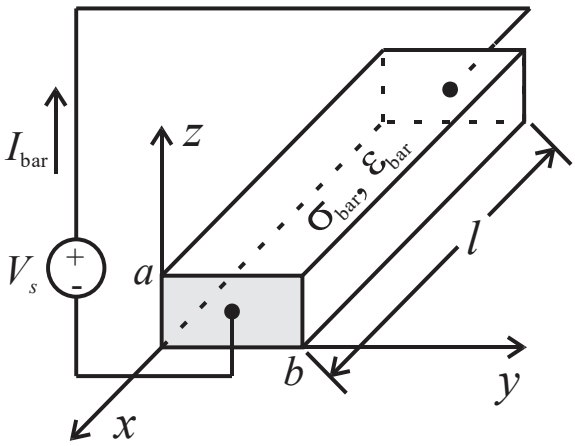
EE 381 Electric and Magnetic Fields Quiz #9 (Fall 2026)

Name KEY A

Instructions: **Open book & notes**. Show all work for full credit, and use notation & units as given in class. Place answers in indicated spaces.

Seeking to animate a candy bar ($a = 14$ mm, $b = 28$ mm, $l = 112$ mm, $\sigma_{bar} = 1.1$ S/m, $\varepsilon_{bar} = 2.2\varepsilon_0$), a deranged EE student connects it to a voltage source V_s driving a current $I_{bar} = 8$ A as shown. Assuming the current is uniformly distributed across the cross section of the candy bar, find the vector current density, electric field, and electric flux density induced in the bar. Also, determine the voltage V_s required and resistance R_{bar} of the animated confectionery treat. For extra credit, find the power density in the bar.



Per (5.2) and picture, $\bar{J} = \hat{a}_x \dfrac{I}{S} = \hat{a}_x \dfrac{8}{0.014(0.028)} \Rightarrow \bar{J} = \hat{a}_x 20{,}408.16 \text{ (A/m}^2\text{)}$.

Per (5.11), $\bar{E} = \bar{J} / \sigma = \hat{a}_x 20408.16 / 1.1 \Rightarrow \bar{E} = \hat{a}_x 18{,}552.88 \text{ (V/m)}$.

Per (5.34), $\bar{D} = \varepsilon \bar{E} = 2.2(8.8541878 \times 10^{-12})\, \hat{a}_x 18{,}552.88 \Rightarrow \bar{D} = \hat{a}_x 3.61395 \times 10^{-7} \text{ (C/m}^2\text{)}$.

Per (5.16), $R_{bar} = \ell / \sigma S = 0.112 / [1.1(0.014)0.028]$ $\Rightarrow$ **$R_{bar} = 259.74\ \Omega$** .

Find voltage using Ohm's Law, $V_S = I_{bar} R_{bar} = 8\ (259.74)$ $\Rightarrow$ **$V_S = 2077.92$ V** !

Extra Credit

Per (5.19), $w_P = \bar{E} \bullet \bar{J} = \hat{a}_x 18{,}552.88 \bullet \hat{a}_x 20{,}408.16$ $\Rightarrow$ **$w_P = 378.63 \times 10^6$ W/m^3** !

Bonus: $P_{bar} = I_{bar}^2 R_{bar} = 8^2\ (259.74) = 16{,}623.36$ W (Yikes, it's gonna melt/vaporize!)

$\bar{J} = \hat{a}_x 20{,}408.16 \text{ (A/m}^2\text{)}$ $\bar{E} = \hat{a}_x 18{,}552.88 \text{ (V/m)}$

$\bar{D} = \hat{a}_x 361.395 \text{ (nC/m}^2\text{)}$ $V_s = 2077.92$ V $R_{bar} = 259.74\ \Omega$

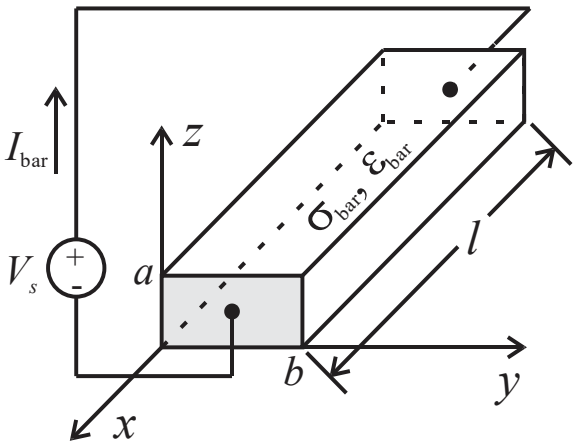
Extra credit: power density = **$w_P = 3.7863 \times 10^8$ W/m^3 = 378.63 MW/m^3**

EE 381 Electric and Magnetic Fields Quiz #9 (Fall 2026)

Name KEY B

Instructions: **Open book & notes**. Show all work for full credit, and use notation & units as given in class. Place answers in indicated spaces.

Seeking to animate a candy bar ($a = 16$ mm, $b = 32$ mm, $l = 128$ mm, $\sigma_{bar} = 1.3$ S/m, $\varepsilon_{bar} = 2.3\varepsilon_0$), a demented EE student connects it to a voltage source V_s driving a current $I_{bar} = 6$ A as shown. Assuming the current is uniformly distributed across the cross section of the candy bar, find the vector current density, electric field, and electric flux density induced in the bar. Also, determine the voltage V_s required and resistance R_{bar} of the energetic confectionery treat. For extra credit, find the power density in the bar.



Per (5.2) and picture, $\bar{J} = \hat{a}_x \dfrac{I}{S} = \hat{a}_x \dfrac{6}{0.016(0.032)} \Rightarrow \bar{J} = \hat{a}_x 11{,}718.75 \text{ (A/m}^2\text{)}$.

Per (5.11), $\bar{E} = \bar{J} / \sigma = \hat{a}_x 11718.75 / 1.3 \Rightarrow \bar{E} = \hat{a}_x 9{,}014.423 \text{ (V/m)}$.

Per (5.34), $\bar{D} = \varepsilon \bar{E} = 2.3(8.8541878 \times 10^{-12})\, \hat{a}_x 9014.423 \Rightarrow \bar{D} = \hat{a}_x 1.83575 \times 10^{-7} \text{ (C/m}^2\text{)}$.

Per (5.16), $R_{bar} = \ell / \sigma S = 0.128 / [1.3(0.016)0.032] \Rightarrow \mathbf{R_{bar} = 192.308\ \Omega}$.

Find voltage using Ohm's Law, $V_S = I_{bar} R_{bar} = 6\ (192.308) \Rightarrow \mathbf{V_S = 1153.85\ V}$!

Extra Credit

Per (5.19), $w_P = \bar{E} \bullet \bar{J} = \hat{a}_x 9{,}014.23 \bullet \hat{a}_x 11{,}718.75 \Rightarrow \mathbf{w_P = 105.638 \times 10^6\ W/m^3}$!

Bonus: $P_{bar} = I_{bar}^2 R_{bar} = 6^2\ (192.308) = 6{,}923.1$ W (Yikes, it's gonna melt/vaporize!)

$\bar{J} = \hat{a}_x 11{,}718.75 \text{ (A/m}^2\text{)}$ $\bar{E} = \hat{a}_x 9{,}014.42 \text{ (V/m)}$

$\bar{D} = \hat{a}_x 183.575 \text{ (nC/m}^2\text{)}$ $V_s = \mathbf{1153.85\ V}$ $R_{bar} = \mathbf{192.308\ \Omega}$

Extra credit: power density = $\mathbf{w_P = 1.05638 \times 10^8\ W/m^3 = 105.638\ MW/m^3}$