# 5.E: Inertia (Exercises)

## Q1

Carry out the details of the calculation of the gravitational Doppler effect in section 5.2.

## Q2

A student argues as follows. At the center of the earth, there is zero gravity by symmetry. Therefore time would flow at the same rate there as at a large distance from the earth, where there is also zero gravity. Although we can't actually send an atomic clock to the center of the earth, interpolating between the surface and the center shows that a clock at the bottom of a mineshaft would run faster than one on the earth's surface. Find the mistake in this argument.

## Q3

Somewhere in outer space, suppose there is an astronomical body that is a sphere consisting of solid lead. Assume the Newtonian expression $\Phi = -GM/r$ for the potential in the space outside the object. Make an order of magnitude estimate of the diameter it must have if the gravitational time dilation at its surface is to be a factor of 2 relative to time as measured far away. (Under these conditions of strong gravitational fields, special relativity is only a crude approximation, and that's why we won't get more than an order of magnitude estimate out of this.) What is the gravitational field at its surface? If I have a week's vacation from work, and I spend it lounging on the beach on the lead planet, do I experience two weeks of relaxation, or half a week?