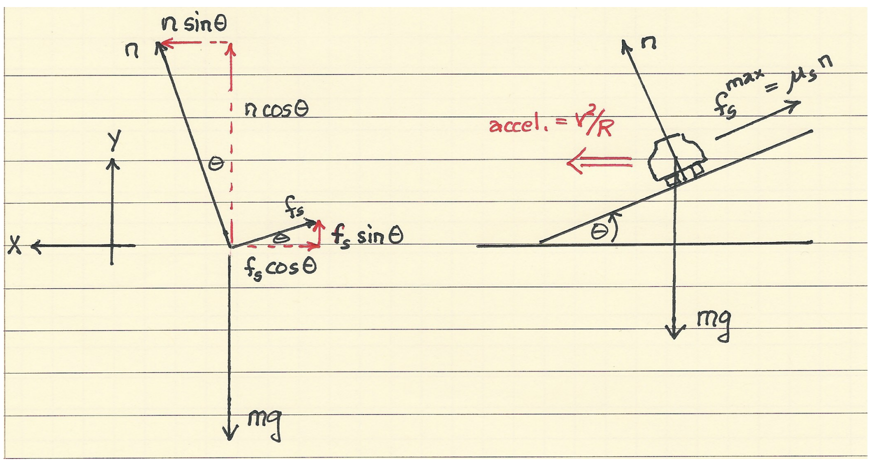
Chapter 5 Problem 102

A racetrack curve has a radius 120 m and is banked at an angle of 18°. The coefficient of static friction between the tires and the roadway is 0.300. A race car with mass 900 kg rounds the curve with the minimum speed needed to not slide down the banking. (a) As the car rounds the curve, what is the normal force exerted on it by the road? (b) What is the car's speed?

First of all, we can calculate the normal force exerted by the incline by solving $\sum F_x = mv^2/R$ or $\ldots \sum F_y = 0$.

Let's draw a free-body diagram with a coordinate system and components of forces along the x and y directions.



Notice that the direction of the x axis is in the direction of the acceleration to help simplify the equations, $\sum F_x = mv^2/R$ and $\sum F_y = 0$.

$$\sum F_x = m\frac{v^2}{R} \qquad \Rightarrow \qquad -f_s \cos\theta + n \sin\theta = m\frac{v^2}{R} \tag{1}$$

$$\sum F_y = 0 \qquad \Rightarrow \qquad f_s \sin\theta + n \cos\theta - mg = 0 \tag{2}$$

Making the substitution for the *static friction*, $f_s = \mu_s n$, we can re-write equations 1 and 2 and solve for v^2 using Eq. 1, and the normal force n using Eq. 2, and find:

$$v^2 = \frac{R}{m} n(\sin\theta - \mu_s \cos\theta) \tag{3}$$

$$n = \frac{mg}{(\mu_s \sin\theta + \cos\theta)} \tag{4}$$

Using Eq. 4, we can calculate the normal force n (part a). Substituting the value of the normal force into Eq. 3, we can solve for the velocity (part (b)).