August 14, 2015
Prelim Exam – Day 1

Begin each problem on a separate sheet of paper. Write your **Prelim ID #** in the top right-hand corner of each and every page you submit.

Problem 1:

A ball is thrown with speed v from the edge of a cliff of height h.

(a) How much time does it take the ball to hit the ground?

(b) At what inclination angle should it be thrown so that it travels the maximum horizontal distance?

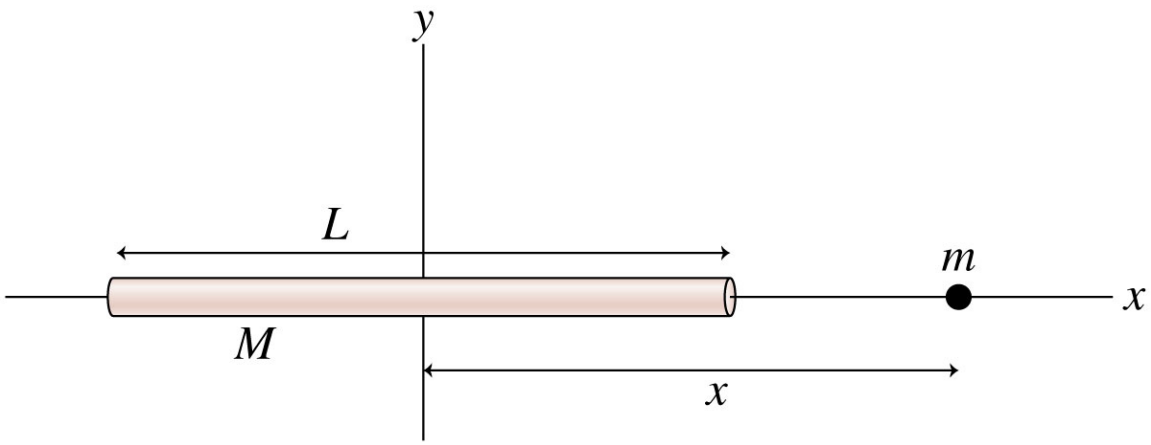
(c) What is this maximum distance? Assume the ground below the cliff is horizontal.

Problem 2:

The figure shows a particle of mass m at a distance x from the center of a very thin cylinder of mass M and length L. The particle is outside the cylinder, so $x > L/2$.

(a) Calculate the gravitational potential energy of these two masses.

(b) Calculate the magnitude of the gravitational force on m when it is at position x.



Problem 3:

Find the magnetic field vector $\boldsymbol{B}$ a distance s from an infinitely long straight wire carrying a steady current I. Calculate the amplitude of the field to show that it decays with $1/s$.

(Hint: Use the Biot-Savart law

$$\boldsymbol{B}(\boldsymbol{r}) = \frac{\mu_0}{4\pi} I \int_{C'} \frac{d\boldsymbol{r}' \times \boldsymbol{r}}{r^3},$$

where $\boldsymbol{r}$ is the position vector of any point in space from the unit contour vector (line element) $d\boldsymbol{r}'$ along the contour C' of the wire. The contour vector points in the direction of the current.)

Problem 4:

Write down the (real) electric and magnetic fields for a monochromatic plane wave of amplitude E_0, frequency ω, and phase angle zero that is

(a) traveling in the negative x direction and polarized in the z direction

(b) traveling in the direction from the origin to the point (1, 1, 1), with polarization parallel to the x-z plane.

In each case, sketch the wave, and give explicit Cartesian components of **k** and **n**.

Problem 5:

A beam of light consisting of wavelengths between 430 nm and 680 nm is directed onto a diffraction grating at normal incidence. The first-order spectrum produced by the grating has an angular spread of 20.0° from smallest to largest wavelength. Calculate the grating spacing.