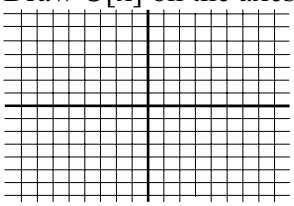
Appendix D: Questions to Probe the Student Understandings on Classical Pre-requisites of Quantum Mechanics

Interview question

The potential energy U[x] is defined so that it has four values in five regions of the x axis:

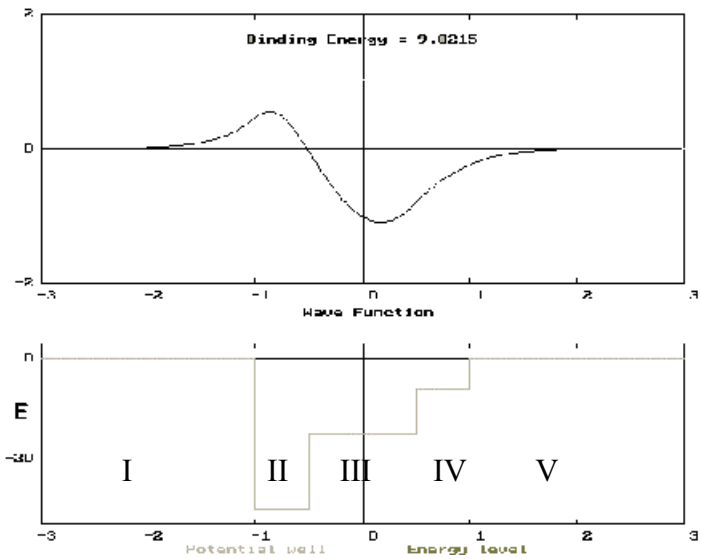
Region I:	$x < -1$	$U[x] = 0$	eV
Region II:	$-1 < x < 0$	$U[x] = -7.5$	eV
Region III:	$0 < x < +0.5$	$U[x] = -15$	eV
Region IV:	$+0.5 < x < +1$	$U[x] = -30$	eV
Region V:	$1 < x$	$U[x] = 0$	eV

Draw U[x] on the axes below:



Exam question, Spring 96

In the figure below is shown a plot of a one-dimensional potential energy function U[x] (lower plot) and the wavefunction (upper plot) of an eigenstate for an electron in the influence of that potential. The energy, E, associated with that state is also shown on the energy plot. Distances are measured in nanometers and energies in eV.



The potential energy U[x] is defined so that it has four values in five regions of the x axis:

Region I: x < -1 U[x] = 0
Region II: -1 < x < -0.5 U[x] = -30
Region III: -0.5 < x < +0.5 U[x] = -15
Region IV: +0.5 < x < +1 U[x] = -6
Region V: 1 < x U[x] = 0

1.1 If the particle were moving classically (i.e., its motion were described by Newton's laws) in the potential U[x], and it had an energy E, which of the following statements would be true? List all that apply.

(a) It would move the fastest when it was in region II.
(b) It would move the fastest when it was in region III.
(c) If we took a photograph of the particle at a random time, we would never find it in region IV.
(d) If we took a photograph of the particle at a random time, we would be most likely to find it in region II.
(e) If we took a photograph of the particle at a random time, we would be most likely to find it in region III.

1.2 If the particle were moving quantum mechanically (i.e., its motion were described by the Schrödinger equation) in the potential U[x], and it had an energy E, which of the following statements would be true? List all that apply.

(a) If we measured the position of the particle at a random time, we would never find it in region I.
(b) If we measured the position of the particle at a random time, we would never find it in region IV.
(c) If we measured the position of the particle at a random time, we would most likely find it in region II.
(d) If we measured the position of the particle at a random time, we would most likely find it in region III.
(e) The state shown represents the lowest energy state that can be found in this well.

Conceptual Quiz for the Probability

1. Consider the following coin tossing experiments:

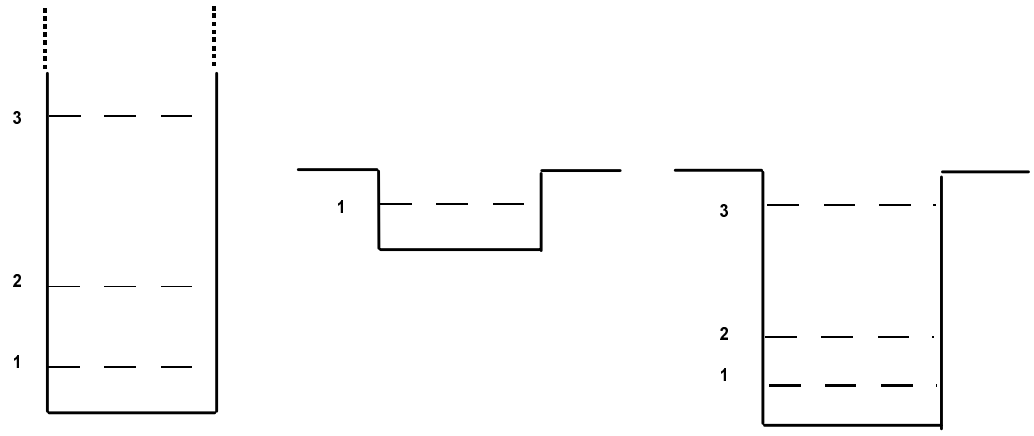
- Suppose you tossed a coin three times and get three heads in a row. Is the probability of getting a head on the next toss greater than, less than, or equal to 50%? Explain your reasoning.
- If you toss a coin one hundred times, what do you expect to happen? If you toss it another one hundred times, do you expect to get the same number of heads and tails? Explain your reasoning.

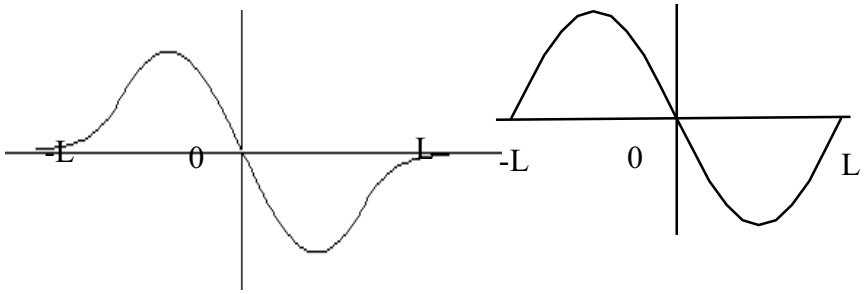
2. Suppose the student average SAT score at Enormous State University is 1000. Your friend is in a writing class of 10 students. Her score was 1100. What is the most probable average of the other 9 students? Explain your reasoning.

Conceptual Quiz for the Potential Well

a. The wave functions shown are associated with two of the energy levels. Which ones do you think they are associated with? Explain your reasoning.

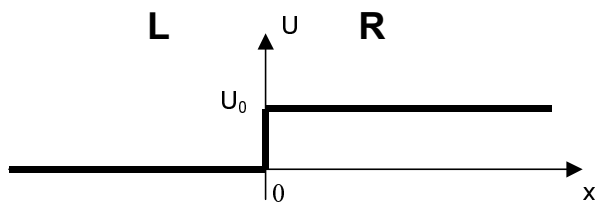
b. For these two states, approximately where in the well would the electron most likely be found? Explain your reasoning.





Physics 420 final exam questions, Spring 99

1. (30 points) Put your answer to each problem in the box at the right of the question. Give as many answers as you think are correct. If none are correct, write N. All of the questions refer to the following situation. A beam of electrons of energy E is incident in the physical system possessing the potential shown at the right. (**left or L means x < 0, right or R means x > 0.**)



A. The beam is incident from the L and $E > U_0$. Which of the following is true?
(a) all the electrons are transmitted to the right
(b) only a part of the electron beam reflects back to the left
(c) all of the electrons reflect back to the left
(d) the total energy of the electrons is less on the R than on the L

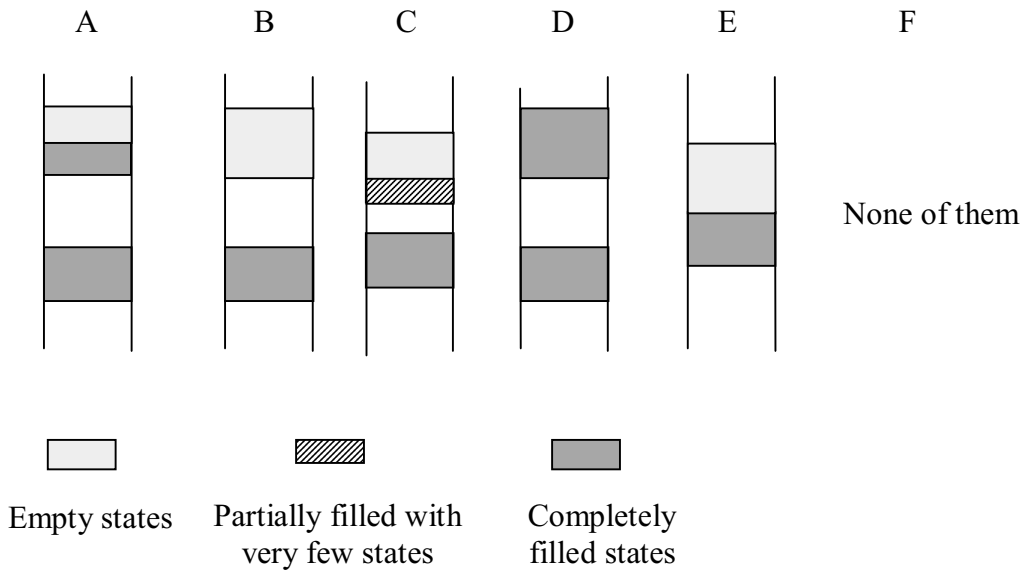
B. The beam is incident from the L and $E < U_0$. Which of the following is true?
(a) all the electrons are transmitted to the right
(b) some electrons reflect back to the left
(c) all of the electrons reflect back to the left
(d) no electrons will ever be found in the region x>0.

C. The beam is incident from the L and $E > U_0$. Which of the following is true?
(a) the wavelength of the electrons on the L is greater than those on the R
(b) the wavelength of the electrons on the L is equal to those on the R
(c) the wavelength of the electrons on the L is less than those on the R
(d) no electrons will ever be found on the R

D. The beam is incident from the R with $E > U_0$. Which of the following is true?
(a) all the electrons are transmitted to the left
(b) a part of the electron beam reflects back to the right
(c) the kinetic energy of the electrons on the L is greater than on the R
(d) the amplitude of the electron's wave function is greater on the L

E. The beam is incident from the left and $E > U_0$. Which of the following is true?
(a) the momentum of the electrons on the L is the same as those on the R
(b) the momentum of the electrons on the L is greater than those on the R
(c) the momentum of the electrons on the L is less than those on the R
(d) the kinetic energy of the electrons on the L is greater than those on the R

2. (20 points) Consider the following band diagrams. For the different materials, select one of the diagrams that can best represent the band structure of the corresponding material.



(If you choose "F", please sketch your own diagram and explain your reasoning)

i. Conductor

ii. Insulator

iii. Semiconductor

iv. Resistor