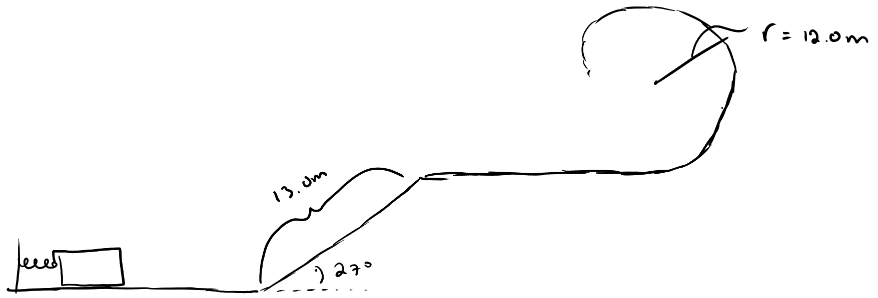
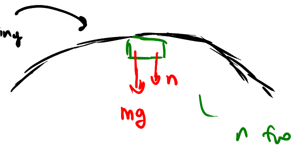
A block of mass 7.00 kg is pushed against a horizontal elastic spring with a spring constant of k=50.0 N/m. The block is released from rest and moves up a 27 degree incline that is 13.0 m long. It then travels along another horizontal surface before entering a loop of radius 12.0m. All surfaces are frictionless. Find the minimum spring compression needed in order for the block not to lose contace with the loop when it's at the top of the loop.



1) Find minimum velocity @ top of loop

figure out v: think about forces $F_c = m\frac{v^2}{r}$

track exerting force on car to change direction of $\vec{v}$



$F_c = mg + n = m\frac{v^2}{r}$

n from curvature of track

$F_{net,y} = n + mg = m\frac{v^2}{r}$

increasing speed just increases n, so @ minimum speed, $n = 0$. So $mg = m\frac{v^2}{r} \rightarrow g = \frac{v^2}{r} \rightarrow v = \sqrt{rg}$

2) apply conservation of energy

$$\frac{1}{2}k(\Delta x)^2 = mgh + \frac{1}{2}mv^2 = mgh + \frac{1}{2}mrg$$

$$h = h_{ramp} + 2r = L\sin\theta + 2r$$

$$\frac{1}{2}k(\Delta x)^2 = mg(L\sin\theta + 2r) + \frac{1}{2}mrg = mg(L\sin\theta + 2r + \frac{1}{2}r) = mg(L\sin\theta + \frac{3}{2}r)$$

$$\Delta x^2 = \frac{2mg}{k}(L\sin\theta + \frac{3}{2}r)$$

$$\Delta x = \sqrt{\frac{2mg}{k}(L\sin\theta + \frac{3}{2}r)} = \sqrt{\frac{2(7.00\,kg)(9.81\,\frac{m}{s^2})}{50.0\,N/m}\left(13.0m\sin(27°) + \frac{3}{2}(12.0m)\right)}$$

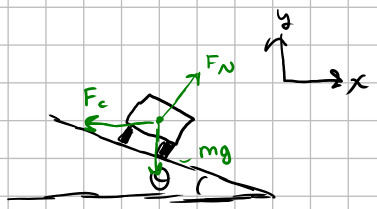
$$\boxed{\Delta x = 8.1m}$$

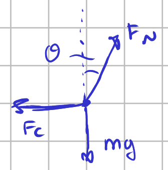
If a car takes a banked curve at less than a given speed, friction is needed to keep it from sliding towards the inside of the curve.

a) Calculate the minimum speed (in m/s required to take a 120m radius curve banked at 17 degrees so you don't slide inwards (assuming there is no friction)

b) what is the minimum coefficient of friction needed to take the same curve at 13 km/h?

a)





(1) $\sum F_x = F_N \sin(\theta) - F_c = 0$

F_c = Centripetal force = $m\frac{v^2}{r}$

(2) $\sum F_y = F_N \cos\theta - mg = 0$

Solve for F_N using (2)

$F_N \cos\theta - mg = 0$

$F_N \cos\theta = mg$

$F_N = \frac{mg}{\cos\theta}$

Plug in expressions for F_c & F_N in (1), solve for v

$\frac{mg}{\cos\theta}\sin\theta - m\frac{v^2}{r} = 0$

$mg\tan\theta - m\frac{v^2}{r} = 0$

$g\tan\theta - \frac{v^2}{r} = 0$

$\frac{v^2}{r} = g\tan\theta$

$v = \sqrt{rg\tan\theta} = \sqrt{(120m)(9.81\,m/s^2)\tan(17°)} = \boxed{18.97\,m/s}$