Answer Script Upload Link: https://forms.gle/9LhfytbWyG6Rbjto8

ASUTOSH COLLEGE

(Affiliated to University of Calcutta)

Semester 5- Examination

Physics-Hons

Paper- CC11

Practical Examination

Full Marks-30

Time- 2Hrs

Answer any ***one*** question

1. A particle of mass 'm' bound within the one-dimensional square well of width 'a', such that potential can be stated as

$V(x)= V_0$, for $x < a/2$

$V(x)=0$, for $-a/2 < x < a/2$

$V(x)=V_0$, for $x > a/2$

where V_0 = 15 eV, a= 5 **Å**

(a) Write a python program for determining eigenvalues of the bound state particle in a one-dimensional potential well by solving the following transcendental equation

$\sqrt{(u_0^2 - v^2)} = v\tan(v)$ for even ordered states

$\sqrt{(u_0^2 - v^2)} = -v\cot(v)$ for odd ordered states

where, $u_0 = \frac{2\pi^2 m a^2 V_0}{h^2}$ $u = \frac{a\sqrt{2\pi^2 m(V_0 - E_n)}}{h}$ $v = \frac{a\sqrt{(2\pi^2 m E_n)}}{h}$

'h' is planks constant and 'E_n' is the energy eigenvalues to be determined.

(Student may express the result in terms of 'Hartree atomic units' or 'eV')

(b) Write a python program for determining the eigenfunctions using appropriate boundary conditions and plotting normalized eigenfunctions.

[15+8+(2+5)]

2. A particle of mass 'm' bound within the one-dimensional harmonic oscillator potential, such that potential can be stated as

$$V(x) = \frac{1}{2} m\omega^2 x^2$$

Using dimensionless forms of energy $e = \frac{8\pi E}{h\omega}$ and length $\bar{x} = \sqrt{\frac{2\pi m\omega}{h}}$x we get the Schrodinger's equation in following form

$$\frac{d^2\psi(\bar{x})}{dx^2} = -[e - \bar{x}^2]\psi(x)$$

'h' is planks constant, 'ω' is angular frequency, and 'e' is the energy eigenvalues to be determined.

(a) Write a python program that uses the shooting method to determine the lowest five energy eigenvalues of one-dimensional quantum Harmonic oscillator.
(Student may express the result in terms of 'Hartree atomic units' or 'eV')

(b) Write a python program for determining the eigenfunctions integrating given form of Schrodinger's equation using Runge Kutta 4th order method using appropriate boundary conditions and plotting normalized eigenfunctions.

[15+8+(2+5)]

3. The 's' wave radial equation for an electron of mass 'm_e', charge 'e' bound within the central potential (hydrogen atom) of following form

$$V(r) = \frac{-e^2}{4\pi\epsilon_0 r}$$

is of the following form :

$$\frac{d^2u}{dx^2} + E'u + \frac{2u}{x} = 0$$

using dimensionless forms of energy $E' = \frac{E}{\frac{e^4 m_e}{8\epsilon_0^2 h^2}}$ and length $x = \frac{r}{\frac{\epsilon_0 h^2}{\pi e^2 m_e}}$

where 'h' is planks constant, 'ϵ_0' is dielectric permittivity of vacuum.

(a) Write a python program that uses Numerov algorithm to solve for the ground and first excited state energy eigenvalues of the hydrogen atom.
(Student may express the result in terms of 'Hartree atomic units' or 'eV')

(b) Write a python program for determining the eigenfunctions integrating given form of Schrodinger's equation using appropriate boundary conditions and plotting eigenfunctions.

[15+8+7]