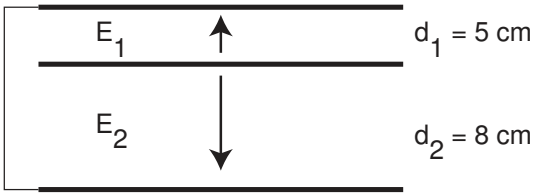
PHY102 : Assignment 4

1. (Purcell 3.5) A charge q is located a distance h above a conducting plane. Asked to predict the amount of work that would have to be done to move this charge out to infinite distance from the plane, one of you say that it is the same as the work required to separate to infinite distance two charges Q and $-Q$ which are initially $2h$ distance apart, hence $W = Q^2/4\pi\epsilon_0(2h)$. Another one calculates the force that acts on the charge as it is being moved and integrates Fdx, but gets a different answer. What did the second student get, and who is right ?

2. (Purcell 3.8) Three conducting plates are placed parallel to one another, as shown in the figure. The outer plates are connected by a wire. The inner plate is isolated and carries a net surface charge density σ (the combined value from the top and bottom faces of the plate). In what proportion must this charge divide itself into a surface charge σ_1 on one face of the inner plate and a surface charge σ_2 on the other side of the same plate ?



3. (Purcell 3.7) The two metal spheres in (a) are connected by a wire; the total charge is zero. In (b) two oppositely charged conducting spheres have been brought into the positions shown, inducing charges of opposite sign in A and B. If now C and D are connected by a wire as in (c), it could be argued that something like the charge distribution in (b) ought to persist, each charge concentration being held in place by the attraction of the opposite charge nearby. What about that? Can you prove it wont happen ? (see text for figure)

4. (Purcell 3.11) A 100-pF capacitor is charged to 100 volts. After the charging battery is disconnected, the capacitor is connected in parallel to another capacitor. If the final voltage is 30 volts, what is the capacitance of the second capacitor. How much energy was lost, and what happened to it ?

5. (Purcell 3.21) Imagine the xy plane, the xz plane, and the yz plane all made of metal and soldered together at the intersections. A single point charge Q is located a distance d from each of these planes. Describe by a sketch the configuration of image charges you need to satisfy the boundary conditions. What is the direction and magnitude of the force that acts on the charge Q ?

6. A point charge q is located between two parallel infinite conducting planes, a distance d from one end and $l - d$ from the other. Where should image charges be located so that the electric field is everywhere perpendicular to the planes ?

7. A conducting spherical shell has charge Q and radius R_1. A larger concentric conducting spherical shell has charge $-Q$ and radius R_2. If the outer shell is grounded, explain why nothing happens to the charge on it. If instead the inner shell is grounded, find its final charge.