**Problem 5.32** The $x$–$y$ plane separates two magnetic media with magnetic permeabilities $\mu_1$ and $\mu_2$ (Fig. P5.32). If there is no surface current at the interface and the magnetic field in medium 1 is

$$ H_1 = \hat{x}H_{1x} + \hat{y}H_{1y} + \hat{z}H_{1z} $$

find:

(a) $H_2$
(b) $\theta_1$ and $\theta_2$
(c) Evaluate $H_2$, $\theta_1$, and $\theta_2$ for $H_{1x} = 2$ (A/m), $H_{1y} = 0$, $H_{1z} = 4$ (A/m), $\mu_1 = \mu_0$, and $\mu_2 = 4\mu_0$

![Figure P5.32: Adjacent magnetic media (Problem 5.32).](image)

**Solution:**

(a) From (5.80),

$$ \mu_1 H_{1n} = \mu_2 H_{2n}, $$

and in the absence of surface currents at the interface, (5.85) states

$$ H_{1t} = H_{2t}. $$

In this case, $H_{1z} = H_{1n}$, and $H_{1x}$ and $H_{1y}$ are tangential fields. Hence,

$$ \mu_1 H_{1z} = \mu_2 H_{2z}, $$

$$ H_{1x} = H_{2x}, $$

$$ H_{1y} = H_{2y}, $$

and

$$ H_2 = \hat{x}H_{1x} + \hat{y}H_{1y} + \hat{z} \frac{\mu_1}{\mu_2} H_{1z}. $$
(b)  

\[ H_{1t} = \sqrt{H_{1x}^2 + H_{1y}^2}, \]

\[ \tan \theta_1 = \frac{H_{1t}}{H_{1z}} = \frac{\sqrt{H_{1x}^2 + H_{1y}^2}}{H_{1z}}, \]

\[ \tan \theta_2 = \frac{H_{2t}}{H_{2z}} = \frac{\sqrt{H_{2x}^2 + H_{2y}^2}}{H_{2z}} = \frac{\mu_2}{\mu_1} \tan \theta_1. \]

(c)  

\[ \mathbf{H}_2 = \hat{x} 2 + \hat{z} \frac{1}{4} \cdot 4 = \hat{x} 2 + \hat{z} \quad \text{(A/m)}, \]

\[ \theta_1 = \tan^{-1} \left( \frac{2}{4} \right) = 26.56^\circ, \]

\[ \theta_2 = \tan^{-1} \left( \frac{2}{1} \right) = 63.44^\circ. \]