Solution
Worksheet 3 – Problem 9

For part (a) and (b), the question is asking for the *magnitude* of the field, so you compare the absolute values of the net fields, and not worry about the signs.

(a) Use Gauss's Law to find $\boldsymbol{E}$ of EACH plate, then sum the two fields to get the total field between 2 plates. You should get the following order:

$$III > I = II > IV$$

(b) The Gaussian surface now encloses BOTH plates, because you are looking for the net field outside (left or right doesn't matter). Again, use $E = \sigma/2\epsilon_0$, where

$$\sigma = (Q_1 + Q_2)/A$$

You should get the following order:

$$IV > II > III > I$$

(c) From (a), you see that the net field between the two plates is

$$\boldsymbol{E} = \frac{Q}{2\epsilon_0 A}\,\hat{\boldsymbol{x}} + \frac{Q}{\epsilon_0 A}(-\hat{\boldsymbol{x}}) = \frac{Q}{2\epsilon_0 A}(-\hat{\boldsymbol{x}})$$

Which points to the left. An electron always travels in the opposite direction of the electric field, so it's going to the right. Answer: it will hit the **right** plate.

(d) Use $F = ma = qE$ and $x = \frac{1}{2}at^2$to find t, since the electron starts from rest with a constant acceleration (thanks to the constant electric field of a plane charge!).
We have:

$$a = \frac{q_e E}{m_e} = \frac{q_e}{m_e}\frac{Q}{2\epsilon_0 A}$$

$$x = \frac{1}{2}at^2 = \frac{3}{4}d$$

Hence:

$$t = \sqrt{\frac{2x}{a}} = \sqrt{\frac{3d}{2} \times \frac{2A\epsilon_0 m_e}{Qq_e}} = \sqrt{\boldsymbol{\frac{3Ad\epsilon_0 m_e}{Qq_e}}}$$