Problem 1:
The electric and magnetic fields representing a plane wave (propagating in vacuum) are specified as follows:

$$\vec{E} = \hat{\imath} E_0 \cos[kz - \omega t] \qquad \vec{B} = \hat{\jmath} B_0 \cos[kz - \omega t]$$

with $E_0 = 10^9 V/m$ and $\omega = 5 \times 10^{15} s^{-1}$.
A) Identify the wave vector $\vec{k}$ of this plane wave and express it, using the dispersion relation, in terms of ω

B) Use complex representation plus operator uquivalencies, and Ampere's law to show that $B_0 = E_0/c$

C) Calculate the instantaneous Poynting vector $\vec{S}$ at the origin of coordinate system, $x, y, z = 0$ for a general time t

D) Calculate the time-averaged Poynting vector $\langle \vec{S} \rangle$ and

E) What energy corresponds to a single photon in this plane wave?

E) Calculate the photon flux Φ (i.e. the number of photons crossing a given area per unit of time) over an area of $A = 100 \mu m^2$

Problem 2:
The electric and magnetic fields representing a plane wave (propagating in vacuum) are specified as follows:

$$\vec{E} = \hat{k} E_0 \sin[\frac{2\pi}{\lambda}\hat{n}.\vec{r} - \frac{2\pi c}{\lambda} t] \qquad \vec{B} = \frac{\hat{i} - \hat{j}}{\sqrt{2}} B_0 \sin[\frac{2\pi}{\lambda}\hat{n}.\vec{r} - \frac{2\pi c}{\lambda} t]$$

with $E_0 = 1V/m$ and $\lambda = 1\mu m$ and $\hat{n} = (1,1,0)/\sqrt{2}$
A) Explain the meaning of $\hat{n}$

B) Use complex representation and Faraday's law to show that $cB_0 = E_0$

C) Calculate the instantaneous Poynting vector $\vec{S}$ at the origin of coordinate system, $x, y, z = 0$ for a general time t

D) Calculate the time-averaged Poynting vector $\langle \vec{S} \rangle$ and

E) What energy corresponds to a single photon in this plane wave?

E) Calculate the photon flux Φ (i.e. the number of photons crossing an area per unit of time) over an area of $A = 1m^2$