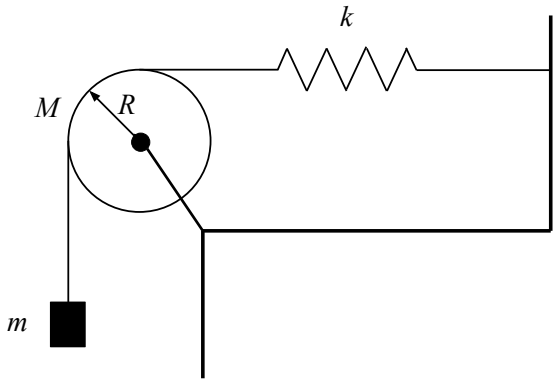
Physics 4A: Assignment 4
Winter 2020

Solutions are not considered complete without the logical argument and/or full calculation.

1. A block of mass m is attached to the end of a light string which runs over a frictionless, solid, disk-shaped pulley of mass M, and connects to one end of a spring of force constant k. The other end of the spring is fixed to a wall. The block initially sits at equilibrium, but then is pulled downward a distance $x_{\max}$ and released.



   (a) Find the extension of the spring when the system is in equilibrium.

   (b) Draw a force diagram for the block, and another for the pulley, when the mass is below its equilibrium position.

   (c) Find an expression for the period of the oscillation of the block.

2. [**Extra Credit Question**] Newton's law of universal gravitation is

$$F = \frac{Gm_1m_2}{r^2}$$

where $G = 6.67 \times 10^{-11}$ Nm^2/kg^2 is the universal gravitational constant, m_1 and m_2 are the masses of a pair of objects interacting by gravity, r is the distance between the objects' centers of mass.

(a) Clearly showing your work, calculate an expression for the potential energy of this system of two masses, in terms of G, m_1, m_2, and r. Choose $r \to \infty$ to be the zero of potential energy.

(b) The *escape speed* is the minimum speed that a particle must have at the surface of a planet to be able to overcome the gravitational attraction to the planet and in principle continue moving away until it is infinitely far from the planet. Using conservation of energy, find an expression for the escape speed from a planet with mass M_P and radius R_P.

(c) Over the past decade many planets have been discovered using the Kepler Space Telescope and various techniques. One such planet is Kepler-42d, a planet orbiting a star 131 light years away in the constellation Cygnus. Kepler-42d has a mass 0.9 times Earth's mass and a radius 0.57 times Earth's radius. What is the escape speed for Kepler-42d in kilometers per second? Compare it to the escape speed from Earth.