

Physics 322 Problem Set #6 (Trapped in an Infinite Well)

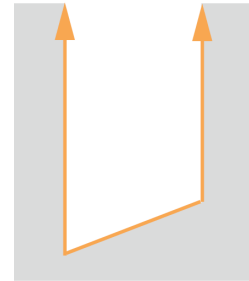
Due Friday, March 6 at 4:00 pm

MIDTERM #1 FOLLOWUP: Are you are unsatisfied with your MidTerm #1 exam score? Would you like to get up to 10 points back? Set up an appointment before Friday, March 6 to talk to Juan about “what went wrong with this exam?” You should be prepared to discuss your answer to that question both in terms of what were your wrong answers and what do you think you can do to better prepare for the next exam.

ASSUMED READING: Before starting this homework, you should read Chapter 5.1 through 5.6 of Harris’ *Modern Physics*.

SCORING: There are 45 points possible on this Problem Set (not including extra credit). Scoring per problem is indicated.

1. **[Harris 5.15] (5 points)** Consider a particle bound in an infinite well, where the potential inside is not constant, but a linearly varying function. Suppose the particle is in a fairly high energy state, so that its wave function stretches across the entire well; that is, it isn’t caught in the “low spot.” Decide how, if at all, its wavelength should vary. Then sketch a plausible wave function.



2. **[Harris 5.20 Modified] (10 points)** A comet in an extremely elliptical orbit around a star has, of course, a maximum orbital radius. By comparison, its minimum orbit radius may be nearly 0.
 - a. Write an expression for the total energy of the comet in terms of the masses involved, velocity of the comet, and orbital radius.
 - b. Make a plot of the potential energy and a plausible total energy versus radius on the same set of axes (you should consider yourself “inspired” by Figure 5.3, but don’t copy it, atoms are not solar systems).
 - c. Identify the classical turning point(s) in your plot. What keeps the comet from hitting the Sun?
3. **[Harris 5.25] (10 points)** An electron is trapped in a quantum well (practically infinite). If the lowest-energy transition is to produce a photon of 450 nm wavelength, what should be the well’s width? **HINT:** First determine which transition will be the lower energy transition possible.

4. **[Harris 5.26] (5 points)** Because protons and neutrons are similar in mass, size, and certain other characteristics, a collective term, *nucleons*, has been coined that encompasses both of these constituents of the atomic nucleus. In many nuclei, nucleons are confined (by the strong force, discussed in Chapter 11) to dimensions of roughly 15 femtometers. Photons emitted by nuclei as the nucleons drop to lower energy levels are known as gamma particles. Their energies are typically in the MeV range. Why does this make sense?
5. **[Harris 5.29 tweaked] (10 points)** A tiny $1\mu\text{g}$ particle is in a 1 cm wide enclosure and takes a year to bounce from one end to the other and back.
- How many nodes are there in its enclosure?
 - How would your answer change if the particle were more massive or moving faster?
 - Will the “particle” behave like a particle or a wave? *Clearly explain your reasoning.*
6. **[Harris 5.9 modified] (5 points)** A *half*-infinite well has an infinitely high wall at the origin and one of finite height U_0 at $x=L$.
- Like the finite well, the number of allowed (bound) states is limited. Why is the number of allowed states limited?
 - Assume that it has two states, of energy E_1 and E_2 , where E_2 is not much below U_0 . Make a sketch of the potential energy, then add plausible sketches of the two allowed wave functions on separate horizontal axes whose heights are E_1 and E_2 .