

Problem 7.31 A wave traveling in a lossless, nonmagnetic medium has an electric field amplitude of 24.56 V/m and an average power density of 2.4 W/m². Determine the phase velocity of the wave.

Solution:

$$S_{\text{av}} = \frac{|E_0|^2}{2\eta}, \quad \eta = \frac{|E_0|^2}{2S_{\text{av}}},$$

or

$$\eta = \frac{(24.56)^2}{2 \times 2.4} = 125.67 \, \Omega.$$

But

$$\eta = \frac{\eta_0}{\sqrt{\epsilon_r}} = \frac{377}{\sqrt{\epsilon_r}}, \quad \epsilon_r = \left(\frac{377}{125.67} \right)^2 = 9.$$

Hence,

$$u_p = \frac{c}{\sqrt{\epsilon_r}} = \frac{3 \times 10^8}{3} = 1 \times 10^8 \, \text{m/s}.$$
