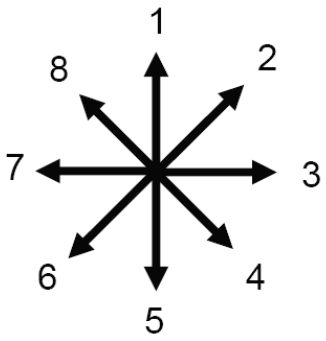
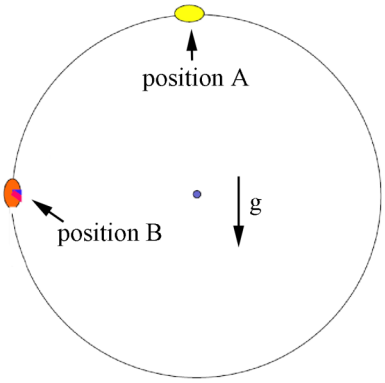
Problem Solving Circular Motion Kinematics
Challenge Problems

Problem 1

A bead is given a small push at the top of a hoop (position A) and is constrained to slide around a frictionless circular wire (in a vertical plane). Circle the arrow that best describes the direction of the acceleration when the bead is at the position B.





Problem 2

The earth is spinning about its axis with a period of 23 hours 56 min and 4 sec. The equatorial radius of the earth is 6.38×10^{6} m. The latitude of Cambridge, Mass is $42^{o}\ 22'$.

a) Find the velocity of a person at MIT as they undergo circular motion about the earth's axis of rotation.

b) Find the person's centripetal acceleration.

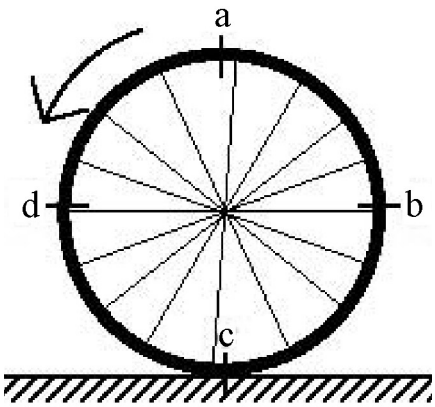
Problem 3: Earth and a Geostationary Satellite

The earth is spinning about its axis with a period of 23 hours 56 minutes and 4 seconds. The equatorial radius of the earth is 6.38×10^6 m. The latitude of Cambridge, Mass is $42° 22'$.

Find the magnitude of the velocity and the centripetal acceleration with respect to the earth's axis of a person at MIT as they undergo circular motion about the earth's axis of rotation.

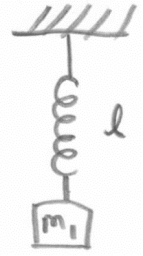
Problem 4:

A bicycle tire rolls without slipping along the ground with its center of mass moving with speed v_0. You may neglect any rolling resistance. What is the speed with respect to the ground of each of the four marked points on the tire shown in the figure below? Explain each of your answers.

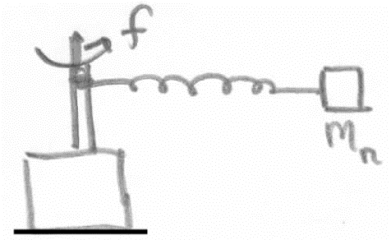


Problem 5: Uniform Circular Motion

Consider a spring with negligible mass that has an unstretched length $l_0 = 8.8\times10^{-2}\,\text{m}$. A body of mass $m_1 = 1.5\times10^{-1}\,\text{kg}$ is suspended from one end of the spring. The other end of the spring is fixed. After a series of oscillations has died down, the new stretched length of the spring is $l = 9.8\times10^{-2}\,\text{m}$.



part a)



parts b) - d)

a) Assume that the spring satisfies Hooke's Law when it is stretched. What is the spring constant?

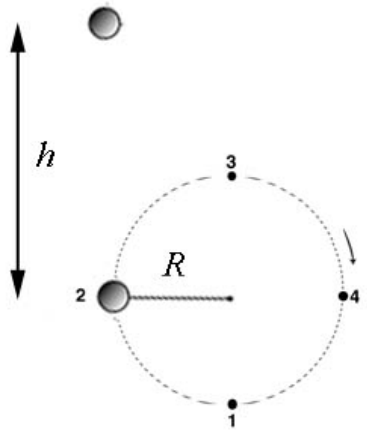
The body is then removed and one end of the spring is attached to the central axis of a motor. The axis of the motor is the vertical direction. A small ball of mass $m_n = 3.0\times10^{-3}\,\text{kg}$ is then attached to the other end of the spring. The motor rotates at a constant frequency $f = 2.0\times10^{1}\,\text{Hz}$.

b) How long does it take the ball to complete one rotation?

c) What is the angular frequency of the ball in radians per second?

Problem 6: Whirling Stone

A stone (or a ball in the demo), attached to a wheel and held in place by a string, is whirled in circular orbit of radius R in a vertical plane. Suppose the string is cut when the stone is at position 2 in the figure, and the stone then rises to a height h above the point at position 2. What was the angular velocity of the stone when the string was cut? Give your answer in terms of R, h and g.



8.01SC Physics I: Classical Mechanics