SIO 182 Assignment 1.

Given 9 January, due 16 January.

1) Using the known mass of Earth, the polar and equatorial radii, and the length of day, check the values of polar and equatorial gravity given on page 10 of the notes. (Use a result that we will prove later; a symmetric mass distribution behaves as though it were a point mass, so you can use Newton's Law.)

2) Derive an expression for the vertical component of gravity across the top of a buried sphere. Compute and plot (using Matlab) the profile of the vertical component of gravity across a sphere with a density of 1000 kg/m^3 (1 g/cm^3) higher than the surrounding rock, a diameter of 50 m, buried at a depth of 50 m to its center. Repeat again for a sphere buried at a depth of 100 m. (Ditto on the use of Newton's Law.)

To make a comparison of shape also plot profiles normalized to the peak value (i.e. divide the results by the maximum so that all curves go from zero to one) on the same plot.

3) Compute the density of

i) a dry quartz sandstone with a porosity of 40%

ii) the same rock fully saturated with water

iii) the rock partially saturated with water such that 50% of the pores are wet

4) In the Cavendish experiment, the large lead balls were 300 mm diameter and 158 kg each and the small balls 51 mm in diameter and 0.73 kg each. Calculate the force of attraction between one pair of balls when they were just touching.

The small balls were on a beam that was 1.8 m long (you can assume this distance is center to center of the balls). A torsion fiber obeys a version of *Hook's law* in angular form:

$$\tau = -\kappa\theta$$

where θ is the rotation angle (in radians!), κ is the spring constant and τ is the torque (Nm). The beam acts as a horizontal pendulum, and the spring constant can be obtained from the period of oscillation T through

$$T = 2\pi\sqrt{\frac{I}{\kappa}}$$

where I is the moment of inertia of the beam (assume the beam mass can be neglected and just use the ball mass). Cavendish observed an oscillation period of 20 minutes. What is the maximum angle of deflection that he would have been able to observe if he bought the large masses just in contact with the small masses, as we consider above? Convert this to a distance at the end of the beam.