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**MATRIC NUMBER: 16/SCI15/001**

**DEPARTMENT: MATHEMATICAL AND PHYSICAL SCIENCES**

**PROGRAMME: PHYSICS WITH ELECTRONICS**

**SOLUTION TO THE ONLINE ASSIGNMENT QUESTIONS OF THE COURSE:**

**PHY 402: QUANTUM MECHANICS II**

**DEADLINE: MONDAY, 11TH MAY, 2020.**

**COURSE LECTURER: DR. BADMUS**

1. For time-independent perturbation theory, show that the perturbed energy is the expectation value of the perturbed Hamiltonian in the unperturbed state.

Solution:

Suppose we have a Hamiltonian that’s only slightly different from one for which we know the exact solution.

Ĥ = Ĥ0 + Ĥ1

Where:

Ĥ = Full Hamiltonian

Ĥ0 = Hamiltonian we can solve

Ĥ1 = Small perturbation

Let us assume the perturbed energy levels and the new quantum states can be treated as superpositions of terms in a kind of series solution to the full problem i.e.

=

And

From

........................................(\*)

This implies that by expanding Equation (\*), we have:

Multiplying out terms, we have:

* Zeroth order terms (0th) as:
* First order terms (1st) as:
* Second order terms (2nd) as:

In order to get the 1st order perturbation of the energy En:

We multiply through the first order terms by

As Hamiltonians can only operate on a function of the same order, we simplify while factorizing out energy as a constant.

However, from Normalization, we see that;

Therefore,

This implies that the perturbed energy is the expectation value of the perturbed Hamiltonian in the unperturbed state.

1. Find the first-order correction to the energy of a particle in an infinite square well if the ‘’floor’’ of the well is raised by a constant value V0

Solution:

V(x)

V0

0

a

Figure : Hypothetical sketch of the infinite square well

=

Let the unperturbed wave function be:

Let the perturbation Hamiltonian be H1 = V0

The first-order energy correction will be:

But =

Therefore, we have;

Recall that from trigonometric identities, we have:

Therefore, that gives us:

Substituting, we then have:

Substituting in the limits, we have;

Note that as tends to 0;

We have,

* This implies that the corrected energy level is