m_{sun}}{r^2} = m_{mercury}\frac{v^2}{r}$. We can enter the masses of Mercury, of the sun, and the distance that Mercury is from the sun in it's orbit. These are all in the back of your book. We find $r = 57.9 * 10^{10}m, m_{mercury} = 3.3 * 10^{23}kg, m_{sun} = 1.99 * 10^{30}kg$. Plugging in these numbers we find $v = 15145m/s$.

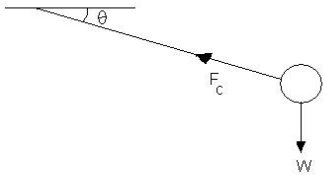
3. If you were to strip the Earth down to it's solid inner core (see page 174 of your book), what would be the acceleration due to gravity you would feel while standing on it's surface?
Ans) The density of the inner core is about $13500kg/m^3$ and the radius is about 1150000m. This means that, using the density equation of $\rho = M/V$ and the fact that the volume is given by $V = 4/3 * \Pi r^3$, the mass of the solid inner core is $M = 8.6 * 10^{22}kg$. We can now use our sum of forces equations, with the only force being gravity, to find the acceleration an object would feel.

$$\Sigma F = G\frac{mM}{r^2} = ma$$
$$a = Gm/r^2 = 4.34m/s^2$$

Obviously if we removed that much mass from the Earth, the acceleration due to gravity would be much less, less than half of what it currently is.

4. You, after being stranded on a deserted island, are trying to use a slingshot to get some food. If you sling the 1kg stone around at 12m/s at a radius of .2m, what angle does the sling and stone make with the horizontal?
Ans) Start by drawing a free body diagram with the centripetal force and the

force of gravity as the only forces acting on the stone. The centripetal force is provided by the sling.



We can, since we know the all of the information in the y-direction, use that equation to solve for the angle.

$$\begin{aligned} \Sigma F_y = F_c * sin\Theta - W = 0 \\ W = mg = 9.8N \\ F_c = m * v^2/r = 28.8N \\ \Theta = \arcsin(9.8N/28.8N) = 20^o \end{aligned}$$