Topic-Level learning goals for *Electrons as Waves; Probability Waves*

UBC PHYS 250, *Introduction to Modern Physics*, Summer 2009
(updated July 30, 2009)

3. Electrons as waves and particles

b. electrons as waves

- Explain the interpretation and significance of the pattern observed when a beam of electrons is sent through two very closely spaced slits and detected on a screen behind them.
- Explain what was observed in the Davisson-Germer experiment and how these observations support the interpretation of electrons as waves.

4. Electrons as probability waves.

- Given a particle description of an electron or photon, relate that to an equivalent wave description, and vice-versa.
- Calculate the Broglie wavelength of a particle given the momentum, and vice-versa. Make quantitative predictions for what will be detected on screen behind two closely spaced slits when particles of known mass and energy are shot at the slits.
- Describe the double-slit experiment for light and electrons and explain why the interference pattern is different depending on whether or not a measurement is made as to which slit the photon/electron passes through
- Analyze the implications of the results of the double slit experiment in terms of the description of the position of an initial electron
- Explain what is meant by the eigenstates of an electron, in terms of the energy, position and momentum, when the electron is both free and when it is confined in some potential energy well.
- Write down the mathematical description of the wave functions for momentum eigenstates and highly localized positions of free electrons.
- Explain how a wave function can be used to describe a general complex superposition of all position eigenstates
- Calculate the probability for finding a particle in a given region of space from its wave function.
- Qualitatively relate the shape of the wave function to the relative probability of finding the particle at different positions in space, and in different momentum ranges.
- Qualitatively relate the shape of the wave function to the kinetic energy of a particle at different locations in space
- Argue why it is plausible that one can describe any function as a suitable superposition of sinusoidal functions
- Argue how the description of a particle in terms of a wave function implies the Heisenberg uncertainty principle, and be able to use this principle to calculate the minimum possible uncertainty in measurements of position and momentum of particles.