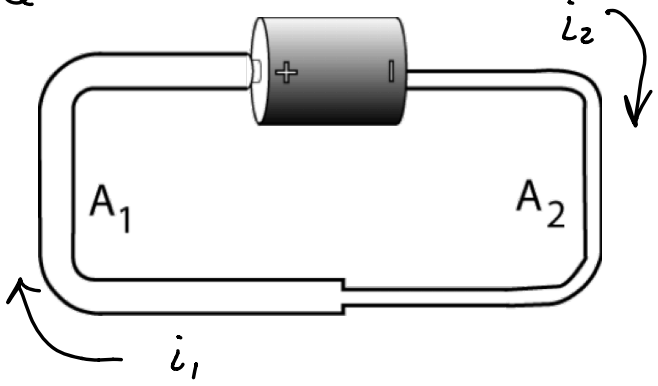
Review thick vs thin wire

CQ 18.3.d



$$i_1 = i_2$$

$$n_1 A_1 \bar{v}_1 = n_2 A_2 \bar{v}_2$$

$$n_1 = n_2$$

$$A_1 \bar{v}_1 = A_2 \bar{v}_2$$

$$\bar{v}_1 = \frac{A_2}{A_1} \bar{v}_2 = \frac{1}{4} \bar{v}_2$$

$$\bar{v}_1 = \frac{1}{4} \bar{v}_2$$

$$\bar{v} = u \bar{E}$$

$$u_1 E_1 = \frac{1}{4} u_2 E_2$$

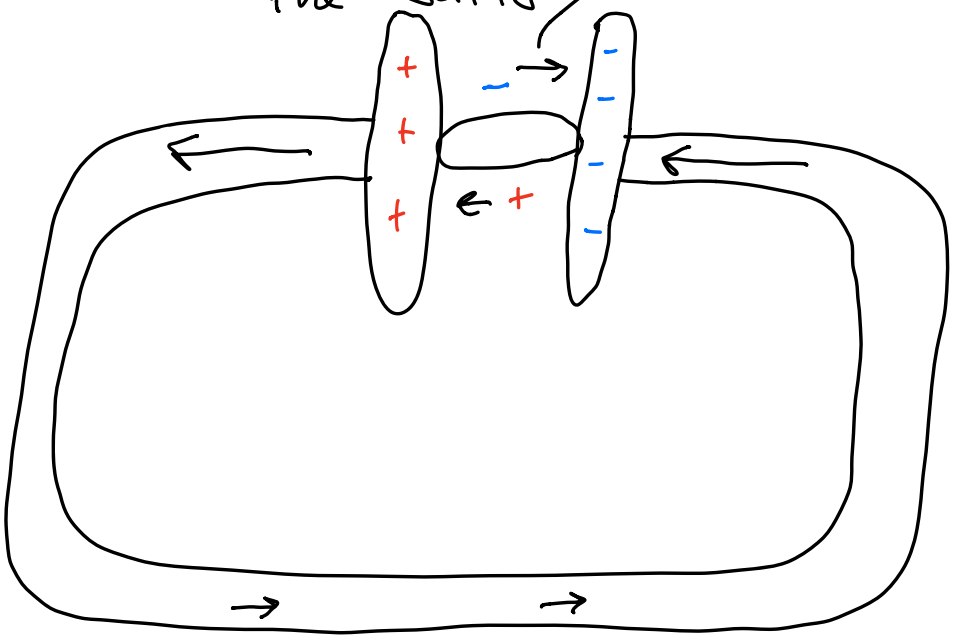
$$u_2 = u_1 \qquad E_1 = \frac{1}{4} E_2$$

CQ 18.4.a

Ans: 3

How is this field created?

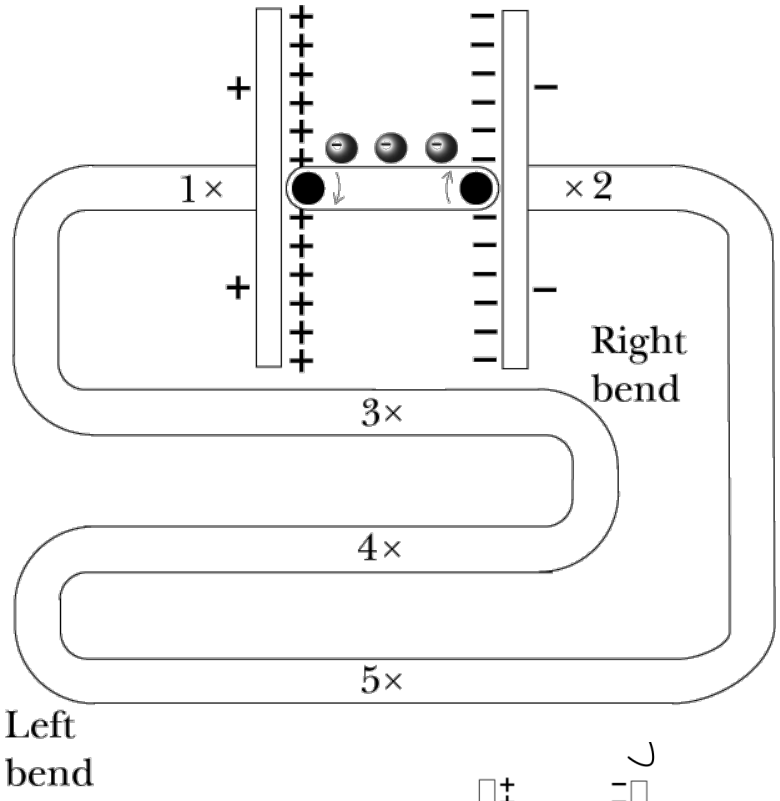
- Assume it all comes from the battery



E not uniform $\Rightarrow$ i not uniform

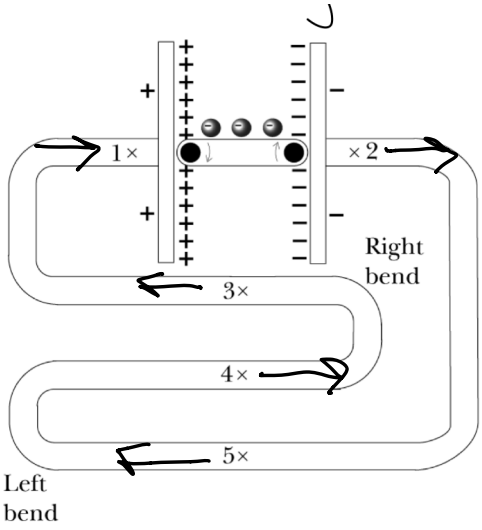
E_{net} not just due to battery!

Consider the following circuit

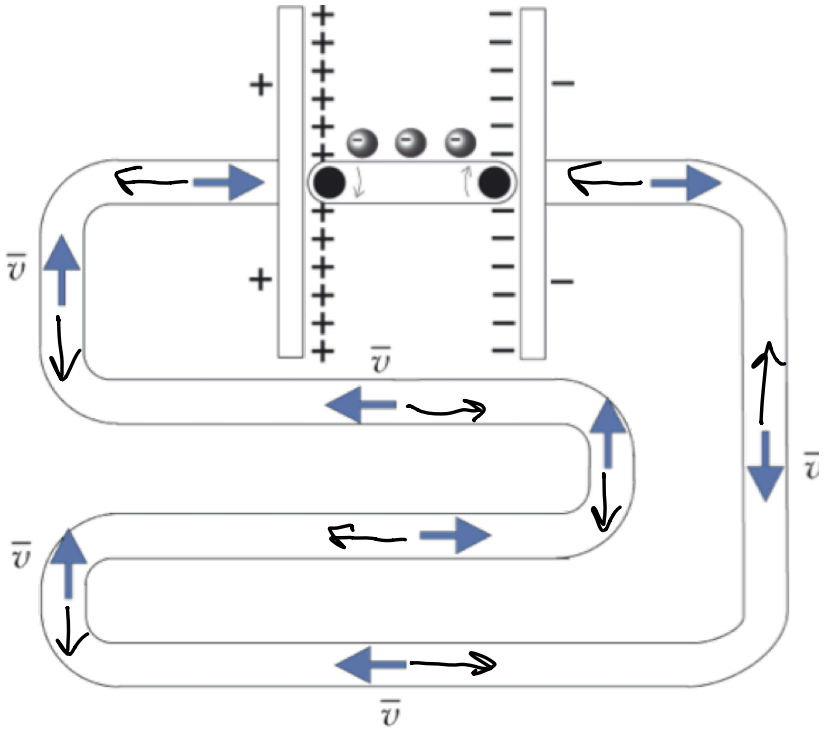


Steady state

Drift v

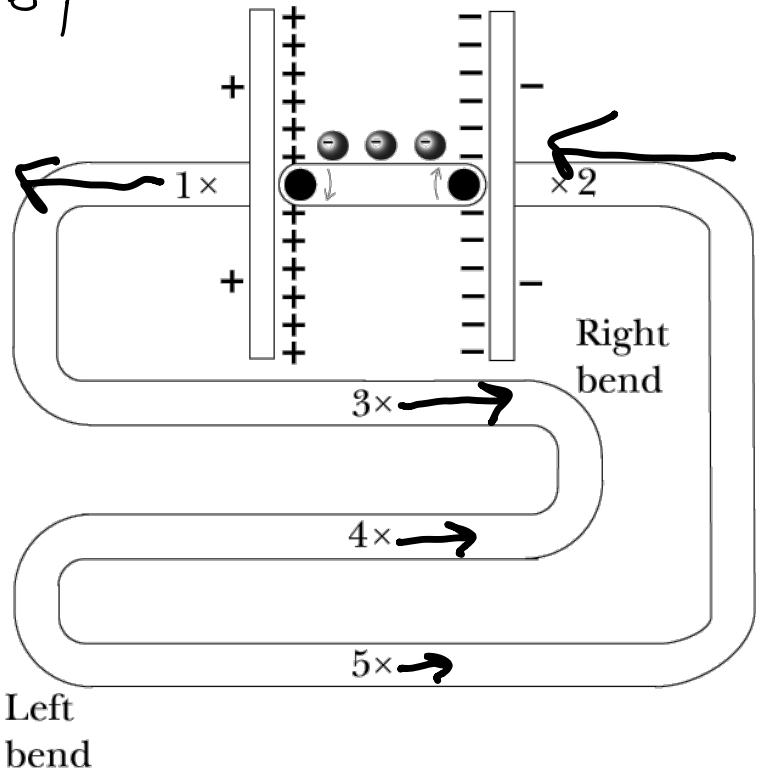


Steady state field

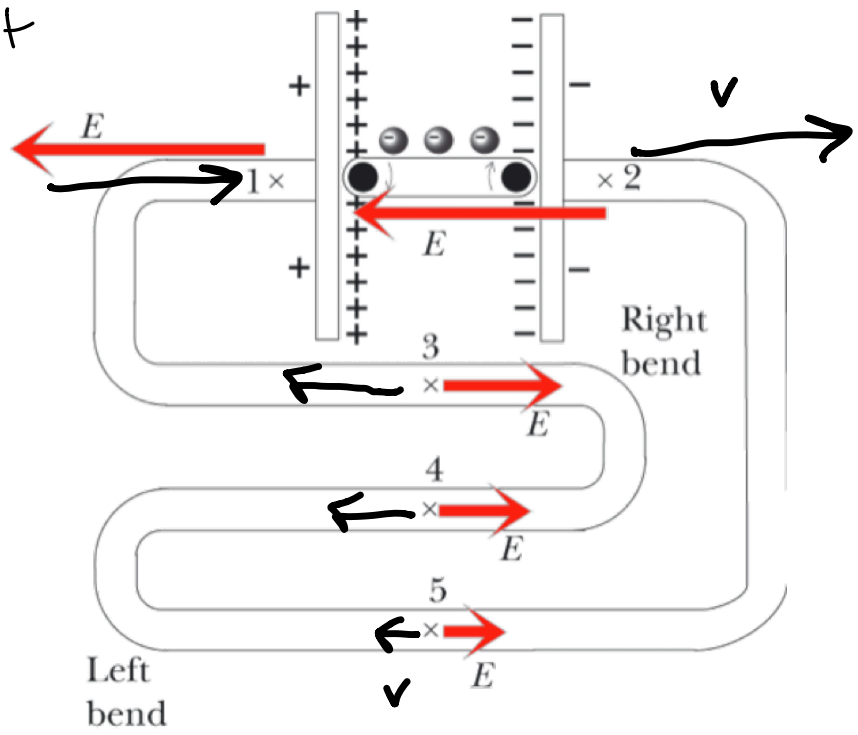


E battery only

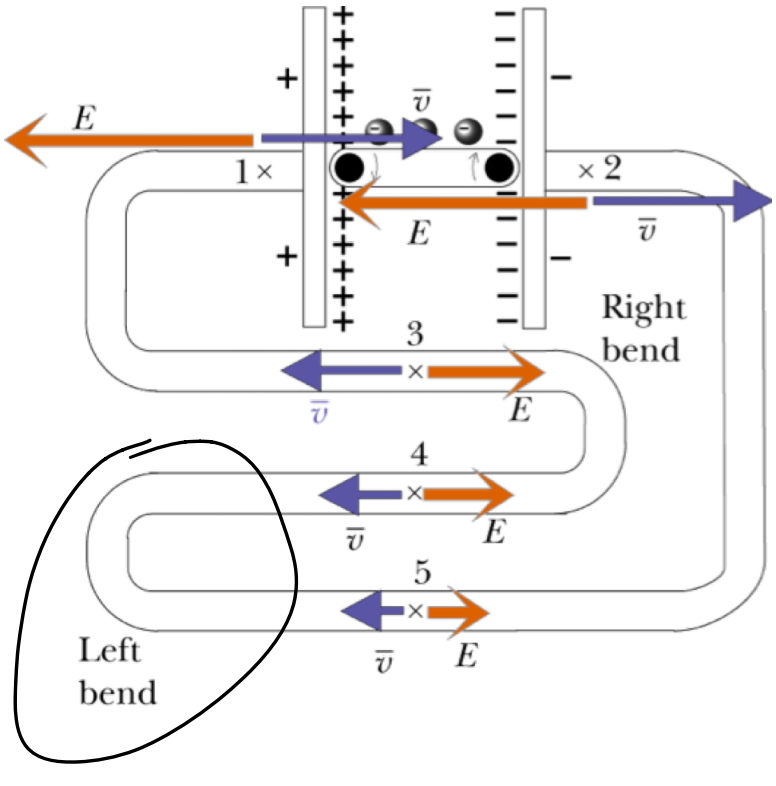
(dipole)



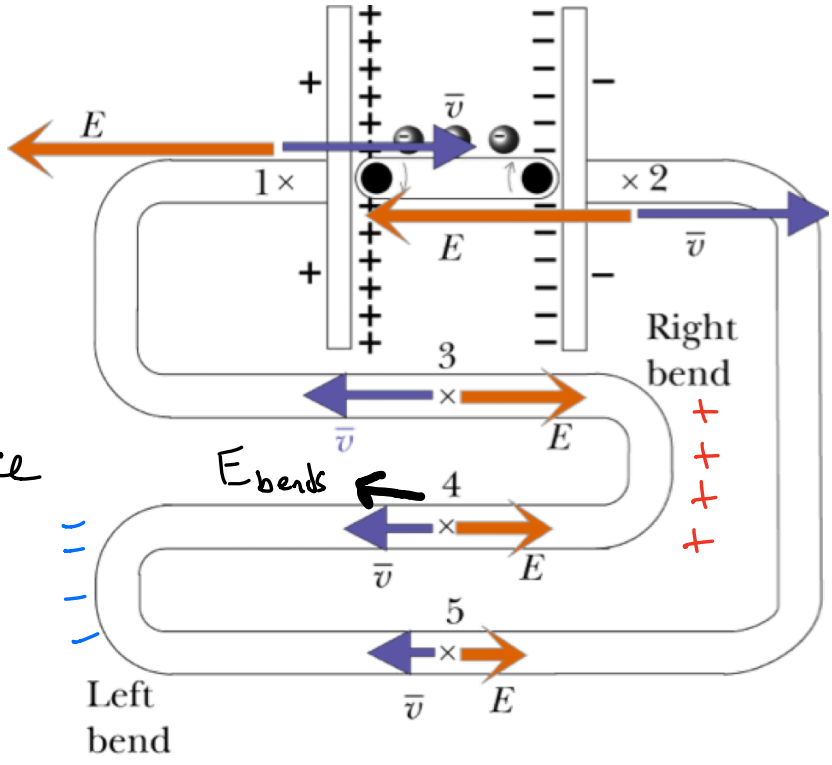
v_{drift}

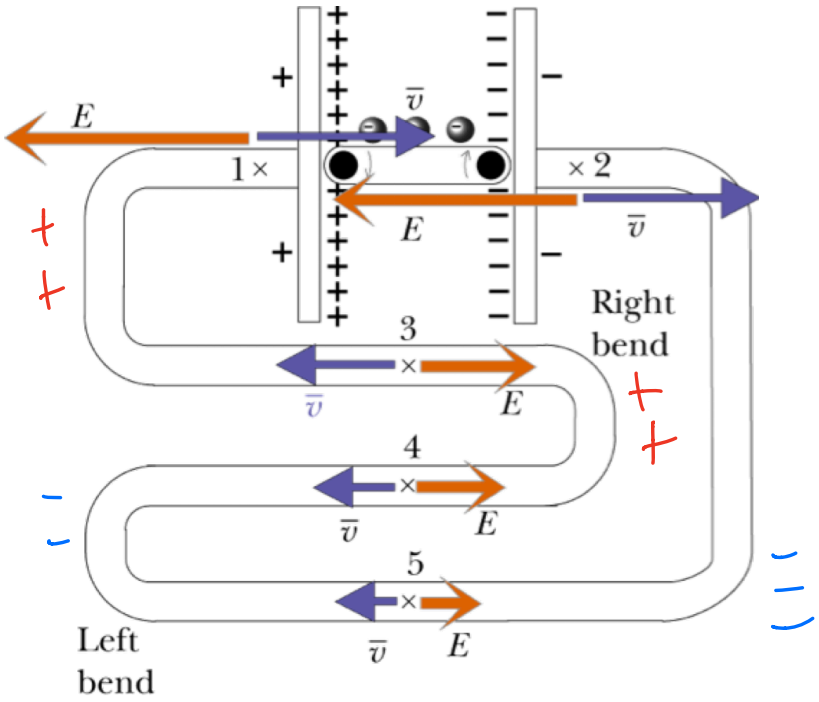


What starts to happen?



Charge accum until balance

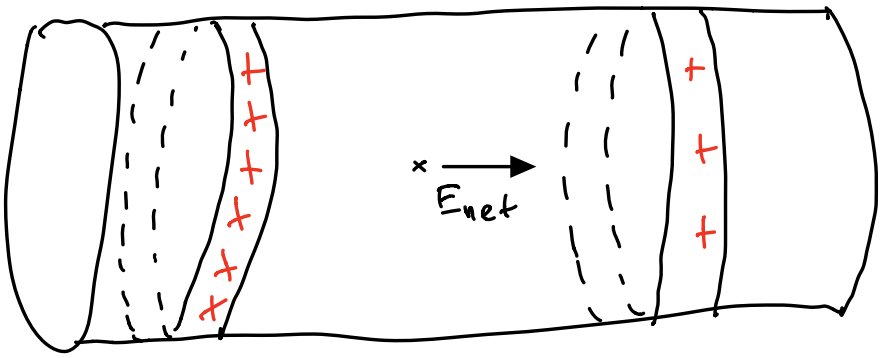




Key Point

- $\vec{E}$ in the wire comes from battery + surface charges

- Surface charge accumulates so that steady state current is uniform
  - How fast does this happen?
    - $\vec{E}$ moves at speed of light
    - Surface charges form very quickly $c = 3 \times 10^{10} \frac{cm}{s}$ $t \sim 1ns$
- Change in surface charge leads to $\underline{E}$ field



Larger gradient ⟶ Larger Field

- Wire is still overall charge neutral:

  charges have separated to form small "pockets"

- Amount of excess charge is very small

3V battery ⟶ $10^{-9}\ \frac{C}{m^2}$