Problem 2.45)

a) $\boldsymbol{E}^{(\text{total})} = \boldsymbol{E}^{(\text{inc})} + \boldsymbol{E}^{(\text{ref})} = E_o\hat{\boldsymbol{x}}\,\{\cos[(\omega/c)z - \omega t] - \cos[(\omega/c)z + \omega t]\} = 2E_o\hat{\boldsymbol{x}}\sin(\omega z/c)\sin(\omega t).$

$\boldsymbol{H}^{(\text{total})} = \boldsymbol{H}^{(\text{inc})} + \boldsymbol{H}^{(\text{ref})} = (E_o/Z_o)\hat{\boldsymbol{y}}\,\{\cos[(\omega/c)z - \omega t] + \cos[(\omega/c)z + \omega t]\} = 2(E_o/Z_o)\hat{\boldsymbol{y}}\cos(\omega z/c)\cos(\omega t).$

b) The E-field vanishes where $\sin(\omega z/c) = 0$, that is, $z = 0, -\lambda/2, -\lambda, -3\lambda/2, \ldots$. Here $\lambda = 2\pi c/\omega$.
The H-field vanishes where $\cos(\omega z/c) = 0$, that is, $z = -\lambda/4, -3\lambda/4, -5\lambda/4, \ldots$.

c) Energy density of the E-field: $\tfrac{1}{2}\varepsilon_o|\boldsymbol{E}|^2 = 2\varepsilon_o E_o^2\sin^2(\omega z/c)\sin^2(\omega t).$
Energy density of the H-field: $\tfrac{1}{2}\mu_o|\boldsymbol{H}|^2 = 2\varepsilon_o E_o^2\cos^2(\omega z/c)\cos^2(\omega t).$

d) $\boldsymbol{S}(z,t) = \boldsymbol{E}^{(\text{total})} \times \boldsymbol{H}^{(\text{total})} = (E_o^2/Z_o)\,\hat{\boldsymbol{z}}\,\sin(2\omega z/c)\sin(2\omega t).$

The z-dependence of the Poynting vector, $\sin(2\omega z/c) = \sin(4\pi z/\lambda)$, reveals that $\boldsymbol{S}(z,t)$ is zero at all integer multiples of $\lambda/4$. Therefore, where either the E-field or the H-field of the standing wave has a node, no energy flows at all. The energy only flows along z in between these adjacent nodes, which are separated by intervals of $\Delta z = \lambda/4$. The time-dependence of the Poynting vector, $\sin(2\omega t)$, shows that energy flow along z changes direction at twice the optical frequency ω. There are periodic instants when the energy is entirely in the E-field, followed by instants when the energy is entirely in the H-field. In between, the energy moves either slightly to the right or slightly to the left along z, in order to maintain the E- and H-field energy profiles found in part (c).