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PHYS - 230 LAB

LAB QUIZ #6

A car is going through a circular left curve during a rainy day, as shown on Figure 1. The figure shows the car moving as seen from above, and the car is represented by the red box and the road is the black circular arc. The speed of the car is assumed constant throughout the circular motion. The radius of the curve is $R = 10.0\,m$ and the static coefficient of friction between the car tires and the road is $\mu_s = 0.3$ (it is this low due to the wet road condition).

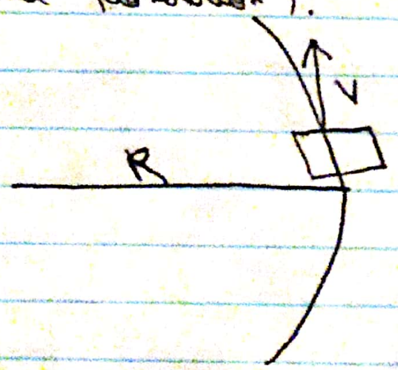


Figure 1

(a) If the road is flat (that is, no banking angle), what is the maximum speed the car can have while going through this curve?

(b) Now consider that the road has a banking angle $\theta = 20°$, as shown on figure 2 (the car is shown from behind as it goes through the curve). What is the maximum velocity it can have now? The radius and coefficient of friction remain the same.

P.T.O

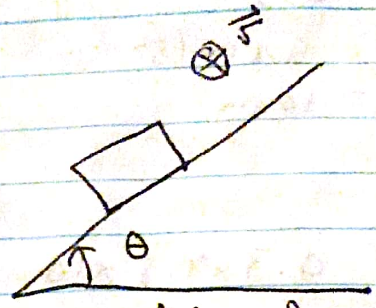
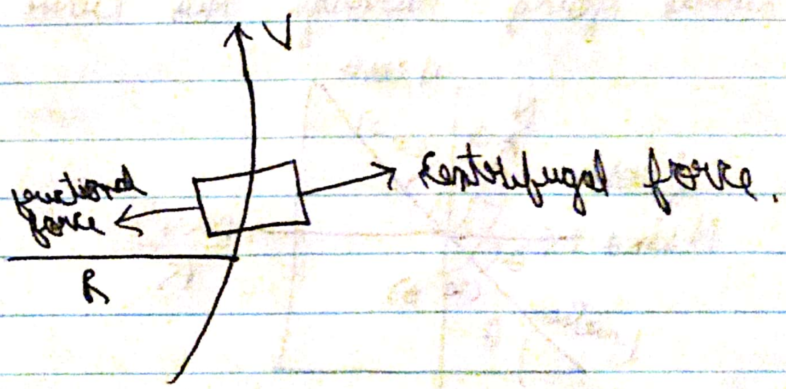


Figure 2

EXTRA CREDIT (+2 pts):- In the same situation described in part (b), what is the minimum velocity so the car does not start sliding down the banked road?

Ans:- (a)



$$\text{Centrifugal force} = \frac{mv^2}{R}$$

$$\text{Frictional force} = \mu mg$$

For the car to stay in that circular motion:-

$$\frac{\cancel{m}v^2}{R} \le \mu \cancel{m}g$$

$$\Rightarrow \frac{v^2}{R} \le \mu g$$

$$\Rightarrow v^2 \le \mu g R$$

(2)

P.T.O

Given :- $\mu = 0.3$
$g = 9.8\ m/s^2$
$R = 10\ m$

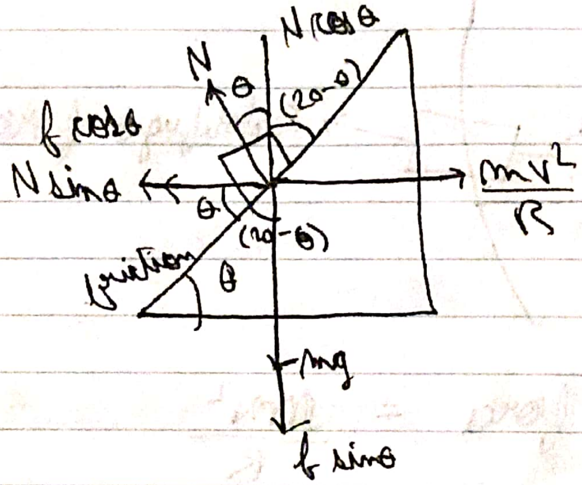
$\therefore\ v^2 \le 0.3 \times 9.8 \times 10$

$v \le \sqrt{29.4}$

$\Rightarrow v \le 5.422$

$\therefore$ The maximum speed that the car can have while going through this curve is $5.422\ m/s$

(b)



$$N \sin\theta + f_{max} \cos\theta = \frac{mv^2}{R}$$

$$\Rightarrow N \sin\theta + \mu N \cos\theta = \frac{mv^2}{R} \quad [\because f_{max} = \mu N]$$

$$\Rightarrow N (\sin\theta + \mu \cos\theta) = \frac{mv^2}{R} \longrightarrow (1)$$

Subsequently, $N \cos\theta = mg + f_{max} \sin\theta$

$$\Rightarrow N \cos\theta - \mu N \sin\theta = mg \quad [\because f_{max} = \mu N]$$

$N(\cos\theta - \mu \sin\theta) = mg \longrightarrow (2)$

Dividing (1) & (2), we get :-

$$\frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta} = \frac{v^2}{Rg}$$

We have :- $v = v_{max}$, $R = 10m$, $g = 9.8\ m/s^2$, $\theta = 20°$,

& $\mu = 0.3$

$$\therefore\ v_{max}^2 = \frac{\sin 20° + 0.3\cos 20°}{\cos 20° - 0.3\sin 20°} \times 10 \times 9.8$$

$$\therefore\ v_{max} = \sqrt{73.045}$$

$$\therefore\ v_{max} = 8.546\ m/s$$

Maximum velocity in this case = 8.546 m/s