Solution

(a)

$$E(r,t) \;=\; \frac{2p\hat{r}}{r^3}(1-ikr)e^{ikr-i\omega t}$$

(b)

$$E(r,t) \;=\; \frac{2p\hat{r}}{r^3}\sqrt{1+k^2r^2}e^{ikr-i\arctan kr-i\omega t}$$

(c)

If $E(r,t)=e^{i\Phi(r,t)}$ the phase velocity is v_p such that $\Delta\Phi=0$ corresponds to $\Delta r=v_p\Delta t$ for small changes of r,t, and phase. For infinitesimal Δt

$$d\Phi(r,t) \;=\; \frac{\partial\Phi}{\partial r}dr+\frac{\partial\Phi}{\partial t}dt \;=\; 0 \quad\Rightarrow\quad v_p \;=\; \frac{dr}{dt}\Big|_{\Phi=\text{const}} \;=\; -\frac{\frac{\partial\Phi}{\partial t}}{\frac{\partial\Phi}{\partial r}}$$

In our case $\Phi(r,t) \;=\; kr-\arctan kr$ so

$$v_p \;=\; \frac{\omega}{k}\frac{1+k^2r^2}{k^2r^2}$$

As $r\to\infty$ $v_p\to\frac{\omega}{k}$