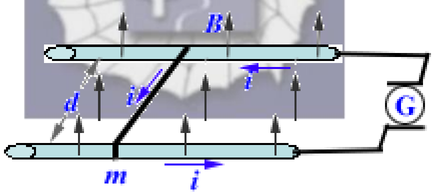
445.

<u>Problem 34.42 (RHK)</u>

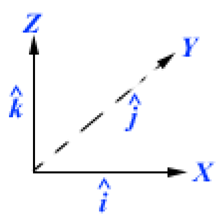
A metal wire of mass m slides without friction on two horizontal rails spaced a distance d apart, as shown in the figure. The track lies in a vertical uniform magnetic field, $\vec{B}$*. A constant current,* i*, flows from generator G along one rail, across the wire, and back down the other rail. We have to find the velocity* (*speed and direction*) *of the wire as a function of time, assuming it to be at rest at* $t = 0$.



<u>Solution:</u>

We fix a coordinate system as shown in the figure. In this coordinate system the magnetic field is

$$\vec{B} = B\hat{k}.$$



The direction of the current flowing through the sliding wire is $-\hat{j}$. Force on the current carrying sliding wire of length d in magnetic field $\vec{B}$ will be

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

Therefore, force on the sliding wire will be

$$\vec{F} = -di\,\hat{j} \times B\hat{k} = -dBi\,\hat{i}.$$

Mass of the wire is m. It slides without friction on the horizontal rails. As calculated above, it experiences a force of magnitude $F = dBi$ acting in the $-\hat{i}$ direction. It therefore moves with constant acceleration

$$a = \frac{dBi}{m}$$

in $-\hat{i}$ direction. If we use the initial condition that at $t = 0$ the sliding wire was at rest, its velocity as a function of time will be given by the function

$$\vec{v}(t) = -\frac{dBit}{m}\hat{i}.$$