

PHY 360 – FALL 2003
INTRODUCTION TO MODERN PHYSICS

MIDTERM III

December 2, 2003

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Name: _____

Signature: _____

I.D. #: _____

Instructions:

- Use only the front side of the sheets for the exam.
- Use the back side for intermediate calculations and everything that you don't want the instructor to grade.
- If you need more sheets of paper ask them to the instructor, don't use your own.
- If you cannot solve a part of a problem and you need that result for the rest of the problem, solve the remaining of the problem using symbols instead of numerical values.

Part I**Part 1:**

- a) Use Schrödinger equation to **derive** the time dependent wavefunction of an electron moving with energy E toward the positive x -axis in a constant potential energy $U(x)=U$ for $-\infty < x < \infty$.
- b) Is that an eigenfunction of the operator momentum? Explain.
- c) What is the DeBroglie wavelength of the electron in terms of the total energy E and the potential U ?

Solution:

Part II

A particle is described by the wavefunction:

$$\psi(x) = \begin{cases} C \cdot (4x - x^2) & 0 \leq x \leq 4 \\ 0 & \text{elsewhere} \end{cases}$$

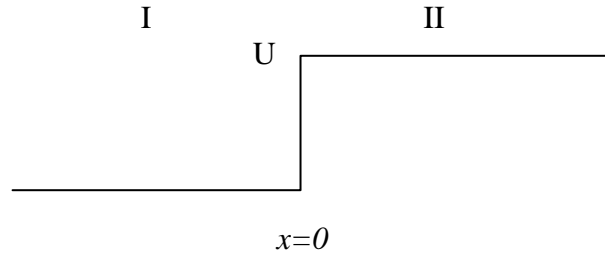
where x is in nm and C is a constant.

- a) What is the value of C that normalizes the probability associated with the wavefunction?
- b) Calculate the expectation and uncertainty for the particle momentum.

Solution:

Part III

An electron with energy $E < U$ is incident (from left to right) on the step barrier shown in the figure. [$U(x)=0$ for $x < 0$, $U(x)=U$ for $x > 0$]



- What is the expression for the wave function in region I? Explain.
- What is the expression for the wave function in region II? Explain.
- What are the conditions that a wavefunction must satisfy?
- Write the relations between the parameters of the two functions. Note: write the system of equations, don't solve it.
- If we measure the particle position, can we find it in region II? Explain.

Solution:

Part IV

a) What is the wavelength of the photon emitted by an electron confined in a box of length $L=10^{-10}$ m going from the $n=4$ to the ground level?

b) Draw the wavefunction and probability density of a particle in the $n=3$ level of the following potential:

$$U(x) = \begin{cases} 0 & L/2 < x < L/2 \\ U & \text{elsewhere} \end{cases}$$

NOTE: assume for the particle energy that $E < U$.

Solution:
