72. A projected space station consists of a circular tube that will rotate about its center (like a tubular bicycle tire) (Fig. 5–42). The circle formed by the tube has a diameter of about 1.1 km. What must be the rotation speed (revolutions per day) if an effect equal to gravity at the surface of the Earth (1.0 g) is to be felt?

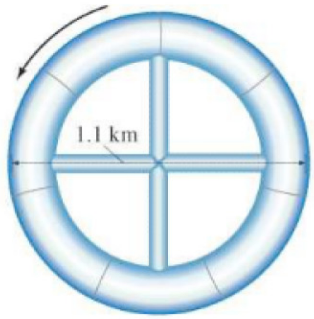

FIGURE 5–42 Problem 72.

73. A jet pilot takes his aircraft in a vertical loop (Fig. 5–43). (*a*) If the jet is moving at a speed of 1300 km/h at the lowest point of the loop, determine the minimum radius of the circle so that the centripetal acceleration at the lowest point does not exceed 6.0 g's. (*b*) Calculate the 78-kg pilot's effective weight (the force with which the seat pushes up on him) at the bottom of the circle, and (*c*) at the top of the circle (assume the same speed).

FIGURE 5–43 Problem 73.

74. Derive a formula for the mass of a planet in terms of its radius r, the acceleration due to gravity at its surface g_P, and the gravitational constant G.

75. A plumb bob (a mass m hanging on a string) is deflected from the vertical by an angle θ due to a massive mountain nearby (Fig. 5–44). (*a*) Find an approximate formula for θ in terms of the mass of the mountain, m_M, the distance to its center, D_M, and the radius and mass of the Earth. (*b*) Make a rough estimate of the mass of Mt. Everest, assuming it has the shape of a cone 4000 m high and base of diameter 4000 m. Assume its mass per unit volume is 3000 kg per m^3. (*c*) Estimate the angle θ of the plumb bob if it is 5 km from the center of Mt. Everest.

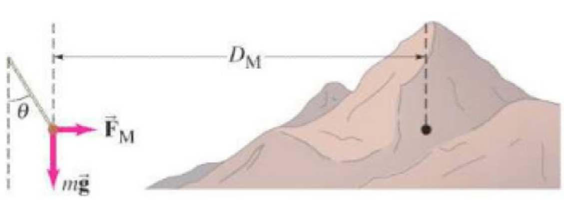

FIGURE 5–44 Problem 75.

76. A curve of radius 67 m is banked for a design speed of 95 km/h. If the coefficient of static friction is 0.30 (wet pavement), at what range of speeds can a car safely handle the curve?

77. How long would a day be if the Earth were rotating so fast that objects at the equator were apparently weightless?

78. Two equal-mass stars maintain a constant distance apart of 8.0×10^{10} m and rotate about a point midway between them at a rate of one revolution every 12.6 yr. (*a*) Why don't the two stars crash into one another due to the gravitational force between them? (*b*) What must be the mass of each star?

79. A train traveling at a constant speed rounds a curve of radius 235 m. A lamp suspended from the ceiling swings out to an angle of 17.5° throughout the curve. What is the speed of the train?

80. Jupiter is about 320 times as massive as the Earth. Thus, it has been claimed that a person would be crushed by the force of gravity on a planet the size of Jupiter since people can't survive more than a few g's. Calculate the number of g's a person would experience at the equator of such a planet. Use the following data for Jupiter: mass $= 1.9 \times 10^{27}$ kg, equatorial radius $= 7.1 \times 10^4$ km, rotation period $=$ 9 hr 55 min. Take the centripetal acceleration into account.

81. Astronomers using the Hubble Space Telescope deduced the presence of an extremely massive core in the distant galaxy M87, so dense that it could be a black hole (from which no light escapes). They did this by measuring the speed of gas clouds orbiting the core to be 780 km/s at a distance of 60 light-years $(5.7 \times 10^{17}\,\text{m})$ from the core. Deduce the mass of the core, and compare it to the mass of our Sun.

82. A car maintains a constant speed v as it traverses the hill and valley shown in Fig. 5–45. Both the hill and valley have a radius of curvature R. (*a*) How do the normal forces acting on the car at A, B, and C compare? (Which is largest? Smallest?) Explain. (*b*) Where would the driver feel heaviest? Lightest? Explain. (*c*) How fast can the car go without losing contact with the road at A?

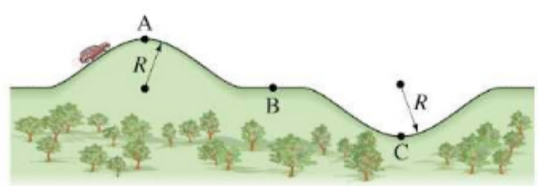

FIGURE 5–45 Problem 82.

83. The Navstar Global Positioning System (GPS) utilizes a group of 24 satellites orbiting the Earth. Using "triangulation" and signals transmitted by these satellites, the position of a receiver on the Earth can be determined to within an accuracy of a few centimeters. The satellite orbits are distributed evenly around the Earth, with four satellites in each of six orbits, allowing continuous navigational "fixes." The satellites orbit at an altitude of approximately 11,000 nautical miles [1 nautical mile = 1.852 km = 6076 ft]. (*a*) Determine the speed of each satellite. (*b*) Determine the period of each satellite.