Quantum Physics PHY4215 - Exercise Sheet 1.

1. The Taylor expansion formula (which you encountered in MT1) allows you to develop a series expansion for a function $f(x)$ near $x = x_0$, in terms of powers of $(x - x_0)$. For $x_0 = 0$, the expansion takes the form

$$\begin{aligned} f(x) &= f(0) + xf^{(1)}(0) + \frac{x^2}{2}f^{(2)}(0) + \frac{x^3}{6}f^{(3)}(0) + \cdots \\ &= \sum_{n=0}^{\infty} \frac{x^n f^{(n)}(0)}{n!} \end{aligned}$$

Here $f^{(n)}(0)$ is the n'th derivative of $f(x)$, evaluated at $x = 0$. Use this to derive the first four terms in the binomial expansion

$$(1+x)^a = 1 + ax + \frac{a(a-1)}{2}x^2 + \frac{a(a-1)(a-2)}{3!}x^3 + \cdots$$

[6]

Consider the relativistic equation for the energy of a particle of mass m and momentum p

$$E = \sqrt{p^2c^2 + m^2c^4}$$

and derive the expansion

$$E = mc^2 + \frac{p^2}{2m} - \frac{p^4}{8m^3c^2} + \cdots$$

[6]

2. (a) The visible spectrum ranges in wavelengths λ from 380nm to 750nm. Using the equation $c = f\lambda$, find out the range of frequencies f for visible light. The speed of light is $c = 3.0 \times 10^8$ m s^{-1}. **[4]**

(b) Photons of have energy hf, where the Planck's constant is $h = 6.6 \times 10^{-34}$Js. What is the range of energies of photons of visible light ? Give your answer in Joules (J). Convert your answer to electron-Volts (eV). One eV is 1.6×10^{-19}J. **[4+4]**

3. Find the power per unit area radiated from the sun's surface in the wavelength range 600.0 to 605.0 nm.

[6]