1. [4 points] Four conducting spheres of equal radii are arranged as shown in a perfect square pattern. We use the notation that $Q_i$ are the total charges on each sphere and $V_i$ are the potentials (referred to infinity as usual).

We start with all the spheres neutral (all $Q$’s and $V$’s are zero). Making use of uniqueness and symmetry, what can you say about the charges and potentials on the spheres after each step of the following process? (For example, I give the answer to part (a)).

(a) A charge $q$ is added to sphere 1.
(Answer: $Q_1 = q$, $Q_2 = Q_3 = Q_4 = 0$; and we can’t say much about the $V$’s except $V_2 = V_3$.)
(b) A wire is temporarily connected between spheres 1 and 3 and then removed.
(c) A wire is temporarily connected between spheres 2 and 3 and then removed.
(d) A wire is temporarily connected between spheres 1 and 4 and then removed.

2. [3 points] This is essentially the second half of Griffiths 3.3 (you did the first half in HW 4.3): Find the general form of a harmonic function with full cylindrical symmetry, i.e., $V$ depends only on $s$ in cylindrical coordinates.

3. [4 points] Consider Earnshaw’s theorem for the case of a positive test charge $Q$ at the origin surrounded by eight fixed positive charges $q$ at $r' = (\pm 1, \pm 1, \pm 1)$, i.e., on the corners of a surrounding cube. It seems like the charge $Q$ should be trapped. However, write a formula for how the potential $V(r)$ coming from the eight corner charges (i.e., ignoring $Q$) behaves along the $x$ axis, i.e., for $r = (x, 0, 0)$. Then use a calculator or other computational device to report the values of the potential energy $QV(r)$ of the test charge for several small values of $x$. What do you find? (You can express your results “in units of $Qq/4\pi\epsilon_0$."


5. [5 points] Griffiths 3.10 (line charge above conducting plane).

Check: If you did this right, the total linear surface charge $\lambda_{\text{surf}} = \int_{-\infty}^{\infty} \sigma(y)dy$ induced on the metal surface should turn out to be just $-\lambda$. 