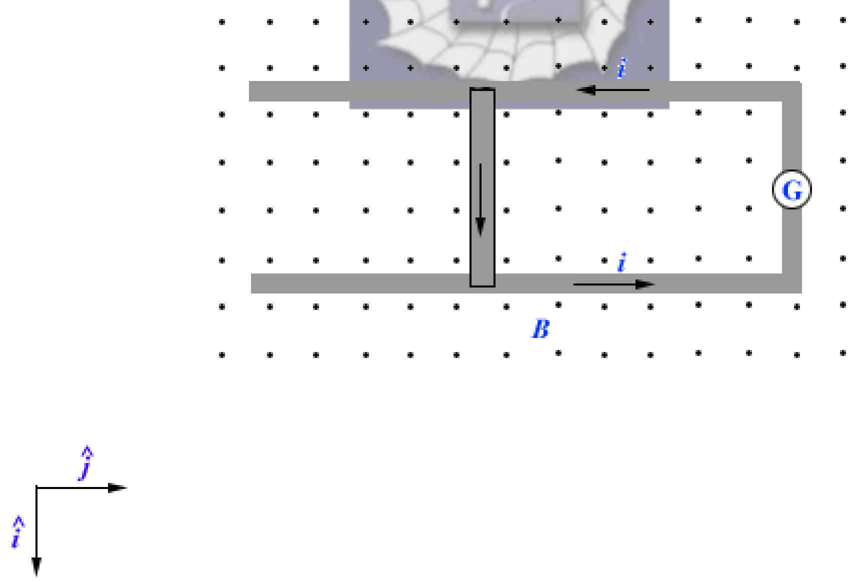
491.

<u>Problem 36.21 (RHK)</u>

A conducting rod of mass m and length L slides without friction on two long horizontal rails. A uniform vertical magnetic field $\vec{B}$ *fills the region in which the rod is free to move; as shown in the figure. The generator G supplies a constant current i that flows down one rail, across the rod, and back to the generator along the other rail. We have to find the velocity of the rod as a function of time, assuming it to be at rest at* $t = 0$.



<u>Solution:</u>

The force on a current carrying conductor in a uniform magnetic field is given by the Lorentz force law,

$\vec{F} = i\vec{L} \times \vec{B}$.

$\vec{L}$ is a vector length of the conductor in the direction of the flow of current in it, and $\vec{B}$ is the magnetic field acting on the current carrying conductor. In our problem $\vec{B} = B\hat{k}$ and $\vec{L} = L\hat{i}$.

The current flowing in the conducting rod through the rails is maintained by the generator at a constant value i. Therefore, force on the rod will be

$$\vec{F} = iLB\hat{i} \times \hat{k} = iLB\left(-\hat{j}\right).$$

We note that the force on the conducting rod will be along the negative y-axis.

As the mass of the sliding rod is m and that the rod is assumed to slide on the rails without friction, it will move with acceleration

$$a = \frac{iLB}{m}.$$

We are given the initial condition that the conducting rod starts from rest at $t = 0$. Therefore, the velocity of the rod as a function of time will be

$$\vec{v} = -\frac{iLBt}{m}\hat{j}.$$

The direction of motion of the rod is away from the generator.