Modern Physics
Problem Set 11

JC-49) **Semiconductor Device**
In a particular semiconductor device an oxide layer forms a barrier 0.60 nm wide and 9.0 eV high between two conducting wires. Electrons with energy 4.0 eV approach the barrier.

a) (10 points) What fraction of the incident electrons will tunnel through the barrier?
b) (10 points) What energy (in eV) would the electrons need to increase the tunneling fraction by a factor
of 2? (Hint: Solving equation 6 -16 is difficult. Try to see if you can deduce the answer.)

JC-50) **Steps and Barriers**

a) (10 points) Write down the wave functions for the three regions of the potential barrier (Figure 6.6 in your textbook) for the situation that $E < U_0$. Be sure to draw a figure and label the regions. Use the boundary conditions at $x = 0$ and $x = L$ to find four relationships among the 6 coefficients. Do not try to solve the relationships.
b) (10 points) Suppose the particles are incident on the barrier from the left. Which coefficient(s) should be set to zero? Be sure to justify your answer.

JC-51) **Tunneling of Protons and Electrons**
(10 points) Given the same particle energy and barrier height and width, which would tunnel more readily: a proton or an electron? Is this consistent with the usual rule of thumb governing whether classical or nonclassical behavior should prevail?

JC-52) **1D Atom**
This problem asks you to fill in a few of the steps from the derivation in lecture.

a) (10 points) By substituting the wave function $\psi(x) = Axe^{-bx}$ into the Schoedinger equation for a 1-D atom, show that a solution can be obtained for $b = 1/a_0$.
b) (10 points) Derive the expression for the ground state energy.

JC-53) **Angular Momentum in the Hydrogen Atom**
An electron is in an angular momentum state with $l = 3$.

a) (10 points) What is the length of the electron's angular momentum vector?
b) (10 points) How many different possible z components can the angular momentum vector have?
c) (10 points) What are the values of the angle that the L vector makes with the z-axis? Make a table of your answers. Express your answer in degrees.

Talk 1) **Second Draft of Slides**
(10 points) Turn in a second draft of your slides in pdf format. Email your pdf to cooley@physics.smu.edu before start of class on due date.