Physics 102– Pledged Problem 4

Time allowed: **2 hours at a single sitting**
Due 5PM Monday, Februray 12, 2007, in the boxes marked Phys 101-102 in the physics lounge. You may use your own textbook, your notes, and a non-programmed calculator. You may also consult the on-line solutions to the corresponding suggested problems. You should consult no other help. Show how you arrived at your answer; the correct answer by itself may not be sufficient.
Further instructions:
(a) Write legibly on **one** side of 8.5" x 11" white or lightly tinted paper.
(b) Staple all sheets together, including this one, in the upper left corner. Make one vertical fold.
(c) On the outside, print your name in capital letters, your LAST NAME followed by your FIRST NAME.
(d) Below your name, print the phrase "Pledged Problem 4", followed by the due date.
(e) Write and sign the pledge, with the understanding that you may consult the materials noted above.
(f) Indicate your **start time** and **end time**.

I. A positive point charge of $+Q$ is located on the x-axis at $x = -a$. A second negative point charge $-Q$ is located on the x-axis at $x = 2a$. Take the zero of the electrostatic potential to be at infinity.

(a) For this charge configuration, determine the electrostatic potential $V(x)$ for all points on the x-axis. Sketch $V(x)$ vs. x.
(b)At what point(s) on the x-axis is $V(x)$=0? What is the electric field $\vec{E}$ at those locations?
(c) Determine the electrostatic potential $V(y)$ for all points along the y-axis.

(d) Now suppose a third charge $+Q$ is moved from very far away to the point on the positive y-axis at $y = a$. How much work must be done to move this third charge to this location?
(e) What is the electric field at the location of the third charge, $x = 0, y = a$? How do you reconcile this answer with your answer in (d)?
(f) Determine the total electrostatic potential energy of this charge configuration both before and after the third charge is moved into place.

II. A spherical shell of *nonconducting* material has an inner radius a and outer radius b. It carries a uniform *volume* charge distribution ρ. Take the zero of the electrostatic potential to be zero at infinity. Express your answers in terms of ρ, a, b, q, and possibly other constants.

(a) Determine the total charge Q contained in the spherical shell.
(b) Determine the electrostatic potential $V(r)$ as a function of r for $r > b$.
(c) Determine the electric field $\vec{E}(r)$ for the region $a < r < b$. Using this result for $\vec{E}$, determine the potential $V(r)$ for the region $a < r < b$.
(d) Determine the potential $V(r)$ for the region $r < a$. (e) Sketch $V(r)$ for all r and indicate any points or regions where the electric field $\vec{E}$ is zero.
(f) If a small positive charge q is released from rest at $r = 2b$, determine its kinetic energy when it is at the location $r = 10b$.