

PHYSICS 454
1st HOMEWORK
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Hand in: Thursday 13^h October 2016

1. Show that if ψ_1 and ψ_2 are eigenfunctions of the operator A with a common eigenvalue a , then any linear combination of them $c_1\psi_1 + c_2\psi_2$ will be an eigenfunction of A with the same eigenvalue a . (3 marks)
2. A broadcasting transmitter radiates 1000 kW at frequency of 1.0 MHz.

A) What is the energy E in eV of each quantum (photon) radiated? (2 marks)
B) How many quanta N are emitted in each period of oscillation of the electromagnetic field? (3 marks)
3. You are given the function $\psi(x) = Nx \exp(-\lambda|x|)$ (with $\lambda > 0$)
 - i) Find N . (5 marks)
 - ii) Find the uncertainty in the position Δx . (10 marks)
 - iii) Find the uncertainty in the momentum Δp . (10 marks)
 - iv) Find the product $(\Delta x)(\Delta p)$. Show that it confirms Heisenberg uncertainty relation. (2 marks)

You are given:

$$\int x e^{ax} dx = \frac{(ax-1)e^{ax}}{a^2}, \quad \int x^2 e^{ax} dx = \frac{(a^2x^2 - 2ax + 2)e^{ax}}{a^3}$$

$$\int x^3 e^{ax} dx = \frac{(a^3x^3 - 3a^2x^2 + 6ax - 6)e^{ax}}{a^4},$$

$$\int x^4 e^{ax} dx = \frac{(a^4x^4 - 4a^3x^3 + 12a^2x^2 - 24ax + 24)e^{ax}}{a^5}.$$