Physics 3P70

Homework assignment No. 1

Due September 26, 2018 (Wed)

Questions: **Marks**

1. Estimate the de Broglie wavelength of a pedestrian with a mass of 60 kg and a velocity of 1 m/s. Explain why we do not see the wave nature of macroscopic bodies. **(1)**

2. Find the frequency $\nu_m(T)$ for which the energy density $u(\nu, T)$ of the black-body radiation has its maximum. Assuming the Sun to be a "black body" with a surface temperature $T = 6000K$, estimate ν_m and the corresponding wavelength λ_m. **(2)**

3. At time $t = 0$ a particle is represented by the wave function

$$\Psi(x,0) = \begin{cases} Ax/a, \text{ if } 0 \le x \le a \\ A(2a-x)/a, \text{ if } a \le x \le 2a \\ 0, \text{ otherwise,} \end{cases}$$

   where A and a are positive constants.
   (a) Normalize Ψ. **(1)**
   (b) Find the probability of finding the particle to the right of a. **(1)**
   (c) What is the expectation value of x? **(1)**

4. Consider the wave function

$$\Psi(x,t) = Ae^{-\lambda|x|}e^{-i\omega t},$$

   where A, λ and ω are positive real constants.
   (a) Normalize Ψ. **(1)**
   (b) Determine the expectation value of x. **(1)**
   (c) Determine the standard deviation, σ_x, of x. **(1)**

5. A particle of mass m moves in the anharmonic potential $U(x) = u_2(x - x_0)^2 + u_4(x - x_0)^4$, where $u_2, u_4, x_0 > 0$. The state of the particle at $t = 0$ is given by

$$\Psi(x, 0) = Ae^{-ax^2/2},$$

where A and a are positive real constants.

(a) Normalize Ψ. **(1)**

(b) Calculate the expectation values of x and x^2. **(1)**

(c) Calculate the average kinetic energy. **(1)**

(d) What is the average force acting on the particle? **(2)**

Total mark = 14