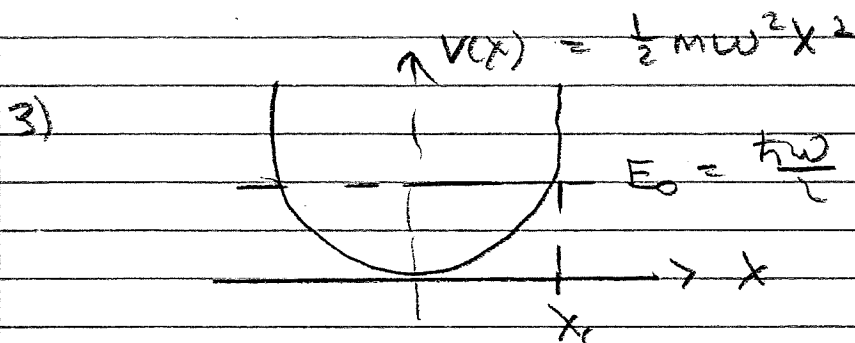


Recitation 7a - Solutions

Problems 1, 2 solutions given in recitation 7 solutions.



$$\frac{\hbar \omega}{2} = \frac{1}{2} m \omega^2 x_c^2 \quad ; \quad x_c^2 = \frac{\hbar}{m \omega} = \frac{\hbar^2 c^2}{2 m c^2 E_0}$$

$$x_c^2 = \frac{(200 \text{ eV} \cdot \text{nm})^2}{2(\frac{1}{2}) 10^6 \text{ eV} \cdot 1 \text{ eV}} = 4 \cdot 10^{-2} \text{ nm}^2$$

$$x_c = 0.2 \text{ nm}$$

$$4) \quad q = \frac{x_c p}{\hbar} \quad a = \frac{1}{\sqrt{2}} (y + i q)$$

$$a^\dagger = \frac{1}{\sqrt{2}} (y - i q)$$

$$\Rightarrow \quad q = \frac{1}{i\sqrt{2}} (a - a^\dagger) = \frac{i}{\sqrt{2}} (a^\dagger - a)$$

$$a^\dagger |n\rangle = \sqrt{n+1} |n+1\rangle, \quad a |n\rangle = \sqrt{n} |n-1\rangle$$

$$\text{and } \langle n | m \rangle = \delta_{nm}$$

$$\text{so } \langle p \rangle = \left\langle \frac{\hbar q}{x_c} \right\rangle = 0$$