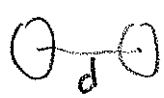
(2.)

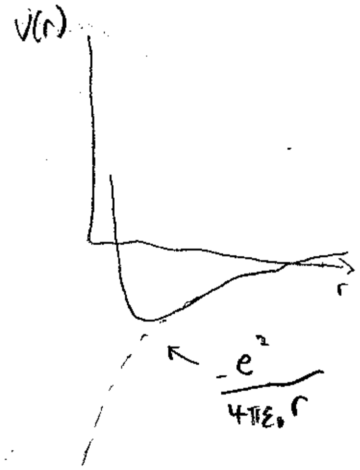
For mass on a spring with $T = 1\,s$,

$$\omega = 2\pi f = \frac{2\pi}{T} = 2\pi \quad s^{-1} \qquad E = \left(n+\tfrac{1}{2}\right)\hbar\omega$$

make some estimates for diatomic Hydrogen



$d \sim 1\,nm$



Assume $-K \doteq \frac{dF}{dx}$ is approximately that of Coulomb attraction from $H^+$ and $H^-$.

(crude assuption)

$$F = -\frac{e^2}{4\pi\varepsilon_0 r^2}$$

$$\frac{dF}{dr} = \frac{3e^2}{4\pi\varepsilon_0 r^3}$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$\omega = \sqrt{\frac{3e^2}{4\pi\varepsilon_0 r^3 m}} \sim \frac{e}{\sqrt{\varepsilon_0 r^3 m}} \sim \frac{(10^{-19}C)}{\left(10^{-11}F/m\,(10^{-9}m)^3\,10^{-27}kg\right)^{\frac{1}{2}}}$$

$$\omega \sim \frac{10^{-38}}{(10^{-65})^{1/2}} = 10^{14}\ s^{-1}$$

so mass on spring has more closely spaced Energy levels.

Physics 267 Problem # 15 Solutions

(1.) $\psi_0(x) = A e^{-\alpha x^2}$

$$U(x) = \frac{1}{2} k' x^2$$

$$-\frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial x^2} + \frac{1}{2} k' x^2 \psi = E \psi$$

$$\frac{\partial \psi}{\partial x} = -2x\alpha A e^{-\alpha x^2} = -2x\alpha \psi$$

$$\frac{\partial^2 \psi}{\partial x^2} = -2\alpha \psi + 4x^2\alpha^2 \psi$$

$$-\frac{\hbar^2}{2m}\left(-2\alpha + 4x^2\alpha^2\right) + \frac{1}{2} k' x^2 = E$$

E must be independent of x. Therefore terms with x dependence must sum to zero.

$$\left(\frac{-\hbar^2}{2m}\left(4\alpha^2\right) + \frac{1}{2} k'\right) x^2 = 0$$

$$\frac{2\hbar^2\alpha^2}{m} = \frac{1}{2} k'$$

$$\alpha = \sqrt{\frac{k' m}{4\hbar^2}}$$

$$E = \frac{\hbar^2 \alpha}{m} = \frac{\hbar}{2}\sqrt{\frac{k'}{m}} = \frac{\hbar w}{2}$$