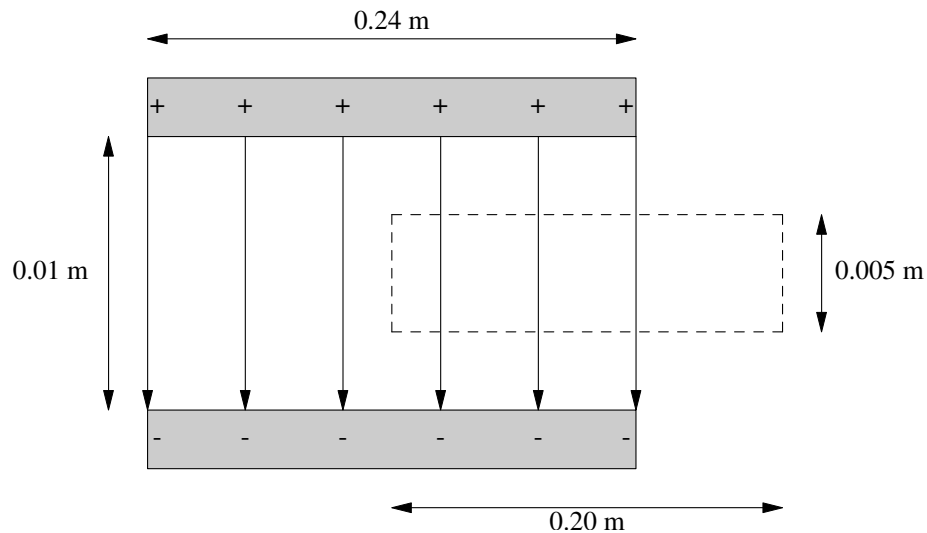


Problem 4: (30 pts.) A parallel plate capacitor is made from two square plates of edge 0.24 m separated in air by 0.01 m.

- a. (10 pts.) What charge would you need on each plate in order to get an electric field of 5,000 N/C between the plates? (Assume the electric field is uniform, with no fringing. This is the usual assumption we made in class.)
- b. (15 pts.) Assume that the field is uniform inside the capacitor, and 0 outside the capacitor, with absolutely no fringing or bending of the lines, as shown in the diagram. (This is the usual assumption we made in class.) What is $\oint \vec{E} \cdot d\vec{s}$ around the dotted path shown in the figure? The dotted path has width 0.20 m and height 0.05 m, and the left hand side is at the exact center of the capacitor. Give a numerical answer.



- c. (5 pts.) Assume there are no other charges or currents present anywhere. Based on your result from part (b), is it possible to actually have the electric field configuration shown in the figure? Explain your reasoning briefly but clearly, using specific equations or physics principles to justify your conclusion.

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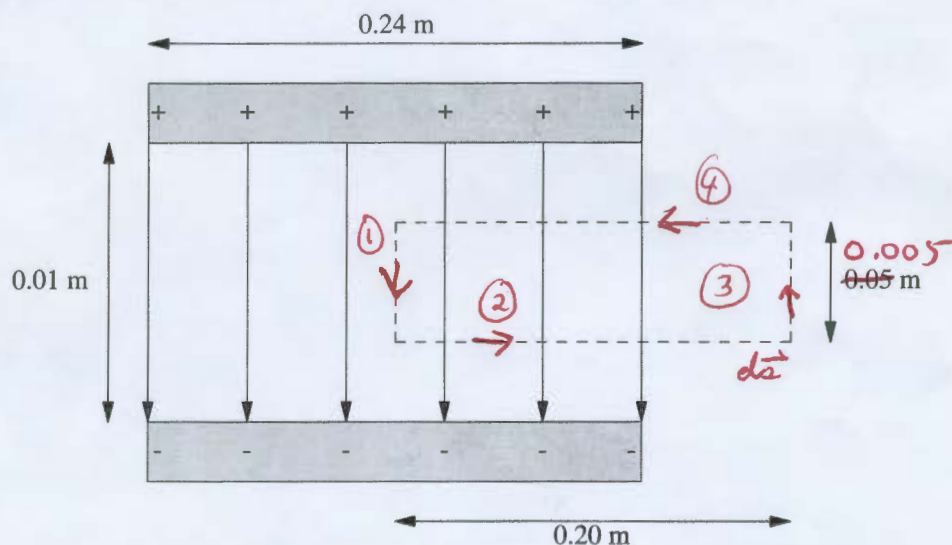
- a. (10 pts.) What charge would you need on each plate in order to get an electric field of 5,000 N/C between the plates? (Assume the electric field is uniform, with no fringing. This is the usual assumption we made in class.)

$$E = \frac{\sigma}{\epsilon_0} = \frac{Q/A}{\epsilon_0} \Rightarrow Q = \epsilon_0 E A = \epsilon_0 E (L^2)$$

$$Q = (8.85 \times 10^{-12}) (5,000) (0.24)^2 = \boxed{2.55 \times 10^{-9} \text{ C}}$$

$$(n: Q = CV = \frac{\epsilon_0 A}{d} V = \epsilon_0 A \frac{V}{d} = \epsilon_0 A E.)$$

- b. (15 pts.) Assume that the field is uniform inside the capacitor, and 0 outside the capacitor, with absolutely no fringing or bending of the lines, as shown in the diagram. (This is the usual assumption we made in class.) What is $\oint \vec{E} \cdot d\vec{s}$ around the dotted path shown in the figure? The dotted path has width 0.20 m and height 0.005 m, and the left hand side is at the exact center of the capacitor. Give a numerical answer.



$$\oint \vec{E} \cdot d\vec{s} = \int_1 \vec{E} \cdot d\vec{s} + \int_2 \vec{E} \cdot d\vec{s} + \int_3 \vec{E} \cdot d\vec{s} + \int_4 \vec{E} \cdot d\vec{s}$$

$$\oint \vec{E} \cdot d\vec{s} = (5,000)(0.005) + 0 + 0 + 0$$

$$= \boxed{25.0 \text{ V}}$$

Because $E = 0$ here
Because $\vec{E} \perp d\vec{s}$

- c. (5 pts.) Assume there are no other charges or currents present anywhere. Based on your result from part (b), is it possible to actually have the electric field configuration shown in the figure? Explain your reasoning briefly but clearly, using specific equations or physics principles to justify your conclusion.

Faraday's Law: $\oint \vec{E} \cdot d\vec{s} = -\frac{d}{dt} \int \vec{B} \cdot d\vec{A}$

Since there are no other charges or currents, $\vec{B} = 0$,
and $\frac{d\vec{B}}{dt} = 0$. Thus $\oint \vec{E} \cdot d\vec{s} = 0$. Since we

found $\oint \vec{E} \cdot d\vec{s} \neq 0$, we have a contradiction.

$\therefore$ we can't actually have this electric field configuration.