PHYS 216 – Assignment #3 – Due Oct 7

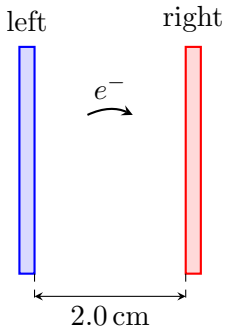
Chapters 6–7: Gauss's Law, Conductors & Electric Potential

Problem 1. Two parallel, initially uncharged metal plates each have area $400\,\text{cm}^2$ and are separated by $2.0\,\text{cm}$ (see below). A total of 1.0×10^{12} electrons are transferred from the left plate to the right plate, and the plates are then isolated. Treat the plates as large compared with their separation; the charge on each plate resides on its inner face (the face toward the other plate).

a. What is the surface charge density on the inner surface of each plate?

b. Find the magnitude and direction of the electric field between the plates.

c. Find the potential difference between the plates. Which plate is at the higher potential?



Problem 2. In a certain region of space the electric potential is

$$V(x, y, z) = -xy^2z + 4xy,$$

where V is in volts and x, y, z are in metres (the implied constants carry the appropriate units).

a. Find the components E_x, E_y, E_z of the electric field.

b. Evaluate $\vec{E}$ (magnitude and direction, in terms of $\hat{\imath}$, $\hat{\jmath}$, $\hat{k}$) at the point $(1, 1, 1)\,\text{m}$.

c. How much work must an external agent do to move a $+2.0\,\mu\text{C}$ charge slowly from the origin to $(1, 1, 1)\,\text{m}$? Does the answer depend on the path taken? Explain.

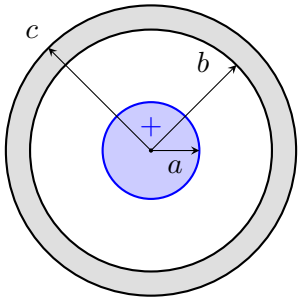
Problem 3. A solid conducting sphere of radius $a = 2.0\,\text{cm}$ carries charge $+5.0\,\mu\text{C}$. It is concentric with a thick conducting spherical shell of inner radius $b = 5.0\,\text{cm}$ and outer radius $c = 6.0\,\text{cm}$ that carries a net charge of $-3.0\,\mu\text{C}$ (see below).

a. Find the charge on the inner and outer surfaces of the shell.

b. Use Gauss's law to find $E(r)$ in each of the four regions: inside the sphere ($0 \le r < a$), the gap ($a < r < b$), inside the shell ($b < r < c$), and outside ($r > c$).

c. Taking $V(\infty) = 0$, find the potential of the shell and of the inner sphere.

d. Sketch $E(r)$ and $V(r)$ on the same horizontal axis, $0 \le r \le 10\,\text{cm}$. Where is V continuous? Where is E discontinuous, and why?



e. Suppose the inner sphere is moved off-centre (without touching the shell), as shown below. Which of your electric-field answers to (b) change, and which do not? Sketch the electric field lines in all regions, showing how they meet each conducting surface.

