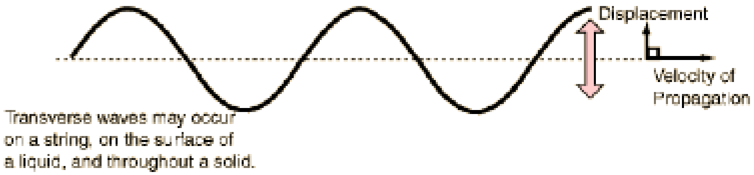
Why light waves are transverse



Suppose a wave propagates in the *x*-direction. Then it's a function of *x* and *t* (and not *y* or *z*), so all *y*- and *z*-derivatives are zero:

$$\frac{\partial E_y}{\partial y} = \frac{\partial E_z}{\partial z} = \frac{\partial B_y}{\partial y} = \frac{\partial B_z}{\partial z} = 0$$

In a charge-free medium,

$$\vec{\nabla} \cdot \vec{E} = 0 \;\; and \;\; \vec{\nabla} \cdot \vec{B} = 0$$

that is,

$$\frac{\partial E_x}{\partial x} + \cancel{\frac{\partial E_y}{\partial y}} + \cancel{\frac{\partial E_z}{\partial z}} = 0 \qquad \frac{\partial B_x}{\partial x} + \cancel{\frac{\partial B_y}{\partial y}} + \cancel{\frac{\partial B_z}{\partial z}} = 0$$

Substituting the zero values, we have:

$$\frac{\partial E_x}{\partial x} = 0 \;\; \text{and} \;\; \frac{\partial B_x}{\partial x} = 0$$

So the longitudinal fields (parallel to propagation direction) are at most **constant**, and not waves.