

Aims and Objectives Quantum Physics I, Session 5

BOUNDARY CONDITIONS AND THE INFINITE SQUARE-WELL POTENTIAL.

Aims (What I intend to do)

- 1) To specify and examine the boundary conditions the wavefunction must meet.
- 2) To look at the wavefunctions of an infinite square-well potential and explore how the boundary conditions dictate both energy quantisation and the zero point energy.
- 3) To find the eigenfunctions and eigenvalues associated with an infinite square-well potential .

Objectives (What you should be able to do after completing the lecture and worksheet)

- 1) To be able to state the boundary conditions a wavefunction must satisfy, and be able to recognize wavefunctions that do not meet these criteria.
- 2) To be able to derive the eigenfunctions for an infinite square-well potential.
- 3) To be able to normalise the eigenfunctions of an infinite square-well potential.
- 4) To be able to find the eigenvalues and explain why the lowest allowed energy state is not zero.

Quantum Physics 1 PHY2002 Worksheet 5

Task 1. Go over your lecture notes and read Young and Freedman, section 40.1 (12th ed) and/or Rae sections 2.3 & 2.4 (5th ed). Note that these two books take different (but equivalent) general solutions for the wavefunction. Young and Freedman use,

$$\psi(x) = A_1 e^{ikx} + A_2 e^{-ikx},$$

whilst Rae uses,

$$\phi(x) = \alpha \sin(kx) + \beta \cos(kx).$$

As often happens in physics, notation may vary from person-to-person, but the physics must remain the same. By comparing the end result in these two books you will see that the predictions that we make are the same for both approaches.

Task 2. Use the uncertainty principle to find the minimum energy you would expect a particle confined to a region of dimension L . How does your result compare with the lowest energy value for the infinite square-well potential we looked at?

Task 3. A coffee bean is confined to reside in a jar. Assuming you can model this as an infinite square-well potential, find the difference in energy between the allowed energy levels and comment on your result.

Task 4. Prepare for the next session (6) by reading about the finite potential well, Rae section 2.5 (5th ed), and Young and Freedman section 40.2 (12th ed).