Q: 4,5

1. $f = 1\,MHz$

$P/A = 20\,W m^{-2}$

a) $\lambda = \frac{c}{f}$

$= \frac{3\times10^{8}}{10^{6}} = 300\ m$

b) $P_r = \frac{1}{2} \varepsilon_0 E_0^2$ E_0 = amplitude electric field

$|\vec{E}| = E_0 = \sqrt{\frac{2P_r}{\varepsilon_0}} = 2.12\times10^{6}\ W$

$P_r = \frac{1}{2}\varepsilon_0|\vec{E}|^2 = \frac{1}{2}\mu_0|\vec{H}|^2$

$\therefore |\vec{H}|^2 = E_0^2 \frac{\varepsilon_0}{\mu_0}$

$= 14.93\ W^2$

$|\vec{H}| = 3.86\,W$

2) $\langle E \text{ density} \rangle = 1\ mJ/m^3$

freq $= 1\,GHz$

energy density electromagnetic field $u = \frac{1}{2}\varepsilon_0 E^2 = 1 \therefore E = \sqrt{\frac{2}{\varepsilon_0}} = 4.75\times10^{5}\ J$

... electric: $\frac{1}{2}\mu_0|\vec{H}|^2$

$\frac{1}{2}\varepsilon_0|\vec{E}|^2 = \frac{1}{2}\mu_0|\vec{H}|^2$

$1\,mJ/m^3 = \frac{1}{2}\mu_0|\vec{H}|^2$: av energy electric field

$|\vec{H}| = 1.26\times10^{3}\ W$: amplitude mag field

Poynting vector : $\vec{N} = \vec{E}\times\vec{H}$

$\vec{E} = \hat{i}E_0 \cos(uz - \omega t)$

$\vec{H} = \hat{j}\left(\frac{u_z E_0}{\mu_0\omega_0}\right)\cos(uz - \omega t)$

$$\vec{N} = \hat{u}\sqrt{\frac{\varepsilon_0}{\mu_0}}\,E_0^2\cos^2(u_z z - \omega t)$$

$= \hat{u}c\langle U_{vpw}\rangle \therefore \langle N\rangle = c\langle U_{vpw}\rangle = \frac{1}{2}c\varepsilon_0 E_0^2$

$N = c$ $U_{vpw} = 1\,mJ/m^3$

3) J_D displacement current density: $10^{-5}\ Am^{-2}$

$f = 10^{8}\,Hz$

$Z_0 = \frac{|\vec{E}|}{|\vec{H}|} = \sqrt{\frac{\mu_0}{\varepsilon_0}}$

$$J_D = \varepsilon_0 \frac{dE}{dt}$$

$$\frac{dE}{dt} = 2\pi E_0 \cos(2\pi f t)$$

max val displacement: $J_{D_{max}} = \varepsilon_0 2\pi E_0$

$$E_0 = \frac{10^{-5}}{\varepsilon_0 2\pi \times 10^8} \simeq 5.65 \times 10^{-9} \ V/m$$

$$B_0 = \frac{E_0}{c} \simeq 1.88 \times 10^{-17} \ T$$

$$\vec{H} = \frac{1}{\mu_0} \vec{B} \quad \therefore \quad H_0 = \frac{1}{\mu_0} B_0 = 1.5 \times 10^{-11}$$

$$Z_0 = \frac{E_0}{H_0} = \frac{5.65 \times 10^{-9}}{1.5 \times 10^{-11}} = 3.77 \times 10^3$$ units?

$$\langle U_{UPW} \rangle = \frac{1}{2} \varepsilon_0 E_0^2$$

$$= 1.41$$ units?

$$U_{UPW_{max}} = \varepsilon_0 E_0$$ ~ unsure

$$= 2.82$$ units?

4) ? — what is intensity? equat's?

5) ?

how do U determine polarisat° state ?

b) $\vec{E} = \hat{i} E_0 \cos (kz - \omega t) - \hat{j} E_0 \cos (kz - \omega t)$

$\therefore \vec{E} = E_0 \cos (kz - \omega t) (i - j)$

linear ✓ $\vec{E} = \hat{i} E_0 \sin(kz - \omega t) - \hat{j} E_0 \sin(kz - \omega t) = E_0 \sin(kz - \omega t)(i - j)$

b) ~~linear~~ ?
sin → imag part ∴ circularly polarized

c) ~~circular~~ linear

d) elliptical ✓ $\vec{E} = \hat{i} E_0 \sin (kz - \omega t) + \hat{j} E_0 \sin (kz - \omega t - \pi/4)$

$= E_0 \sin (kz - \omega t) (\cos\theta\, i - \sin\theta\, j)$

i & j components ∴ ~~circular~~

phase diff $-\frac{\pi}{4}$ ∴ elliptical ✓

$\vec{E} = \hat{i}[E_0 \cos (kz - \omega t)] - \hat{j}[E_0 \cos(kz - \omega t + \frac{\pi}{2})]$

$\therefore E_0 \cos (kz - \omega t)(\cos\theta\, i - \sin\theta\, j)$

~~circular~~

$\frac{\pi}{2} = 90° \therefore$ linear