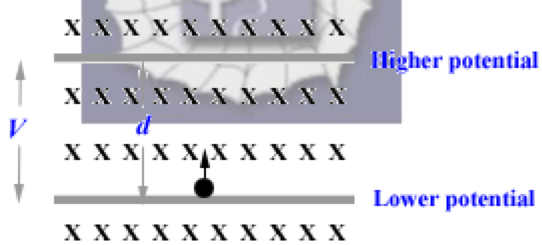
443.

Problem 29.39P (HRW)

As shown in the figure, an electron of mass m, charge e, and negligible speed enters the region between two plates of potential difference V, and plate separation d, initially headed directly toward the higher-potential top plate in the figure. A uniform magnetic field is directed perpendicular to the plane of the figure. We have to find the minimum value of B at which the electron will not strike the top plate.



Solution:

As the magnetic field only changes the direction of motion and not the velocity, the speed of the electron when it reaches the top plate will be determined by the potential difference between the higher and the lower plates. The speed *v* when the electron is able to reach the top plate will, therefore, be

$$\frac{mv^2}{2} = eV,$$

or

$$v = \sqrt{\frac{2eV}{m}}.$$

We are asked to find the minimum magnetic field *B* such that the electron will not strike the top plate. If this has to happen then the velocity vector will be parallel to the plates when it approaches the top plate. In this situation the Lorentz force on the electron will be zero, and the electron will graze the top plate and move parallel to it with speed *v*. For the minimum magnetic field, we have the condition

$$eE = evB.$$

As

$$E = \frac{V}{d},$$

$$B = \frac{V}{dv} = \frac{V}{d} \times \sqrt{\frac{m}{2eV}} = \sqrt{\frac{mV}{2ed^2}}.$$