Physics 9C-A Midterm Exam #1 (Winter of 2020)

1. ***Point charges***

As shown in **Figure 1** below, a point charge q_1 = - 2 nC is placed at the origin. Another point charge q_2 = + 1 nC is placed at y = + 4 cm on the y-axis. A test charge Q = - 2 nC is initially at y = + 2 cm on the y-axis (Position **A**). $\varepsilon_0 = 8.85\times10^{-12}$ $C^2/N\cdot m^2$.

(a) (**10 points**) Find the x- and y-components of the net Coulomb force on Q at **A** exerted by q_1 and q_2.

(b) (**10 points**) Find the x- and y-components of the net electric field produced by q_1 and q_2 at x = + 3 cm on the x-axis (Position **B**).

(c) (**10 points**) When Q is moved from **A** to **B**, find the potential energy change for Q, U(Q; **A**) - U(Q; **B**), in the electric field produced by q_1 and q_2.

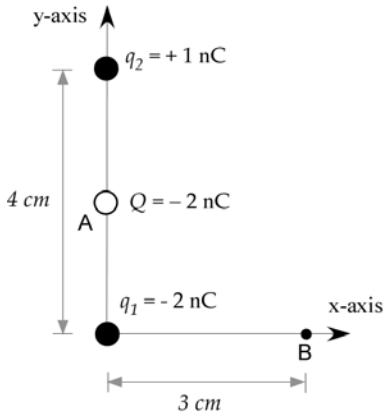

Figure 1

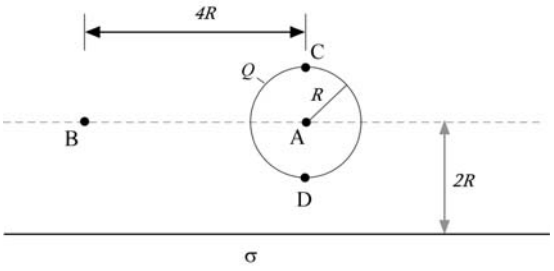

Figure 2

2. ***Combination of two symmetric charge distributions***

As shown in **Figure 2** above, a thin, insulating spherical shell with radius R carries a uniformly distributed charge Q. It is placed above a large sheet of uniform charge with areal density σ so that the center of the spherical shell is 2R from the sheet.

(a) (**15 points**) Find the electric potential difference between the very top (C) and the very bottom (D) of the spherical shell.

(b) (**15 points**) Find the electric potential difference between the center of the spherical shell (A) and the point (B) that is +2R from the charge sheet (on the same side as the spherical shell) and 4R away from the shell center.

(c) (**5 points**) Find the Coulomb force on the spherical shell exerted by the charge sheet. (Explain how you arrive at the answer or you get no points)

(d) (**Extra 5 points**) Find the Coulomb force on the charge sheet exerted by the spherical shell. (Explain the reason behind your answer or you get no points)

(e) (**Extra 10 points**) If you cut a small round hole near the top and the bottom of the shell, what are the total electric fields at C and D now?

3. ***Charges on concentric, spherical conducting shells***

As shown in **Figure 3** below, a small conducting spherical shell with inner radius *a* and outer radius *b* carries a net change -2Q. A larger conducting spherical shell with inner radius *c* (*c* > *b*) and outer radius *d* concentrically encloses the smaller shell and carries a net charge Q.

(a) (**15 points**) Find the electric field in three regions*: r < a; b < r < c, r > d*.

(b) (**8 points**) Find the electric charges on all four surfaces.

(c) (**12 points**) Find the potential difference between the center of the spherical shell and the infinity.

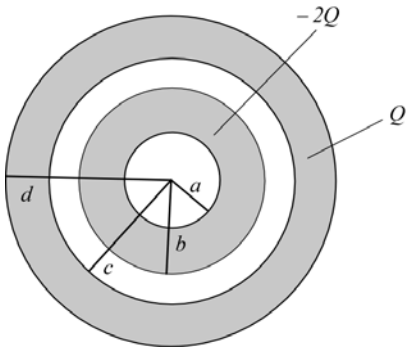

Figure 3