Problem Set 7
P511—Quantum Mechanics, Fall 2008
Steven Gottlieb
Due Tuesday, October 28

1.) We have studied the bound states of the finite square well potential and the δ-function potential. Consider the limit of a square well that becomes narrower and deeper so that the integral of the potential is the same as for the δ-function potential. Show that both give the same bound state energy as the width of the potential approaches 0.

2.) Consider a mass attached to a spring. Let the mass be 1 kg. Let the spring constant $k = 1$ N/m. Consider the mass oscillating with total energy of 1 J.

a) Find the maximum displacement of the mass.

b) At half the maximum displacement, calculate the LHS and the RHS of Eq. (2.4.37) on page 105 of Sakurai. Is the inequality satisfied?

c) The RHS will decrease as the mass approaches the turning point. How close does x have to be to its maximum value for the LHS and RHS to be equal?

d) Next consider a quark with rest mass given by $mc^2 = 5$ GeV, and a spring constant $k = 1 \times 10^5$N/fm. Consider the quark oscillating with a maximum displacement of 0.4fm. Calculate the LHS and RHS of Eq. (2.4.37) on page 105 of Sakurai for this case and compare with part (b).

3.) Using Eq. (2.5.16) on page 112, calculate the wave function and position dispersion after a time t of a Gaussian wave packet that at $t = 0$ is given by Eq. (1.7.35) with $k = 0$. (Your result should agree with the answer to problem 2.7 assigned previously.)