ch 9

Chapter 9: Uniform Circular Motion

Conceptual problems

9.C.1 **(5.00)** A string's tension force supplies the centripetal force needed to keep a yo-yo whirling in a circle. (a) What force supplies the centripetal force keeping a satellite in uniform circular motion around the Earth? (b) What kinds of forces keep a roller coaster held to a looping track?

9.C.2 **(10.00)** Health professionals use a device called a centrifuge to separate the different components of blood. If you allow a sample to sit long enough, Earth's gravity will cause it to separate on its own. This happens because the liquids and solids in blood have different densities. The denser solids sink to the bottom of a test tube, while less dense liquids rise to the top. To speed up the process of separation, a centrifuge spins blood sample tubes at high speeds in uniform circular motion. How does the spinning of the centrifuge speed up the separation process?

9.C.3 **(5.00)** You move a roller coaster with a loop-the-loop from the Earth to your new amusement park on the Moon. (a) How does the minumum speed to complete the loop-the-loop compare between the Earth and the Moon? (b) A roller coaster car starts from rest on a hill that preceeds the loop. On the Earth, if the car is released on the hill from a height *h* above the bottom of the loop, it will have the minimum speed required to get around the loop. Is the release height required to just get around the same loop on the Moon greater than, less than, or equal to *h*?

(a)

(b)

9.C.4 Does an object moving in uniform circular motion have constant centripetal

(5.00) acceleration?

Yes No

9.C.5 **(5.00)** If a satellite in a circular orbit is accelerating toward the Earth, then why doesn't the satellite hit the Earth?

9.C.6 **(5.00)** A father holds his three-year-old daughter's hands and swings her around in a circle, lifting her off her feet. Why is it harder for him to hold on the the faster he turns?

9.C.7 **(5.00)** The hammer throw is a track-and-field event, popular in Scotland, in which a ball on a rope (the "hammer") is whirled around the thrower in a circle before being released. The goal is the send the ball as a projectile as far down the field as possible. At a track meet, the circle in which a ball is whirled by a hammer thrower is at a 45° angle to the ground. To achieve the longest distance, at what point in its tilted circular orbit should the thrower release the ball?

9.C.8 **(7.00)** Two beads are tied to a string at different positions, and you swing the string around your head at a constant rate so that the beads move in uniform circular motion. Bead A is closer to your hand than bead B. Compare (a) the periods of A and B; (b) the speeds of A and B; (c) the centripetal accelerations of A and B.

(a)

(b)

(c)

9.C.9 An object is moving at a constant speed around a circle. (a) In which of these

(7.00) cases does the magnitude of the centripetal acceleration of the object increase? (Assume all other factors are kept the same.) (b) In which case does the centripetal acceleration increase the most?

(a)
- ☐ The object's speed doubles
- ☐ The object's speed is halved
- ☐ The radius of the circle doubles
- ☐ The radius of the circle is halved

(b) [ ]

9.C.10 **(7.00)** Pretend that the Earth is rotating so fast that if you were standing at a fixed point on the equator, your weight would equal the centripetal force required to keep you in uniform circular motion around the Earth's center. If you stood on a scale at the equator, what would it read?

Section 0: Introduction

9.0.1 **(5.00)** Use the simulation in the interactive problem in Section 9.0 to answer the following questions. (a) Is the centripetal acceleration of the car higher when it is moving faster? (b) If the speed of the car remains constant, do the *x* and *y* components of the car's velocity change as the car goes around the track?

(a) ◯ Yes ◯ No
(b) ◯ Yes ◯ No

Section 2: Period

9.2.1 **(5.00)** Jupiter's distance from the Sun is 7.78×10^{11} meters and it takes 3.74×10^{8} seconds to complete one revolution of the Sun in its roughly circular orbit. What is Jupiter's speed?

[ ] m/s

9.2.4 **(7.00)** Long-playing vinyl records, still used by club DJs, are 12 inches in diameter and are played at 33 1/3 revolutions per minute. What is the speed (in m/s) of a point on the edge on such a record?

[ ] m/s

Section 4: Centripetal acceleration

9.4.1 **(5.00)** A runner rounds a circular curve of radius 24.0 m at a constant speed of v m/s. What is the magnitude of the runner's centripetal acceleration?

[ ] m/s^2

9.4.3 **(7.00)** Consider the radius of the Earth to be 6.38×10^6 m. What is the magnitude of the centripetal acceleration experienced by a person (a) at the equator and (b) at the North Pole due to the Earth's rotation?

(a) ______ m/s^2

(b) ______ m/s^2

9.4.6 **(10.00)** You tie a string to a rock and twirl it at a constant speed in a horizontal circle with a radius of 1.30 m, 2.10 m above the ground. The rock comes loose and travels as a projectile a horizontal distance of 9.40 m before striking the ground. (a) What was the magnitude of the centripetal acceleration of the rock when it was on the string? (b) What was its speed when it was on the string?

(a) ______ m/s^2

(b) ______ m/s

Section 6: Newton's second law and centripetal forces

9.6.1 **(5.00)** An astronaut in training rides in a seat that is moved in uniform circular motion by a radial arm *r* meters long. If her speed is 15.0 m/s, what is the centripetal force on her in "G's," where one G equals her weight on the Earth?

______ "G's"

9.6.6 **(7.00)** A car with mass 1600 kg drives around a flat circular track of radius 28.0 m. The coefficient of friction between the car tires and the track is 0.830. How fast can the car go around the track without losing traction?

______ m/s

Section 7: Sample problem: banked curves

9.7.1 **(5.00)** A car with mass 2200 kg goes around a banked circular track in a path with radius 23 m. The track makes an angle of 15° with the horizontal. How fast should the car go around the track so that there will be no "sideways" friction force acting on the tires?

______ m/s

Section 11: Loop-the-loop

9.11.1 **(5.00)** You are designing a roller coaster for a new amusement park on the Moon. You envision a loop with a radius of *r* meters in your track. (a) What minimum speed at the top will a car have to possess in order to successfully negotiate the loop? The gravitational acceleration on the Moon is 1.6 m/s^2. (b) What speed at the top of the loop would a car need to have if the same roller coaster was built on Earth?

(a) [ ] m/s

(b) [ ] m/s

9.11.3 **(5.00)** A road has a hill with a top in the shape of a circular arc of radius 32.0 m. How fast can a car go over the top of the hill without losing contact with the ground?

[ ] m/s

Additional problems

9.A.9 **(7.00)** A relay satellite for satellite TV orbits the Earth above the equator at an altitude of 3.579×10^4 kilometers. This is the altitude required for a geosynchronous orbit − that is, for the satellite to remain above the same point on the Earth's equator as the Earth rotates. What is the speed of the satellite? The Earth has a radius of 6380 kilometers. (Note that a geosynchronous satellite's altitude is several times Earth's radius!)

[ ] m/s

9.A.11 **(10.00)** You are a traffic safety engineer in charge of determining safe speeds for roads. A particular banked curve has a radius of r meters and is banked at an angle of 8.00°. The coefficient of static friction between common tires and this road is 0.870. What is the maximum speed that a car can drive this curve? Use both the bank of the curve and the friction on the tires in determining your answer.

[ ] m/s

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