1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom: $$\frac{d^2y}{dx^2}=A(r)u(r),A(r) = \frac{2m}{\hbar^2}[V(r)-E]$$where, $V(r)=-\frac{e^2}{r}$ Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunction. Remember that the ground state energy of the hydrogen atom is $\approx -13.6 eV$. Take $e =3.795(eV\AA)^{1/2}, \hbar c=1973(eV\AA)$ and $m=0.511\times10^6 eV/c^2 $

2. Solve the s-wave radial Schrodinger equation for an atom: $$\frac{d^2y}{dx^2}=A(r)u(r),A(r) = \frac{2m}{\hbar^2}[V(r)-E]$$ where m is the reduced mass of the system(which can be chosen to be the mass of an electron), for the screened coulomb potential $$V(r) = -\frac{e^2}{r} e^-{r/a}$$ Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e=3.795 (eV\AA)^{1/2}, m=0.511\times10^6 eV/c^2$, and $a = 3\AA,5 \AA, 7 \AA$. In these units $ \hbar c=1973(eV\AA)$. The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for an atom: $$\frac{d^2y}{dx^2}=A(r)u(r),A(r) = \frac{2m}{\hbar^2}[V(r)-E]$$

For the anharmonic oscillator potential $$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940 MeV/c^2,k=100MeVfm^{-2},b=0,10,30 MeVfm^{-3}$ in these units, $c\hbar = 197.3 MeVfm$. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule: $$\frac{d^2y}{dx^2}=A(r)u(r),A(r) = \frac{2\mu}{\hbar^2}[V(r)-E]$$

Where μ is the reduced mass of the two-atom system for Morse potential $$V(r) = D(r^{-2\alpha r\prime}-r^{\alpha r\prime}), r\prime = \frac{r-r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take: $m=940\times 10^6 eV/c^2, D = 0.755501 eV , \alpha =1.44, r_0 = 0.131349 \AA$