Instructor DR. D. Atta.

Assignment # 01. / PHS-201A.

(Perturbation Theory)

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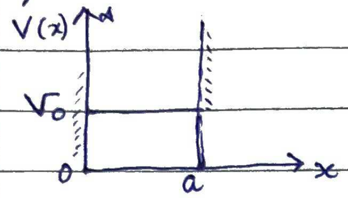
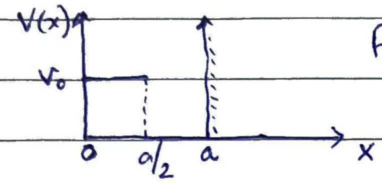
1) We all know the wave function for infinite square well potential is $\psi_n^0(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)$. The perturbation is shown in figure.



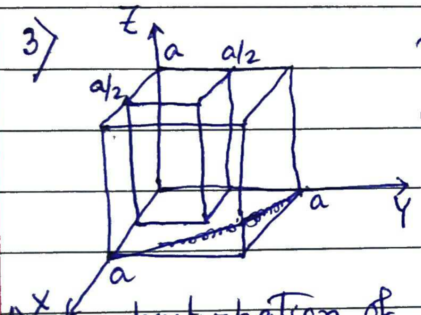
Find the first order correction to energy.



For this case calculate the first order correction to energy.

2) Let there is a bump in a infinite square well potential $H' = A\delta(x - \frac{a}{2})$ where A is constant. Find out the first order correction to energy and wave function.

3)



The perturbation in a 3-dimensional infinite square well is $H' = \begin{cases} V_0, & \text{for } 0 < x < a/2 \text{ and } 0 < y < a/2 \\ 0, & \text{otherwise} \end{cases}$

Calculate the correction of energy and eigenfunction.

~~4) The perturbation of 3-D harmonic oscillator is $H' = \lambda x^2 y z$, λ = constant.~~
~~Calculate correction to ground state and 1st excited state of energy.~~

5) Consider a quantum system with three linearly independent states. Let the Hamiltonian is

$$H = V_0 \begin{pmatrix} 1-\epsilon & 0 & 0 \\ 0 & 1 & \epsilon \\ 0 & \epsilon & 2 \end{pmatrix}$$

where V_0 = constant and ϵ = small number.

(i) Write down the eigenvalue ~~of~~ and eigenvector of unperturb Hamiltonian.

(ii) Solve the exact eigenvalues of H. Expand each of them as power series of ϵ, upto second order.

(iii) Use first and second order nondegenerate perturbation theory to find out the ~~&~~ eigenvalues for the state that grows out of nondegenerate eigenvalue of H^0.

(iv) Use degenerate perturbation theory to find the first order correction to the two initially degenerate eigenvalues and compare the results.

6) Calculate some useful expectation value

$$\left\langle \frac{1}{r} \right\rangle = \frac{1}{n^2 a_0} \; ; \; \left\langle \frac{1}{r^2} \right\rangle = \frac{1}{(l+\frac{1}{2}) n^3 a^2} \; ; \; \left\langle \frac{1}{r^3} \right\rangle = \frac{1}{l(l+\frac{1}{2})(l+1) n^3 a^3}$$

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