NAME _____ DATE _____ CLASS _____

Circular Motion and Gravitation

Problem B

CENTRIPETAL FORCE

PROBLEM

A model airplane with a mass of 3.2 kg moves in a circular path with a radius of 12 m. If the airplane's speed is 45 m/s, how large is the force that the control line exerts on the plane to keep it moving in a circle?

SOLUTION

Given: $m = 3.2\ \text{kg}$

$r = 12\ \text{m}$

$v_t = 45\ \text{m/s}$

Unknown: $F_c = ?$

Use the equation for centripetal force.

$$F_c = m\frac{v_t^2}{r} = 3.2\ \text{kg}\frac{(45\ \text{m/s})^2}{12\ \text{m}}$$

$$F_c = \boxed{540\ \text{N}}$$

ADDITIONAL PRACTICE

1. A 45 kg child riding a Ferris wheel has a tangential speed of 8.5 m/s. Find the magnitude of the centripetal force on the child if the distance from the child to the axis of the wheel is 18 m.

2. A toy model of an amusement park ride has a central shaft that rotates while carts attached to the top of the shaft by threads "fly" outward. The force that keeps the carts in a circular path is provided by the tension in the thread. When the carts are 0.25 m from the center of the shaft, the largest tangential speed that the carts can have without the threads breaking is 5.6 m/s. If the mass of a cart is 0.20 kg, how large is the maximum centripetal force?

3. An automobile with a tangential speed of 48.0 km/h follows a circular road that has a radius of 35.0 m. The pavement is wet and oily, so the coefficient of kinetic friction between the car's tires and the pavement is only 0.500. How large is the centripetal force needed to maintain the car's circular motion? How large is the available frictional force? Is the available frictional force large enough to maintain the automobile's circular motion? Assume the automobile has a mass of 1250 kg.

4. Another automobile with a mass of 1250 kg follows a curved road with a radius of 35 m. This time, however, the road is banked, so that it tilts toward the center of the curve with an angle of 9.5°. If the coefficient of kinetic friction is 0.500, how large is the centripetal force from friction and gravity? If this force is equal to the force needed to maintain the automobile's circular motion, what is the auto's maximum tangential speed?

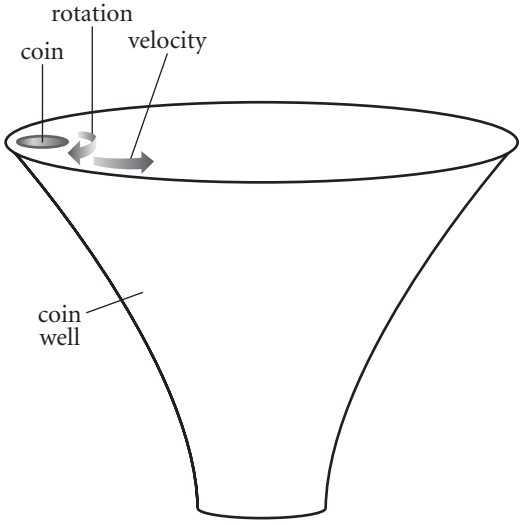
5. A small asteroid with a mass of 2.05×10^8 kg is pulled into a circular orbit around Earth. The distance from the asteroid to Earth's center is 7378 km. If the gravitational force needed to keep the asteroid in orbit has a magnitude of 3.00×10^9 N, what is the asteroid's tangential speed?

6. The first of the great amusement parks on Coney Island, in Brooklyn, New York, was Steeplechase Park. In 1905, one of the rides in the fun house at Steeplechase Park was the "Human Roulette Wheel." This ride consisted of a large wooden wheel, nearly 6 m in diameter, on which several people climbed. The wheel would then spin, causing all but the passengers closest to the center to slide off. Suppose a 55 kg passenger with a tangential speed of 1.3 m/s was just barely able to stay on the wheel. If the magnitude of the frictional force that held the passenger on the wheel was 135 N, how far was the passenger from the center of the wheel?

7. The comets with the longest periods between appearances, as well as comets that appear only once, come from a region of the solar system called the Oort cloud. In the Oort cloud, comets have slow tangential speeds as they orbit the distant sun. Suppose one of these comets has a mass of 7.55×10^{13} kg and moves with a tangential speed of 0.173 km/s relative to the sun. If the magnitude of the gravitational force that keeps the comet in orbit is 505 N, how far is the comet from the sun?

8. A steam governor uses negative feedback to control the speed of a steam engine. Suppose a steam governor has two balls that are each rotating with a tangential speed of 3.7 m/s. The balls are 0.10 m from the rotation axis, and the centripetal force on each ball is 670 N. What is the mass of one of the balls?

9. To encourage donations of loose change, a zoo has placed an interesting type of coin well at its visitor's center. The well is about 1 m tall and is shaped like the flared bell of a trumpet, with the widest part at the top and the hole perpendicular to the ground. A coin placed in a chute and



knocked into the well does not simply drop in, but rolls on its edge around the rim of the well, gradually moving lower down it. If the coin is placed correctly, it can still roll around the well's wall even when the wall is nearly vertical. Consider a half dollar rolling around the top rim of this coin well. The radius of the top of the well is 35.0 cm and the coin rolls around its edge with a tangential speed of 2.21 m/s. If the well's inner wall exerts a force of 0.158 N on the rim of the coin, what is the coin's mass?

10. Since antiquity people have used the sling to increase the speed of a rock and send it swiftly in a specific direction. While the rock is being spun overhead, the force that keeps the rock moving in a circle is provided by the tensile strength of the sling material. Leather has a fairly high tensile strength, so that a strip of leather with a cross-sectional area of 0.25 cm^2 can withstand a pulling force of 800 N. Assume that, for a certain sling, 8.00×10^2 N is the largest possible centripetal force. If the rock in the sling is 0.40 m from the center of rotation and has a tangential speed of 6.0 m/s, what is the largest mass the rock can have?