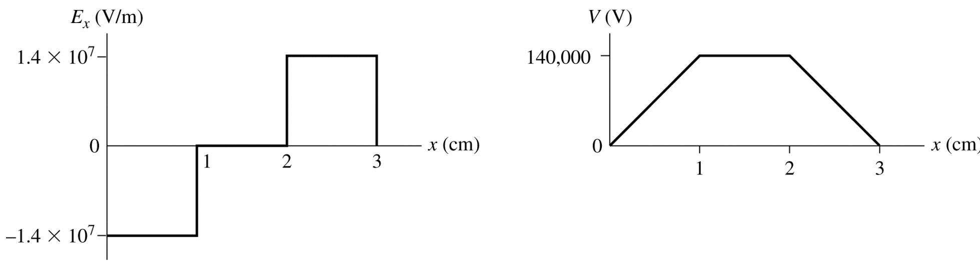
30.39. Model: Assume the electrodes form parallel-plate capacitors with a uniform electric field between the plates.

Visualize:



Please refer to Figure P30.39. The three metal electrodes serve as plates for two capacitors. On the middle electrode, half the charge is located on the left face and half on the right face, thus forming two capacitors. Each plate of the two capacitors carries a charge of ±50 nC.

Solve: **(a)** In the space 0 cm < x < 1 cm, the electric field points to the left and its magnitude is

$$E = \frac{\eta}{\varepsilon_0} = \frac{Q}{A\varepsilon_0} = \frac{50 \times 10^{-9}\ \text{C}}{(0.02\ \text{m})^2 \left(8.85 \times 10^{-12}\ \text{C}^2/\text{N m}^2\right)} = 1.41 \times 10^7\ \text{V/m}$$

In the region 1 cm ≤ x ≤ 2 cm, $\vec{E} = 0$ because in electrostatics the inside of a conductor has no free charge. The electric field in the region 2 cm < x < 3 cm points to the right and has the same magnitude as the electric field in the region 0 cm < x < 1 cm.

(b) The potential difference between two points in space with a uniform electric field is

$$\Delta V = V_\text{f} - V_\text{i} = E\left(x_\text{f} - x_\text{i}\right)$$

Assuming that the negative plate at $x = 0$ m is at zero potential ($V_\text{i} = 0$ V at $x_\text{i} = 0$ cm), $V_\text{f} = x_\text{f}E$, or simply $V = xE$. Thus, the potential increases linearly with distance x from the negative plate in the region $0 \le x \le 1$. At $x = 1$ cm, the potential is

$$V = xE = (1.0 \times 10^{-2}\ \text{m})(1.41 \times 10^7\ \text{V/m}) = 1.41 \times 10^{-5}\ \text{V}$$

The potential must be the same throughout the region 1 cm ≤ x ≤ 2 cm. If this were not the case, we would not have an electrostatic situation with the electric field E = 0 V/m. Using the previous reasoning, the potential decreases linearly in the region 2 cm < x < 3 cm.