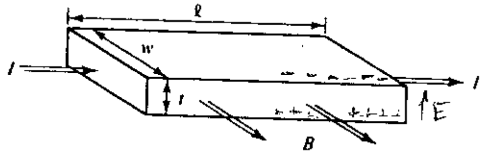
5.39
**Problem ~~5.51~~** (**The Hall effect.**) A current I flows to the right through a rectangular bar of conducting material, in the presence of a uniform magnetic field **B** pointing out of the page (Fig. ~~5.59~~). 5.56

(a) If the moving charges are *positive*, in which direction are they deflected by the magnetic field?

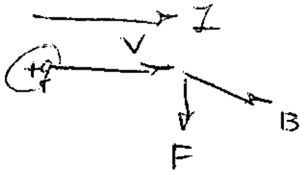
This deflection results in an accumulation of charge on the upper and lower surfaces of the bar, which in turn produces an electrical force to counteract the magnetic one. Equilibrium occurs when the two exactly cancel.

(b) Find the resulting potential difference (the "Hall voltage") between the top and bottom of the bar, in terms of $B$, $v$ (the speed of the charges), and the relevant dimensions of the bar.

(c) How would your analysis change if the moving charges were *negative*? [The Hall effect is the classic way of determining the sign of the mobile charge carriers in a material.]




(a)



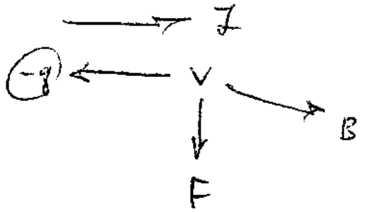

Positive charges moving right would be deflected down by outward $B$.

(b) $F = q\bar{E} + q\bar{v}\times\bar{B} = 0$ when $\bar{E} = -\bar{v}\times\bar{B} = -\nabla V$
(velocity) (voltage)

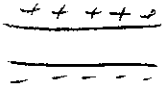
$\nabla V = -\int \bar{E}\cdot d\bar{l} = +\int(\bar{v}\times\bar{B})\cdot d\bar{l} = vBt$

(higher voltage would be on the bottom, for moving ⊕)

(c)




Current due to negative charges moving left would also result in charges deflected down.

But this would make  higher voltage on top. This is what is observed ∴ charge carriers are negative (that is, they obey a left-hand rule).