

# 5.73

## Quiz 21

$$[\mathbf{x}, \mathbf{p}] = i\hbar$$

$$\mathbf{H} = \mathbf{p}^2/2m + (1/2)k\mathbf{x}^2 \quad \text{Harmonic Oscillator}$$

$$\text{Force} = -\frac{dV(x)}{dx} \quad (\text{negative gradient of potential energy})$$

$$\left. \begin{aligned} F &= m \frac{d^2x}{dt^2} = \frac{dp}{dt} \\ p &= m \frac{dx}{dt} \end{aligned} \right\} \quad \text{Newton's laws}$$

$$\frac{d\langle \mathbf{A} \rangle}{dt} = \frac{i}{\hbar} \langle [\mathbf{H}, \mathbf{A}] \rangle + \left\langle \frac{\partial \mathbf{A}}{\partial t} \right\rangle \quad \text{Heisenberg's Equation of Motion}$$

- A. Evaluate  $[\mathbf{H}, \mathbf{p}]$
- B. Relate  $\frac{d}{dt}\langle \mathbf{p} \rangle$  to  $\langle \mathbf{x} \rangle$ .
- C. Evaluate  $[\mathbf{H}, \mathbf{x}]$ .
- D. Relate  $\frac{d}{dt}\langle \mathbf{x} \rangle$  to  $\langle \mathbf{p} \rangle$

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5.73 Quantum Mechanics I  
Fall 2018

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