

2)

$$\phi(p) = \langle p | \psi \rangle = \int dx \langle p | x \rangle \langle x | \psi \rangle =$$

$$= \int dx \psi_p^*(x) \psi(x) = \int_{-L/2}^{L/2} \frac{dx}{\sqrt{2\pi\hbar}} e^{-\frac{i}{\hbar} p x} \frac{1}{\sqrt{L}} =$$

$$= \frac{1}{\sqrt{2\pi\hbar L}} \frac{2\hbar}{p} \sin\left(\frac{pL}{2\hbar}\right)$$

$$|\phi(p)|^2 = \frac{2\hbar}{\pi L} \frac{\sin^2\left(\frac{pL}{2\hbar}\right)}{p^2}$$

$$\langle p \rangle = \int dp |\phi(p)|^2 p = 0$$

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