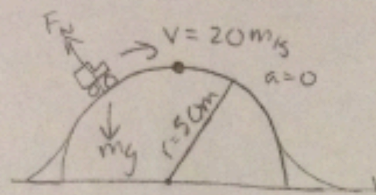
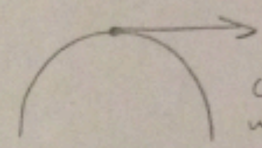
10 pts total Physics F14 Super Quiz II Nov. 25, 2014 Name

1. I'm driving my car at a constant speed of 20 m/s and drive over the top of a hill. We will approximate the hill as the top part of a circle of radius ~~80 m.~~ 50 m My mass is 70 kg. If I had a scale under me what would it read at the moment I was going over the top of the hill? Make sure you include sign (positive or negative).



m=70 kg



tangential path, so the centripetal acceleration will make the scale read less

This is not a momentum, kinematics, or energy problem, this is a dynamics problem

at the top of the hill, how much of a normal force is being exerted? so, since there is centripetal acceleration, the difference due to this acceleration will be added/subtracted from weight due to gravity.

$\tau = I\alpha = mr^2\alpha = 70(50)^2$

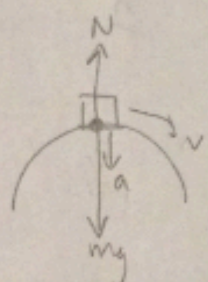
$F_g = mg = (70\,kg)(10\,m/s^2) = 700\,N$

$\omega = \frac{v}{r}$

$v = \omega r$

$a_c = \frac{v^2}{r} = \frac{\omega^2 r \times \omega^2 r}{r} =$

$\Sigma F = ma$



$mg - N = ma_c$

$mg - N = m\frac{v^2}{r}$

$N = mg - \frac{mv^2}{r} = 700\,N - \frac{(70\,kg)(20\,m/s)^2}{50\,m}$

$N = 700\,N - 560\,N = 140\,N$

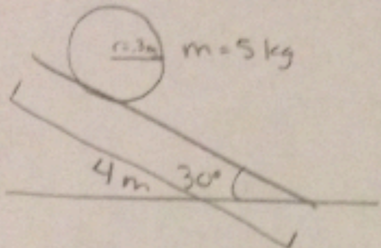
Regularly, the scale would read 700 N or 70 kg, so when going over the hill in this scenario, the scale would read 140 N or 14 kg, which is significantly lighter because of the effect of centripetal acceleration.

2. A disk of radius 30 cm and mass 5 kg rolls 4 m down a 30° incline without slipping, starting from rest. Please find in any order:

a) The rotational velocity at the bottom of the incline

b) The angular acceleration

c) The angle that the disk has rolled through



disk

$I = \frac{1}{2}mr^2$

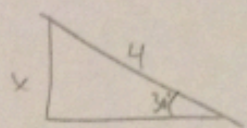
$PE \rightarrow KE$

$PE \rightarrow KE_{trans} + KE_{rot}$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ $\qquad \omega = \frac{v}{r}$

$4\cancel{m}gh = \frac{2}{\cancel{2}}\cancel{m}\omega^2 r^2 + \frac{1}{\cancel{4}}\cancel{m}r^2\omega^2$ $\qquad v = \omega r$

$v^2 = \omega^2 r^2$



$4gh = 2\omega^2 r^2 + \omega^2 r^2$

$4gh = 3\omega^2 r^2$

$\frac{4}{3}gh = \omega^2 r^2$

$4\sin 30° = \frac{x}{4}$

$\omega^2 = \frac{4gh}{3r^2}$ $\qquad \omega = \sqrt{\frac{4gh}{3r^2}} = \sqrt{\frac{4(10\,m/s^2)(2m)}{3(.3)^2}}$

$x = 4(1/2) = 2$

(a) $\boxed{\omega = 17.2\ 1/s}$

now find time

$-1/2$

$\omega_f = \frac{v_f}{r}$ $\quad v_f = \omega_f r = (17.2\ 1/s)(.3m) = 5.2\ \cancel{m/s}$ $\quad v_{ave} = \frac{\cancel{v_i}^{\,0} + v_f}{2} = 2.6\ m/s$

$v_{ave} = \frac{\Delta x}{\Delta t} \Rightarrow$ $5.2\ m/s = 4m/t$ $\quad t = 4m/5.2\ m/s = \cancel{0.77s} \rightarrow 1.54\ s$

(b) $\alpha = \frac{\Delta\omega}{\Delta t} = \frac{17.2 - 0\ 1/s}{0.77s} = \cancel{\boxed{22.3\ 1/s^2}} \rightarrow 11.1/s^2$

(c) total angle elapsed

$\omega_{Ave} = \frac{\Delta\theta}{\Delta t} \Rightarrow \frac{17.2\ 1/s}{2} = \frac{\Delta\theta}{0.77s}$

$\boxed{\theta = 13.2\ \text{radians}}$

or $\quad \theta = \frac{l}{r} = \frac{4m}{.3m} = 13.3$

unitless radians