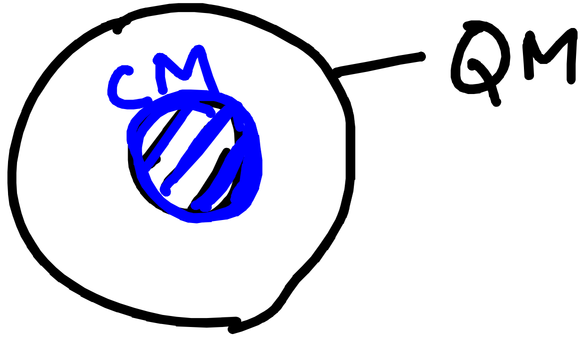
Gedanken Problems
or
Toy Problems



1. Free Particle (classical)

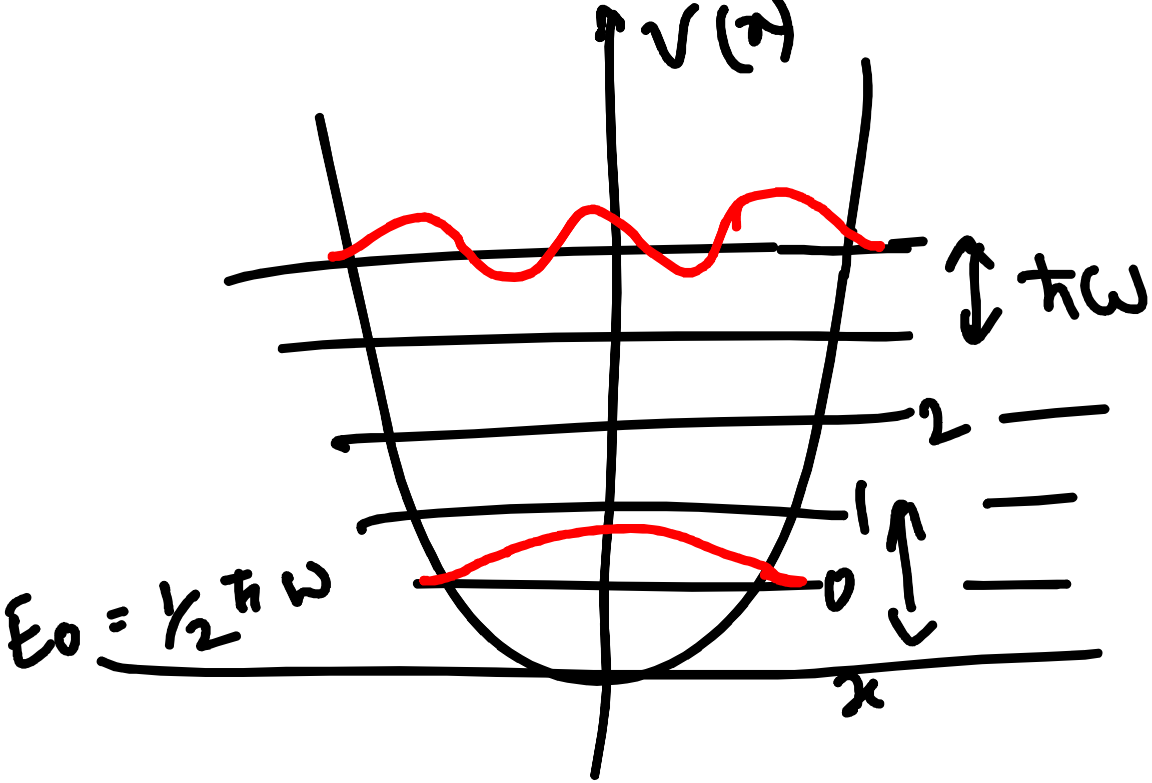
" " " within Bounds (1D, 2D, 3D) (Quantum)

2. SHO (Quantum Soln)

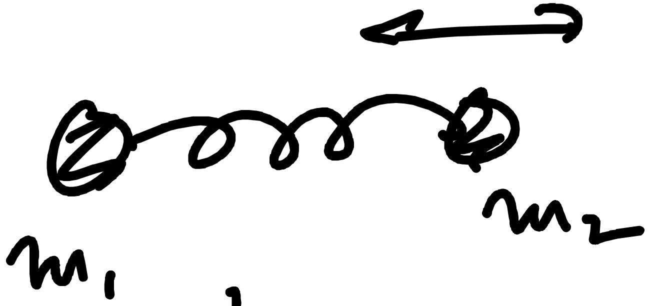
vs classical Spring

Quantum Nature

1. $E_0 \neq 0$
2. Tunnelling



Degeneracy



$$\frac{1}{\mu} = \frac{1}{m_1} + \frac{1}{m_2}$$

$$\Psi_n = c_1 \Phi_1 + c_2 \Phi_2 + \ldots$$

Orthonormal Sets

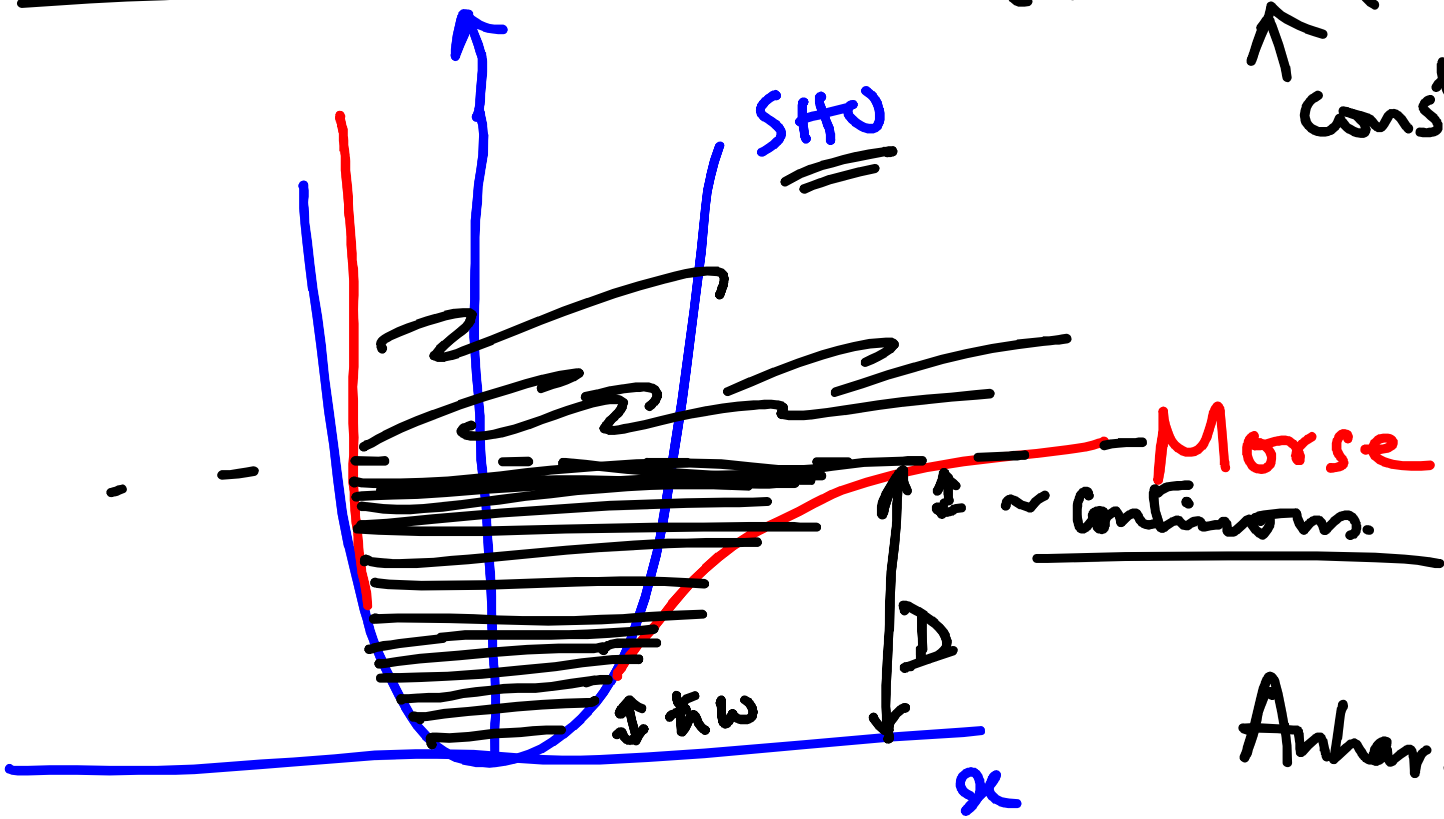
$$P(\Psi) = |c_1|^2 + |c_2|^2 + \ldots$$

$$E_n = \left(n + \frac{1}{2}\right)\hbar\omega$$

Morse Potential

$$V(x) = D\left(1 - e^{-\alpha x}\right)^2$$

const.



$$E_n = \left(n + \frac{1}{2}\right)\hbar\omega - \tilde{x}\left(n + \frac{1}{2}\right)^2$$

Anharmonicity factor

ΔE

is not enough

$\psi \rightarrow |\psi|^2$

$N_n H_n(\alpha x)\exp(-\alpha x^2)$

even

const.

n

n - odd - odd H_n

n - even - even H_n

Nature of wavef.^{n}

Spectroscopists

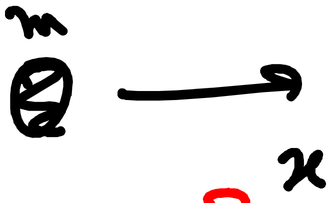
$\frac{E}{hc}$ → Unit L^{-1}

Quantum nature

overlaps of wave f.^{n}s

$\boxed{\text{Rigid Rotor}}$

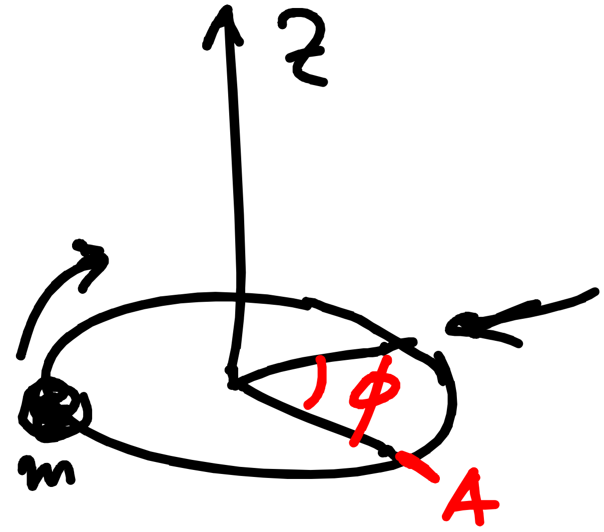
Translation



$$\hat{p}_x = -i\hbar \frac{d}{dx}$$

$$KE = \frac{1}{2} p_x^2$$

$$\boxed{\Delta x \cdot \Delta p_x}$$



Angular momentum

L^2 $\hat{L}_z$

$$KE = \frac{L_z}{2I} = \frac{1}{2} I\omega^2$$

$$\boxed{\Delta\phi \cdot \Delta L_z}$$

Dimension of Angular momentum is same as "$\hbar$".

$$\hat{L}_z \longrightarrow -i\hbar \frac{d}{d\phi}$$

$m \longrightarrow$ "I"

Rigid

Const. "R"

$I = mR^2$

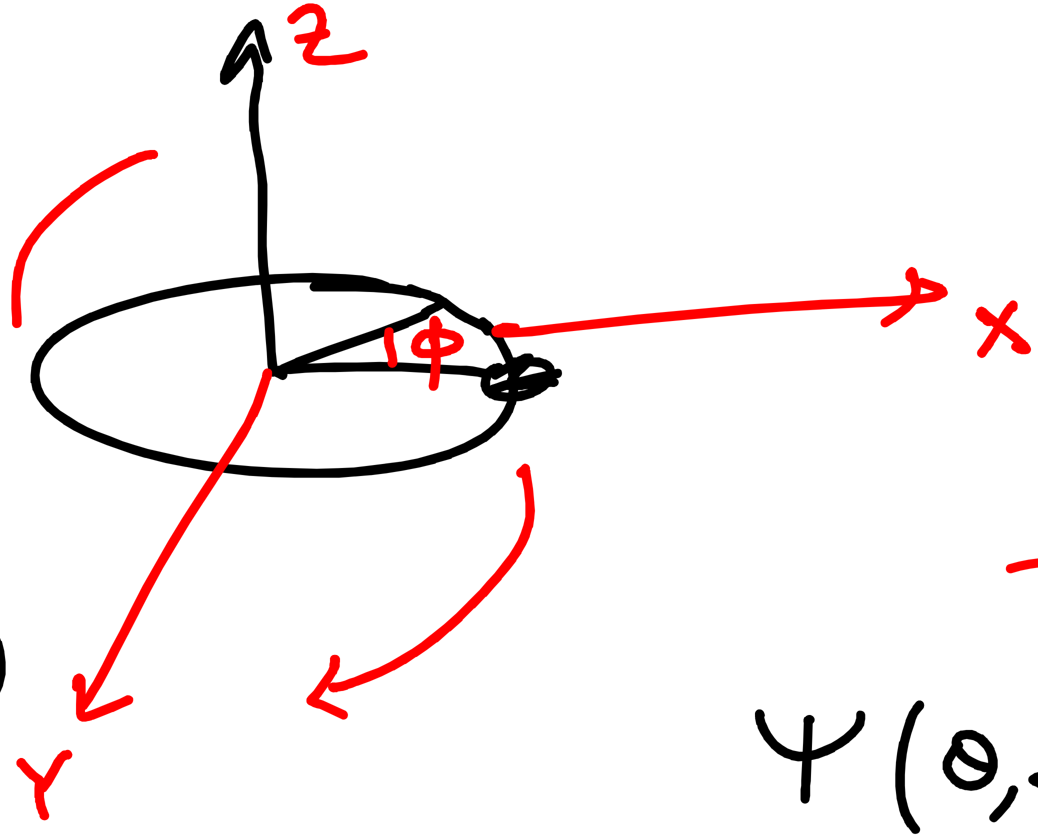
$$\hat{H} = \frac{1}{2I} \hat{L}_z \cdot \hat{L}_z = -\frac{\hbar^2}{2I} \frac{d^2}{d\phi^2}$$

quantum state $\{ \Psi(\phi)$

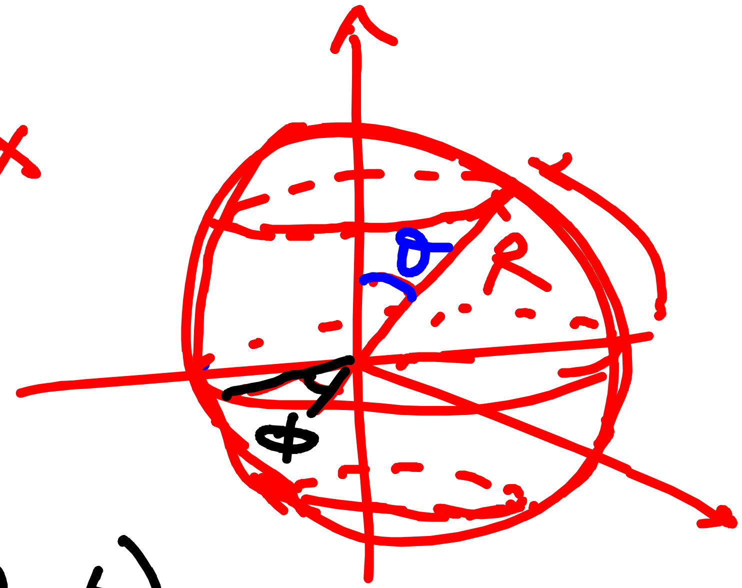
$$\hat{H}\Psi(\phi) = E\Psi(\phi)$$

1D Rigid rotor → particle in a ring

3D → " " " sphere



$\psi(\phi)$



$\Psi(\theta, \phi)$