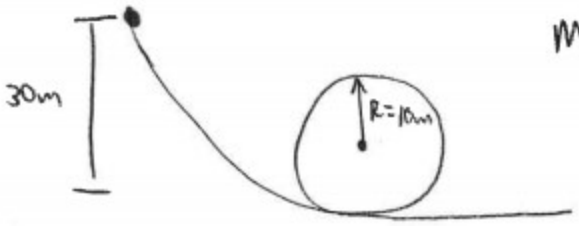
You take your cart with very low mass, low friction wheels to the new loop-de-loop of "death track" that you and your friends just built. You ride your cart down a steep hill and enter a circular loop that towers 20 m high (that is the radius is 10 m). If you stay on the track, you execute a loop and come out the other side at a pretty high speed! You show up late and your friends have already voted that you're going to be the first person to try it. You do some quick calculations and walk up the hill to a place that is 30 m higher than the bottom of the loop. You sit your 70 kg body (Pete's mass) down on a bathroom scale in your cart and go!

a) Do you live or die? Explain completely how you know with all the necessary calculations.
b) If you live, what does the scale read when you are at the top of the loop? If you die, what would the scale have needed to read at the top of the loop in order to save you?



m=70kg

a) Energy I use because initial potential energy changes to kinetic energy as the cart rolls down the hill, then gains potential energy and loses some kinetic energy as it travels the loop, then loses potential and gains kinetic energy again as you come out of the loop.

$$U_{g_0} = K_f + U_{g_f}$$

$$mgh_0 = \frac{1}{2}mv_f^2 + mgh_f$$

$$v_f = \sqrt{2gh_0 - gh_f} = \sqrt{2 \cdot g(h_0 - h_f)} = \sqrt{2 \cdot 10 m/s^2 (30m - 20m)} = \sqrt{20 m/s^2 \cdot 10m} = \sqrt{200}\ m/s$$

$\sqrt{200} \approx 14$ units, therefore your speed at the top of the loop is about 14m/s.

Now, switching to a dynamics lens, to find the minimum speed required to stay on the track you need to assume that normal force = 0 and then solve for the velocity of the cart when N=0.

$$\sum \vec{F} = m\vec{a}_c$$

$$0 + F_g = ma_c$$

$$mg = \frac{mv^2}{r}$$

$$v = \sqrt{rg}$$

FF diagram

Force of gravity and normal force cause centripetal acceleration

a_c, F_g, N

or else N=0 and you fall off the track

your velocity at the top of the loop has to be greater than $\sqrt{rg} \rightarrow \sqrt{10m \cdot 10 m/s^2} = 10 m/s < 14 m/s$

Therefore your speed is high enough, and you live.