Physics 2A
Chapter 5: Dynamics of Uniform Circular Motion

"The answers you receive depend upon the questions you ask." – Thomas Kuhn

"Life is a mirror and will reflect back to the thinker what he thinks into it." – Ernest Holmes

"What we see depends mainly on what we look for." – John Lubbock

"Your thoughts are the architects of your destiny." – David O. McKay

Reading: pages 121 – 129, 135 – 137

Outline:

⇒ uniform circular motion
⇒ centripetal acceleration
⇒ centripetal force
⇒ banked and unbanked curves

Problem Solving

Uniform circular motion problems are solved in much the same way as any other Newton's second law problem. Carry out the set of instructions given in the Chapter 4 handout. Draw a free-body diagram. Place the coordinate system so one of the axes is in the direction of the acceleration, pointing from the object toward the center of its orbit. For most problems you will want to substitute v^2/R for the magnitude of the acceleration. Here v is the speed of the object and R is the radius of its orbit. To see how it is done, you should carefully study the sample problems discussed in the text. Always identify the source of the centripetal force that pulls the object around the circle.

Questions and Example Problems from Chapter 5

Question 1
What is the chance of a light car safely rounding an unbanked curve on an icy road as compared to that of a heavy car: worse, the same, or better? Assume that both cars have the same speed and are equipped with identical tires. Account for your answer.

Problem 1
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 the equator.

Problem 2
Each of the space shuttle's main engines is fed liquid hydrogen by a high-pressure pump. Turbine blades inside the pump rotate at 617 rev/s. A point on one of the blades traces out a circle with a radius of 0.020 m as the blade rotates. (a) What is the magnitude of the centripetal acceleration that the blade must sustain at the point? (b) Express this acceleration as a multiple of $g = 9.80\ m/s^2$.

Problem 3
A 2100 kg demolition ball swings at the end of a 15 m cable on the arc of a vertical circle. At the lowest point of the swing, the ball is moving at 7.6 m/s. Determine the tension in the cable.

Problem 4
A child is twirling a 0.0120 kg ball on a string in a horizontal circle whose radius is 0.100 m. The ball travels once around the circle in 0.500 s. (a) Determine the centripetal force acting on the ball. (b) If the speed of the ball is doubled, does the centripetal force double? If not, by what factor does the centripetal force increase?

Problem 5
A block is hung by a string from the inside roof of a van. When the van goes straight ahead at a speed of 28 m/s, the block hangs vertically down. But when the van maintains this same speed around an unbaked curve (radius = 150 m), the block swings toward the outside of the curve. Then the string makes an angle θ with the vertical. Find θ.

Problem 6
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.

Problem 7
A curve of radius 120 m is banked at an angle of 18^o. At what speed can it be negotiated under icy conditions where friction is negligible?