HW 8, #3

A simple model of electromagnetic wave propagation in a good conductor is obtained by assuming that $\varepsilon = \varepsilon_0$ and $\mu = \mu_0$, that the free current is given by $\vec{J}_f = \sigma \vec{E}$ (where σ is the conductivity), and that there is no free charge ρ_f.

a)   Show that the inclusion of the free current term into the electromagnetic wave equations leads to attenuation of a plane wave.

b)   Assume that $\sigma \gg \omega\varepsilon_0$, where ω is the frequency of the wave, and find the characteristic attenuation length (also called skin depth) of the wave in the conductor. Estimate this length for $\sigma = 10^7 \ (\Omega m)^{-1}$ and a wave of visible light.