Electromagnetic Theory I

Problem Set 2

Due: 16 September 2020

5. a) Prove that an electron placed at the center of a spherical cavity in a conductor is shielded from external gravitational fields. In other words the total force on that electron is zero when the conductor is held fixed in an arbitrary (static and Newtonian) gravitational field.

   b) Prove that the instantaneous acceleration of a similarly placed positron (with charge equal and opposite to that of the electron and mass equal to that of the electron) is twice the normal gravitational acceleration.

   c) Find the instantaneous acceleration of a similarly placed muon, which has the same charge as the electron but a different mass $m_\mu > m_e$. (In fact the muon is about 200 times heavier than the electron).

6. Four identical spherical conductors are placed with their centers at the corners of a square. Number them 1,2,3,4 as you go clockwise around the square. Consider the capacitor coefficients C_{ij} for this system.

   a) Using the symmetry of the problem, together with the reciprocity theorem, determine the number of independent coefficients C_{ij} and choose one of each.

   b) A charge Q is placed on conductor 1, with 2,3,4 initially neutral. Then a wire connects and disconnects conductor 1 in turn with each of the other conductors in the order 2, 3, 4. Find the final charges Q_1, Q_2, Q_3, Q_4 on the four spheres in terms of Q and the independent C_{ij} you chose in part a).

   c) Repeat step b) but in the order 2, 4, 3.

   d) Compare and contrast the results of parts b) and c).

7. Using the Green function to solve an elementary problem can be a little like cracking a peanut with a sledgehammer. However, to test your understanding, apply this method to find the potential everywhere outside a spherical conductor of radius R which is held at the constant potential V.

   a) First find the answer for the desired potential by elementary means (e.g. the method of images).

b) The Dirichlet Green function for this problem is just proportional to the potential for a point charge outside the spherical conductor held at zero potential. Normalizing it appropriately, plug it into the explicit formula for the boundary value solution discussed in class (Lecture notes section 2.4 or Jackson (1.44)), and do the surface integral recovering the result found in part a). (N.B. Jackson's Green functions are a factor of 4π times my Green functions!)

8. J, Problem 2.1