Centripetal Force

Newton's Second Law

$$F = ma$$

$$F_C = \frac{mv^2}{r} = mr\omega^2$$

Some other _____ creates _____ force

- Swinging something from a string → _____
- Satellite in orbit → _____
- Car going around curve → _____

A 1.25-kg toy airplane is attached to a string and swung in a circle with radius = 0.50 m. What was the centripetal force for a speed of 20 m/s? What provides the F$_C$?

What affects Fc more: a change in mass, a change in radius, or a change in speed?

Banked Curves

When a car travels around an _____ curve, _____ provides the centripetal force.
By banking a curve, this reliance on friction can be _____ for a given speed.
The _____ force will provide the centripetal force.

$$\tan(\theta) = \frac{v^2}{rg}$$

(a)   *(b)*
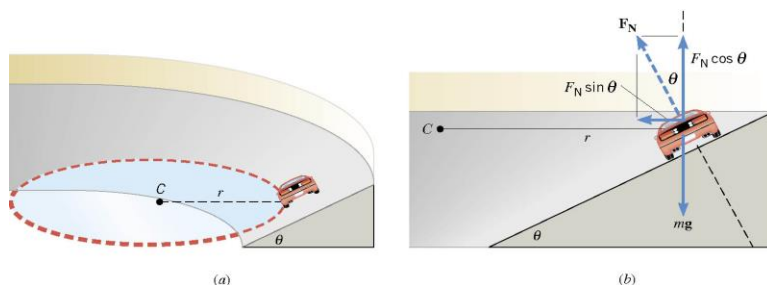
In the Daytona International Speedway, the corner is banked at 31° and r = 316 m. What is the speed that this corner was designed for?

Cars go 195 mph around the curve. How?

Why do objects seem to fly away from circular motion?

How does the spin cycle in a washing machine work?

1. A bug lands on a windshield wiper. Explain why the bug is more likely to be dislodged when the wipers are turned on at the high rather than the low setting.

2. A penny is placed on a rotating turntable. Where on the turntable does the penny require the largest centripetal force to remain in place? Explain.

3. Define centripetal force. Can any type of force (for example, tension, gravitational force, friction, and so on) be a centripetal force? Can any combination of forces be a centripetal force?

4. If centripetal force is directed toward the center, why do you feel that you are 'thrown' away from the center as a car goes around a curve? Explain.

5. Do you feel yourself thrown to either side when you negotiate a curve that is ideally banked for your car's speed? What is the direction of the force exerted on you by the car seat?

6. A 0.015-kg ball is shot from the plunger of a pinball machine. Because of a centripetal force of 0.028 N, the ball follows a circular arc whose radius is 0.25 m. What is the speed of the ball? (Cutnell 5.11) **0.68 m/s**

7. In a skating stunt known as "crack-the-whip," a number of skaters hold hands and form a straight line. They try to skate so that the line rotates about the skater at one end, who acts as the pivot. The skater farthest out has a mass of 80.0 kg and is 6.10 m from the pivot. He is skating at a speed of 6.80 m/s. Determine the magnitude of the centripetal force that acts on him. (Cutnell 5.12) **606 N**

8. At an amusement park there is a ride in which cylindrically shaped chambers spin around a central axis. People sit in seats facing the axis, their backs against the outer wall. At one instant the outer wall moves at a speed of 3.2 m/s, and an 83-kg person feels a 560-N force pressing against his back. what is the radius of a chamber? (Cutnell 5.14) **1.5 m**

9. (a) A 22.0 kg child is riding a playground merry-go-round that is rotating at 40.0 rev/min. What centripetal force must she exert to stay on if she is 1.25 m from its center? (b) What centripetal force does she need to stay on an amusement park merry-go-round that rotates at 3.00 rev/min if she is 8.00 m from its center? (OpenStax 6.23) **483 N, 17.4 N**

10. Calculate the centripetal force on the end of a 100 m (radius) wind turbine blade that is rotating at 0.5 rev/s. Assume the mass is 4 kg. (OpenStax 6.24) 4×10^3 **N**

11. What is the ideal banking angle for a gentle turn of 1.20 km radius on a highway with a 105 km/h speed limit (about 65 mi/h), assuming everyone travels at the limit? (OpenStax 6.25) **4.14°**

12. What is the ideal speed to take a 100 m radius curve banked at a 20.0° angle? (OpenStax 6.26) **18.9 m/s**

13. (a) What is the radius of a bobsled turn banked at 75.0° and taken at 30.0 m/s, assuming it is ideally banked? (b) Calculate the centripetal acceleration. (c) Does this acceleration seem large to you? (OpenStax 6.27) **24.6 m, 36.6 m/s², 3.73 g**

14. At what angle should a curve of radius 150 m be banked, so cars can travel safely at 25 m/s without relying on friction? (Cutnell 5.20) **23°**

15. On a banked race track, the smallest circular path on which cars can move has a radius of 112 m, while the largest has a radius of 165 m, as the drawing illustrates. The height of the outer wall is 18 m. Find the (a) the smallest and (b) the largest speed at which cars can move on this track without relying on friction. (Cutnell 5.22) **19 m/s, 23 m/s**