The qualified Fundamentals of Accelerator Physics candidate should be able to complete the following 3 problems in 30 minutes or less, with the use of undergraduate-level textbooks, if necessary. These concepts will be **briefly** reviewed on the first day of class, but students are expected to have prior exposure to the material.

1. Consider the differential equation for a mass, m, on spring with a spring constant, k:

   $$F = ma = \frac{d^2x}{dt^2} = -kx$$

   Neglecting friction, write a general solution to the equation and an expression for the frequency in terms of m and k.

2. Consider a proton with rest mass m_0=0.938 MeV/c^2, and kinetic energy T=1 GeV. What is the total energy of the proton, in units of GeV? What are the relativistic factors β and γ for the proton? For an electron with mass m_0=0.511 MeV and the same relativistic beta and gamma, what is the kinetic energy of the electron?

3. Consider the following two scenarios:
   a. Imagine two conducting plates with voltages +V and 0, separate by a gap d. Draw a picture of the field lines and write an expression for the electric field in the gap between the plates. Suppose that a particle with positive charge q moves along the direction of the electric field lines. Write an expression for the force on the particle. State the direction of the force.

   b. Now consider a magnetic field with field lines pointing directly vertical. Write and expression for the force on a positively charged particle with charge q traveling to the right with velocity v (perpendicular to the field lines). State the direction of the force.