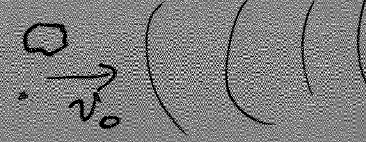
Ch.16 Prob. 67

$r = 2\,\mu m$

$m = 10\,\mu g = 10\times10^{-6}\,g = 10\times10^{-9}\,kg$



$v_0 = 30\,cm/s$

$v_f = 0\,cm/s$

$\Delta t = 1.0\,s$

Find the average electric field amplitude to stop the dust particle.

The area of the dust particle exposed to the wave is

$$A = \pi r^2 = \pi(2.0\times10^{-6}\,m)^2 = \underline{1.26\times10^{-11}\,m^2}$$

The average force on the particle is

$$\bar{F} = m\frac{\Delta v}{\Delta t} = (10\times10^{-9}\,kg)\left(\frac{0-0.30\,m/s}{1.0\,s}\right) = \underline{3.0\times10^{-9}\,N}$$

The average pressure on the particle is

$$p = \frac{F}{A} = \frac{3.0\times10^{-9}\,N}{1.26\times10^{-11}\,m^2} = \underline{238\,\frac{N}{m^2}}$$

Since the collision between the wave and particle is totally inelastic, then $p = \frac{I}{c}$

$\therefore$ The intensity of the wave is

$$I = c\cdot p = (3.0\times10^{8}\,m/s)\left(238\,\frac{N}{m^2}\right) = \underline{7.14\times10^{10}\,\frac{W}{m^2}}$$

Now from the Poynting vector

$$I = \bar{S} = \frac{EB}{2\mu_0} = \frac{E}{2\mu_0}\left(\frac{E}{c}\right) = \frac{E^2}{2\mu_0 c} \rightarrow E = \sqrt{2\mu_0 c I}$$

$$E = \sqrt{2(4\pi\times10^{-7}\,\frac{Tm}{A})(3.0\times10^{8}\,m/s)(7.14\times10^{10}\,\frac{W}{m^2})} = ~~7340\,\frac{V}{m}~~$$

$$= \boxed{7.34\times10^{6}\,\frac{V}{m}}$$