

# EM Spring 02 B

Thin sheets of current flow into and out of the paper as indicated. The current per unit length is  $K = K_0 \text{Re}(e^{-i\omega t})$ , and has the same magnitude in the top and bottom sheets. A conducting slab with thickness  $w$ , constant conductivity  $\sigma$ , and constant magnetic permeability  $\mu$  is placed midway between the two sheets of current. The sheets of current and the slab are parallel to one another, and are perpendicular to this sheet of paper. They can be considered to extend to infinity in the positive and negative  $y$  and  $z$  directions, so that the fields are only a function of the  $x$ -coordinate.

Make the approximation that the time variation is slow enough that the displacement current ( $\partial \vec{D} / \partial t$ ) can be set to zero in Maxwell's equations. Above the top current sheet and below the lower current sheet,  $\vec{H} = 0$  can be assumed.

Designate the time-dependent electric and magnetic fields in regions 1 and 2 (within the conductor) as  $\vec{E}_1, \vec{E}_2, \vec{H}_1$ , and  $\vec{H}_2$ . Use an  $xyz$  coordinate system with axes oriented as indicated in the figure. The goal of this problem is to find  $\vec{E}$  and  $\vec{H}$  in regions 1 and 2 that are generated by the time varying sheets of current.

- Starting from Maxwell's equations, find the solution for the variation of  $\vec{H}_2$  within the conductor as a function of the coordinate  $x$ . Your solution should contain two constants of integration. Use the symmetries of the problem to show that one of these constants is zero. Express  $\vec{E}_2$  within the conductor in terms of this  $\vec{H}_2$ .
- Give the necessary boundary conditions on the fields at the upper surface of the slab. Indicate how these follow from Maxwell's equations.
- Find  $\vec{H}_1$ .
- Find  $\vec{E}_2$  and  $\vec{H}_2$ .
- Find  $\vec{E}_1$ .

