Since the only current that flows is in the \( \hat{\phi} \) direction this is like a finite solenoid. From the direction of \( \vec{K}_b \) the \( B \)-field must be in the \( z \)-direction inside the magnet. \( B \) will have an \( s \)-component because the solenoid is finite in length.

We have

Now, how about \( \vec{H} \)?
\[
\vec{H} = \frac{1}{\mu_0} \vec{B} - \vec{M}.
\]

We must determine the direction of \( \vec{H} \) by examining the relative magnitudes of \( \frac{1}{\mu_0} \vec{B} \) and \( \vec{M} \) because of the minus sign. Outside \( \vec{H} = \frac{1}{\mu_0} \vec{B} \) because \( \vec{M} = 0 \) so it is in the same direction as \( \vec{B} \)

Inside \( \vec{B} < \vec{B}_{\text{inside, solenoid}} = \mu_0 n I \) because \( B \)-lines emerge from the ends. In other words the \( B \)-line density is lower in the finite solenoid than in an infinite solenoid.
Let's temporarily assume $B = \mu_0 nI$ where $nI \rightarrow k_b = M$ for this permanent magnet. Then

$$H_{inside} = \frac{1}{\mu_0} (\mu_0 M) - M = 0$$

Because $B_{inside} < \mu_0 M$, $H_{inside}$ must be in the opposite direction of $M$ and $B_{inside}$.

\[ H \text{-field} \]

$H$ is discontinuous at the end caps of the cylinder. It is as though there are sources of $H$ which would mean that $\nabla \cdot H = 0$ and that there is fictitious magnetic charge on the end caps.

\[ \nabla \cdot \vec{H} = \nabla \cdot \left( \frac{1}{\mu_0} \vec{B} - \vec{M} \right) \]

\[ \nabla \cdot (\vec{H} + \vec{M}) = 0 \] which shows again that $\vec{H}$ and $\vec{M}$ are in opposite directions.