Goal: A very large slab of material of thickness d lies perpendicularly to a uniform magnetic field of intensity $\mathbf{H}_0 = \mathbf{a}_z H_0$. Find the magnetic field intensity inside the dielectric slab if it has a permeability μ or if it is a permanent magnet having a magnetization vector $\mathbf{M}_i = \mathbf{a}_z M_i$.

Steps:

1. State the magnetostatic boundary conditions for tangential and normal components at the interface between the dielectric slab and air.
   Solution:

$$\mathbf{a}_n \cdot \mathbf{B}_1 = \mathbf{a}_n \cdot \mathbf{B}_2$$
$$\mathbf{a}_n \times (\mathbf{H}_1 - \mathbf{H}_2) = \mathbf{J}_s \,.$$

   Here, $\mathbf{J}_s$ is 0.

2. What is the magnetic field intensity $\mathbf{H}$ inside the dielectric slab if the slab material has permeability μ?
   Solution: Tangential Component:

$$\mathbf{a}_n \times (\mathbf{H}_1 - \mathbf{H}_2) = \mathbf{J}_s$$
$$\mathbf{a}_n \times (0 - \mathbf{H}_2) = 0$$
$$\mathbf{a}_n \times \mathbf{H}_2 = 0 \,.$$

   Normal component of the field:

$$\mathbf{a}_n \cdot \mathbf{B}_1 = \mathbf{a}_n \cdot \mathbf{B_2}$$
$$\mathbf{a}_z B_{1n} = \mathbf{a}_z B_{2n}$$
$$\mu_0 H_0 = \mu H_{2n}$$
$$H_{2n} = \frac{\mu_0}{\mu} H_0 \,.$$

   $\therefore \mathbf{H}_2 = \frac{\mu_0}{\mu} H_0 \mathbf{a}_z$

3. What is the magnetic field intensity $\mathbf{H}$ inside the magnetic slab if the slab is a permanent magnet having a magnetization vector $\mathbf{M}_i = \mathbf{a}_z M_i$?
   Solution: Tangential component $\mathbf{a}_n \times \mathbf{H}_2 = 0$. Normal component:

$$\mathbf{a}_z B_{1n} = \mathbf{a}_z B_{2n}$$
$$\mathbf{a}_z \mu_0 H_0 = \mathbf{a}_z \mu_0 \left(H_{2n} + M_i\right)$$
$$H_{2n} = H_0 - M_i$$

   $\therefore$ The magnetic field intensity inside the slab is $\mathbf{H}_2 = (H_0 - M_i)\,\mathbf{a}_z$.

Answer:

$$\mathbf{H}_2 = \frac{\mu_0}{\mu} H_0 \mathbf{a}_z \quad \text{Dielectric slab}$$
$$\mathbf{H}_2 = (H_0 - M_i)\,\mathbf{a}_z \quad \mathbf{M_i} = a_z M_i$$