Circular Motion Worksheet II

(Additional notes about some of the problem can be found on the page following.)

1. A 1000 kg car is going around a flat curve with a radius 30 meters. If the coefficient of friction between the car's tires and the road is 0.5, what is the maximum speed at which the car can make the turn? *12 m/s*

2. Suppose that the coefficient of friction between a typical tire and a particular highway surface is 0.75. What should the minimum radius be for flat curves on this highway if the speed limit is 55 miles per hour? *270 ft*

3. A remote controlled car moves around a curve at a velocity of 1.5 m/s and a centripetal acceleration of 3.6 m/s². What is the radius of the curve? *0.63 m*

4. A string that is 0.65 m long exerts a centripetal force of 11.6 N on a 0.10 kg yo-yo that is whirling on the end of the string. What is the velocity of the yo-yo? *8.7 m/s*

5. An athlete whirls a 7.00 kg hammer tied to the end of a 1.3 m chain in horizontal chain. The hammer makes one complete revolution in 1.0 s.

    (A) What is the centripetal acceleration of the hammer? *51 m/s²*

    (B) What is the tension in the chain? *360 N*

6. What is the ideal, or critical, speed *(the speed for which no friction is required between the car's tires and the surface)* for a car on a curve that has a radius of 50 meters and a banking angle of 15°? *11 m/s*

7. Talladega Motor Speedway in Alabama has turns with radii of 1100 ft that are banked at extreme angles. If a car going 100.0 mph could negotiate the turns at Talladega without any friction between the tires and the pavement, at what angle would the turns have to be banked? (By the way, during races, cars have gone through the turns at about twice that speed.) *33°*

8. A carnival ride has a 2.0 m radius and rotates 1.1 times per second. When the floor drops out, riders are held up by friction.

    (A) What is the velocity of the rider? *14 m/s*

    (B) What coefficient of friction is needed to keep the rides from slipping? *0.10*

Additional Notes Regarding Circular Motion

We've considered calculating centripetal acceleration using the tangential velocity, but what about using its angular velocity? You know that angular velocity is basically how many revolutions per time. Well, a revolution is just the circumference of the circular path ($2\pi r$), and isn't the time for one revolution the period (*T*)? So, you can calculate angular velocity by using $v = 2\pi r/T$.

Now, plug that formula for velocity into the formula we've been using for centripetal acceleration ($a_c = v_T^2/r$), and F=ma, and you get a great new formula for centripetal force: $F = m4\pi^2 r/T^2$.

And last, but not least, we've talked about friction providing the centripetal force necessary to keep a car moving in a circular path, but what if the curve that the car is rounding is banked? By that, I mean, what if the curve isn't flat? Think about it, they often aren't, and that's on purpose!

For this one, let me spare you the details and just tell you that when the road isn't flat, you have to consider the angle of the "bank," and not only the horizontal component of the force of friction, but also the horizontal component of the weight of the car. See – that's why they do the banked thing on purpose; even if there is no friction or reduced friction, given the right speed, a car could still make a curve since the horizontal component of the weight of the car provides a centripetal force that keeps the car on its circular path.

Bottom line, you can calculate the maximum speed (ideal or critical speed) that a car could successfully round the curve without any friction between the tires and the road. $v_{max} = \sqrt{r\mu g \tan\theta}$