## Answer to Electromagnetism Example Question 4

We have that $\nabla \cdot \underline{E} = \begin{pmatrix} \frac{\partial}{\partial x} \\ \frac{\partial}{\partial y} \\ \frac{\partial}{\partial z} \end{pmatrix} \cdot \begin{pmatrix} E_{ox} \\ E_{oy} \\ E_{oz} \end{pmatrix} e^{j(\omega t - k_x x - k_y y - k_z z)}$

$$= [-E_{ox}k_x - E_{oy}k_y - E_{oz}k_z]e^{j(\omega t - \underline{k}\cdot\underline{r})}$$

This can only = 0 for all times $t$ and at all positions $\underline{r}$ provided that the term in square brackets = 0.

Thus $\begin{pmatrix} E_{ox} \\ E_{oy} \\ E_{oz} \end{pmatrix} \cdot \begin{pmatrix} k_x \\ k_y \\ k_z \end{pmatrix} = 0$ which requires that $\underline{E}_o$ (and hence $\underline{E}$) and $\underline{k}$ are perpendicular.

Similarly we have that $\nabla \cdot \underline{B} = \begin{pmatrix} \frac{\partial}{\partial x} \\ \frac{\partial}{\partial y} \\ \frac{\partial}{\partial z} \end{pmatrix} \cdot \begin{pmatrix} B_{ox} \\ B_{oy} \\ B_{oz} \end{pmatrix} e^{j(\omega t - k_x x - k_y y - k_z z)}$

$$= [-B_{ox}k_x - B_{oy}k_y - B_{oz}k_z]e^{j(\omega t - \underline{k}\cdot\underline{r})}$$

Thus $\begin{pmatrix} B_{ox} \\ B_{oy} \\ B_{oz} \end{pmatrix} \cdot \begin{pmatrix} k_x \\ k_y \\ k_z \end{pmatrix} = 0$ which requires that $\underline{B}_o$ (and hence $\underline{B}$) and $\underline{k}$ are also perpendicular.