1. Consider a particle with a mass of 5×10^{-16} kg. Its position is measured within 0.5×10^{-9} m. What is the uncertainty in the velocity?

$\Delta p \Delta x \geq \frac{\hbar}{2}$ $\quad p = mv$

$\Delta v \Delta u \geq \frac{\hbar}{2m}$ $\quad \hbar = \frac{h}{2\pi} \Rightarrow \Delta v \cdot \Delta u \geq \frac{h}{4\pi m}$

$$\Delta u = \frac{h}{4\pi m \Delta v} = \frac{6.626 \times 10^{-34}\ kg m^2/s}{4\pi \times 5 \times 10^{-16} kg \times 0.5 \times 10^{-9} m} = 2.11 \times 10^{-10}\ m/s$$

2. A Is the function Ae^{-ax} an eigenfunction of the operator d^2/dx^2? If yes, what is the eigenvalue?

Yes

$$\frac{d}{dx}(Ae^{-ax}) = Aae^{-ax}$$

$$\frac{d^2}{dx^2}(Ae^{-ax}) = \frac{d}{dx}(-Aae^{-ax}) = Aa^2e^{-ax}$$

eigenvalue $= a^2$

3. ~~Calculate~~ A lamp emits light at a wavelength of 600×10^{-9} m. How many photons does the lamp emit per second? What is the momentum of each photon. ($E = 50W$)

photons lamp emit per second

$\lambda \nu = c \quad \nu = \frac{c}{\lambda} = \frac{2.998 \times 10^8 m/s}{600 \times 10^{-9} m} = 4.997 \times 10^{14}\ s^{-1}$

$E = h\nu \quad N_{photon} = \frac{50\ J}{6.626 \times 10^{-34} \times 4.997 \times 10^{14}/s} = 1.51 \times 10^{24}/s$

momentum of each proton

$\lambda = \frac{h}{p}$

$p = \frac{6.626 \times 10^{-34} J \cdot s}{606 \times 10^{-9} m} = 1.10 \times 10^{-27}\ kg \cdot m/s$