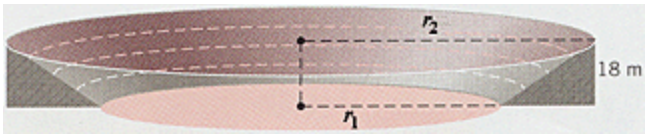
SPH4U – Centripetal Force Challenge Problems

1. On a banked race track, the smallest circular path on which cars can move has a radius r_1 = 112 m, while the largest has a radius r_2 = 165 m, as the drawing illustrates. The height of the outer wall is 18 m.

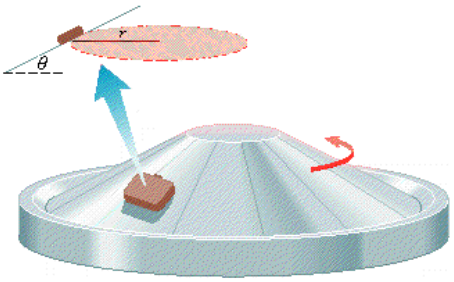


(a) Find the smallest speed at which cars can move on this track without relying on friction. ***(19 m/s)***
(b) Find the largest speed at which cars can move on this track without relying on friction. ***(23 m/s)***

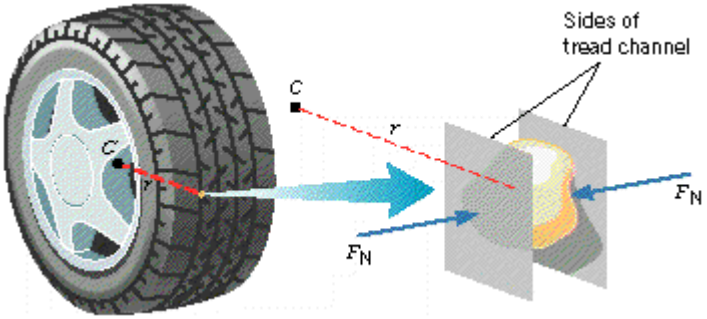
2. A satellite has a mass of 5850 kg and is in a circular orbit 4.10×10^5 m above the surface of a planet. The period of the orbit is two hours. The radius of the planet is 4.15×10^6 m. What is the true weight of the satellite when it is at rest on the planet's surface? ***(2.45×10^4)***

3. A computer is reading data from a rotating CD-ROM. At a point that is 0.030 m from the center of the disc, the centripetal acceleration is 120 m/s^2. What is the centripetal acceleration at a point that is 0.050 m from the center of the disc? ***(2.0×10^2 m/s^2)***

4. The drawing shows a baggage carousel at an airport. Your suitcase has not slid all the way down the slope and is going around at a constant speed on a circle (r = 11.0 m) as the carousel turns. The coefficient of static friction between the suitcase and the carousel is 0.760, and the angle θ in the drawing is 36.0°. How much time is required for your suitcase to go around once? ***(45 s)***

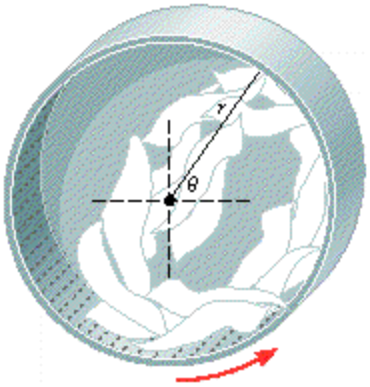


5. A stone has a mass of 6.00×10^{-3} kg and is wedged into the tread of an automobile tire, as the drawing shows. The coefficient of static friction between the stone and each side of the tread channel is 0.71. When the tire surface is rotating at a maximum speed of 13 m/s, the stone flies out of the tread. The magnitude F_N of the normal force that each side of the tread channel exerts on the stone is 1.6 N. Assume that only static friction supplies the centripetal force, and determine the radius r of the tire. ***(0.45 m)***

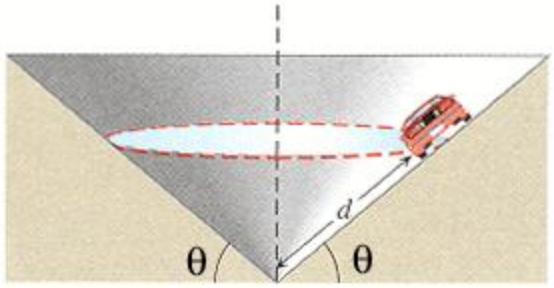


6. A stone is tied to a string (length = 1.10 m) and whirled in a circle at the same constant speed in two different ways. First, the circle is horizontal and the string is nearly parallel to the ground. Next, the circle is vertical. In the vertical case the maximum tension in the string is 15.0% larger than the tension that exists when the circle is horizontal. Determine the speed of the stone. ***(8.48 m/s)***

7. In an automatic clothes drier, a hollow cylinder moves the clothes on a vertical circle (radius r = 32 m), as the drawing shows. The appliance is designed so that the clothes tumble gently as they dry. This means that when a piece of clothing reaches an angle of θ above the horizontal, it loses contact with the wall of the cylinder and falls onto the clothes below. How many revolutions per second should the cylinder make in order that the clothes lose contact with the wall when θ = 70.0°? ***(0.085 rev/s)***



8. A racetrack has the shape of an inverted cone, as the drawing shows. On this surface the cars race in circles that are parallel to the ground, and the surface is at an angle θ = 50°. For a speed of 34 m/s, at what value of the distance d should a driver locate his car if he wishes to stay on a circular path without depending on friction? ***(184 m)***

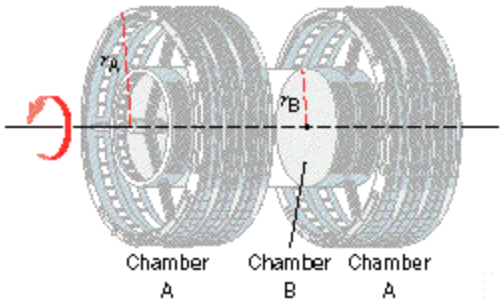


9. To create artificial gravity, the space station shown in the drawing is rotating at a rate of 1.00 rpm. The radii of the cylindrically shaped chambers have the ratio r_A/r_B = 4.00. Each chamber A simulates an acceleration due to gravity of 10.0 m/s^2.

(a) Find r_A. ***(912 m)***

(b) Find r_B. ***(228 m)***

(c) Find the acceleration due to gravity that is simulated in chamber B. ***(2.50 m/s^2)***



10. The earth rotates once per day about an axis passing through the north and south poles, an axis that is perpendicular to the plane of the equator. Assuming the earth is a sphere with a radius of 6.38×10^6 m, determine the speed and centripetal acceleration of a person situated at each of the following.

(a) the equator ***(3.37×10^{-2} m/s^2)***

(b) a latitude of 30.0° north of the equator ***(2.29×10^{-2} m/s^2)***

11. A motorcycle is traveling up one side of a hill and down the other side. The crest is a circular arc with a radius of 45.0 m. Determine the maximum speed that the cycle can have while moving over the crest without losing contact with the road. ***(21.0 m/s)***