5.46 Silicon, at $T = 300$ K, is uniformly doped with phosphorus atoms at a concentration of 2×10^{16} cm^{-3}. A Hall device has the same geometrical dimensions as given in Example 5.8. The current is $I_x = 1.2$ mA and the magnetic field is $B_Z = 500$ gauss $= 5 \times 10^{-2}$ tesla. Determine (*a*) the Hall voltage and (*b*) the Hall field.

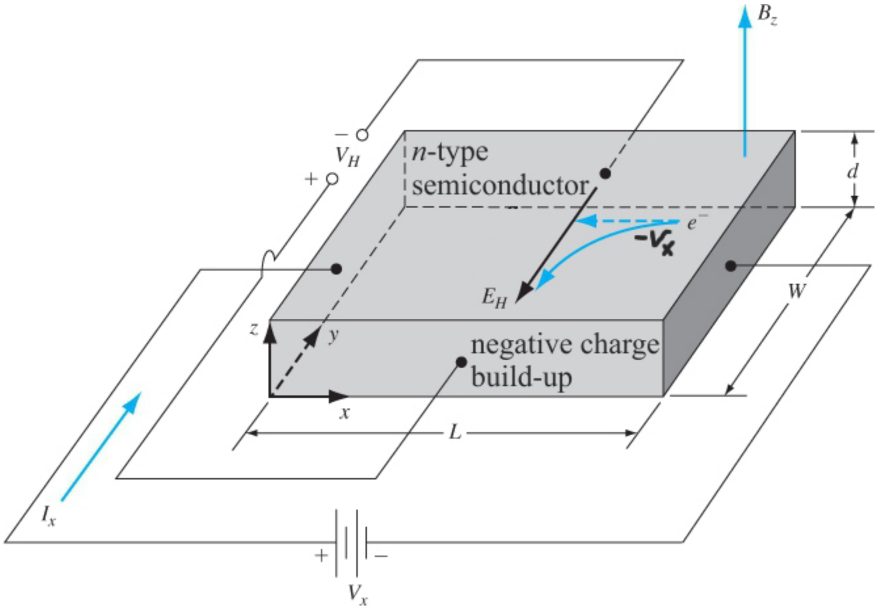

Figure 5.13 | Geometry for measuring the Hall effect.

- From Example 5.8, $L = 10^{-1}$ cm $= 10^{-3}$ m, $W = 10^{-2}$ cm $= 10^{-4}$ m, and $d = 10^{-3}$ cm $= 10^{-5}$ m.
- Per Table 4.3, phosphorous is a donor in silicon.
- Per Table B.4, $n_i = 1.5 \times 10^{10}$ cm^{-3} in silicon at 300 K. Since $N_d >> n_i$, we will set $n = N_d = 2 \times 10^{16}$ cm^{-3}.

a) Per (5.55), with all MKS units,

$$V_H = \frac{-I_x B_z}{n e d} = \frac{-1.2 \times 10^{-3} (5 \times 10^{-2})}{2 \times 10^{22} (1.602176634 \times 10^{-19}) 10^{-5}} \Rightarrow \underline{\underline{V_H = -0.001872 \text{ V} = -1.8272 \text{ mV}}}.$$

b) Per (5.50), the Hall electric field is

$$E_H = V_H / W = -0.001872453 / 10^{-4} \Rightarrow \underline{\underline{E_H = -18.7245 \text{ V/m} = -0.1872 \text{ V/cm}}}.$$