Answer to EM Example Q20

Assume that $\left.\begin{matrix}\underline{E}\\ \underline{v}\end{matrix}\right\} = \left.\begin{matrix}\underline{E}_0\\ \underline{v}_0\end{matrix}\right\} e^{i(\omega t - \underline{k}\cdot\underline{r})}$

Insertion in given eqn. leads to

$$m.\,i\omega\underline{v} = -q\underline{E} - \frac{m\underline{v}}{\tau}$$

$$\underline{v} = \frac{-q\underline{E}}{m(i\omega + 1/\tau)}$$

But $\underline{J} = -Nq\underline{v} = \sigma\underline{E}$ and therefore

plasma conductivity $\sigma = \left[-Nq\right]\cdot\left[\frac{-q}{m(i\omega + 1/\tau)}\right]$

[required expression] $\underline{\sigma = \dfrac{Nq^2}{m(i\omega + 1/\tau)}}$

At low frequencies (constant σ) $\sigma \approx \dfrac{Nq^2\tau}{m}$

$$\Rightarrow \tau = \frac{m\sigma}{Nq^2}$$

$$= \frac{9.1\times10^{-31}\times 6\times10^{7}}{8.5\times10^{28}\times(1.6\times10^{-19})^2}$$

$$\underline{\tau = 2.5\times10^{-14}\,\mathrm{s}}$$

$|\sigma|$ reduced by Factor of 2 when $\omega^2 + \frac{1}{\tau^2} = 4/\tau^2$

$$\Rightarrow \omega = \frac{1}{\tau}\left(4 - 1\right)^{1/2} = 6.9\times10^{13}$$

$$\underline{\nu = 1.1\times10^{13}\,\mathrm{Hz}}$$