Quantum Physics PHY4215 - Exercise Sheet 3

1. The power transmitted through an area A perpendicular to a plane wave is given by

$$P = \frac{1}{\mu_0 c} E_0^2 A \sin^2(kz - \omega t)$$

as described, for example, in Krane eq. 3.8. The time-averaged power (Krane eq. 3.10) is given by

$$\frac{P}{A} = \frac{1}{2\mu_0 c} E_0^2$$

First fix $z = 0$ and do the time averaging. Then explain the time averaging for general z. In both cases, consider an integration over one time period $T = \frac{2\pi}{\omega}$. **[10]**

Hint : In doing the time averaging, you will find it useful to note that $\cos 2\theta = 1 - 2\sin^2\theta$.

2. Find the momentum of

(a) a 10.0 MeV gamma ray.

(b) a 25-keV X ray.

(c) a 1.0- μm infra-red photon.

(d) a 150-Mhz radio-wave photon.

Express the momentum in kg m /s and eV/c.

[8]

3. Electrons are emitted when an ultraviolet light source of wavelength λ illuminates a certain metal curface. If you wanted to increase the number of electrons per unit time emitted from the surface, which one or more of the following measures would work ?

(a) increase the frequency of the light source.

(b) increase the wavelength of the light source.

(c) add a second light source identical to the first light source.

[6]

4. When photons of wavelength 477 nm are incident on a metal surface, electrons of maximum kinetic energy 1.41 eV are emitted from the surface. What is the minimum energy needed to remove an electron from this metal ?

[8]