

PHY 6646 Spring 2002 – Mid-Term Exam 2

Instructions: Attempt both Question 1 (worth 24 points) and Question 2 (worth 26 points). The maximum score for each part of each question is shown in square brackets. To gain full credit you should explain your reasoning and show all working. Please write neatly and remember to include your name on the front page of your answers.

You are allowed to consult Shankar's *Principles of Quantum Mechanics*, your lecture notes, and homework solutions from this course. You may not consult any other books or papers, or communicate with anyone other than the proctor. In accordance with the UF Honor Code, by turning in this exam to be graded, you affirm the following pledge: *On my honor, I have neither given nor received unauthorized aid in doing this assignment.*

Throughout both questions, you should aim to evaluate all integrals explicitly.

1. Consider a one-dimensional harmonic oscillator formed by a particle of mass m and charge q moving in the potential $V(x) = \frac{1}{2}m\omega_0^2x^2$.
 - (a) Suppose that the particle is in its ground state when an electric field E_0 is instantaneously turned on. Afterwards, what is the (exact) probability of finding the particle in its new ground state? [12 points]
 - (b) Suppose instead that the particle starts out at time $t = -\infty$ in its first excited state, $|1\rangle$. It is acted on by an electric field

$$E(t) = E_0 e^{-(t/\tau)^2}.$$

Within first-order perturbation theory, what is the probability that the particle will be found at time $t = +\infty$ in the state $|n\rangle$, where $n \neq 1$? [12 points]

Hint: In answering this question, you may find it helpful to consult Shankar Chapter 7, Section 17.2, and Appendix A.2.

2. Consider scattering from the exponential potential $V(r) = V_0 e^{-\alpha r}$, where α is a positive, real constant.
 - (a) Calculate the differential cross section within the first Born approximation. [12 points]
 - (b) Find the total cross section. [8 points]
 - (c) The exponential potential above can be compared with the Yukawa potential $V(r) = V_0 e^{-\alpha r}/(\alpha r)$. Which of these two potentials focuses its scattering more strongly in the forward ($\theta = 0$) direction? [6 points]

Hint: You can adapt Shankar Eq. (19.3.11) to describe the differential cross section for the Yukawa potential.