PHYSICS 521 - FALL 2007

Homework Set 1

due date: Mon., September 10, 2007

Problem 1.1

A 1-ounce rifle bullet takes 0.5 sec to reach its target. Regarding the bullet as a mass point and neglecting effects of air resistance and earth motion, find the order of magnitude of the spread of successive shots at the target under optimum conditions of aiming and firing.

Problem 1.2

Franck-Hertz experiment. A beam of monoenergetic electrons is used to excite a particular level of an atom. This level is of short duration, owing to radiation back to the ground state. As a result, the inelastically scattered electrons that have lost energy to produce the excited level will not all have the same final energy. If the excited level lasts about 10^{-10} sec, what is the order of magnitude of the electron energy spread measured in eV?

Problem 1.3

Show that the free-particle one-dimensional Schrödinger wave equation

$$i\hbar\frac{\partial}{\partial t}\,\psi(x,t) = -\frac{\hbar^2}{2m}\,\frac{\partial^2}{\partial x^2}\,\psi(x,t)$$

is invariant under Galilean transformations. Do this by showing that, when the transformation

$$x' = x - vt \quad , \qquad t' = t$$

is applied, the transformed wavefunction

$$\psi'(x',t') = f(x,t)\psi(x,t)$$

satisfies the same Schrödinger equation but with primed coordinates. Find $f(x,t)$ explicitly in terms of $x, t, \hbar, m$ and v.
Finally, show that the traveling wave solution

$$\psi(x,t) = A\; e^{i(kx-\omega t)}$$

transforms as expected.

Problem 1.4

How must a wave packet $\psi(\vec{r}, t)$ fall off for large r in order that the volume integral

$$\int |\psi(\vec{r}, t)|^2 \; d^3r$$

converge?

Problem 1.5

Show that if the potential energy $V(\vec{r})$ is changed everywhere by a constant ($V(\vec{r}) \to V(\vec{r}) + V_0$), the time-independent wavefunctions are unchanged.
What is the effect on the energy eigenvalues?

Problem 1.6

Do **EXERCISE 2.** (pp. 86-87) in the textbook.

Problem 1.7

Do **EXERCISE 7.** (p. 89) in the textbook.