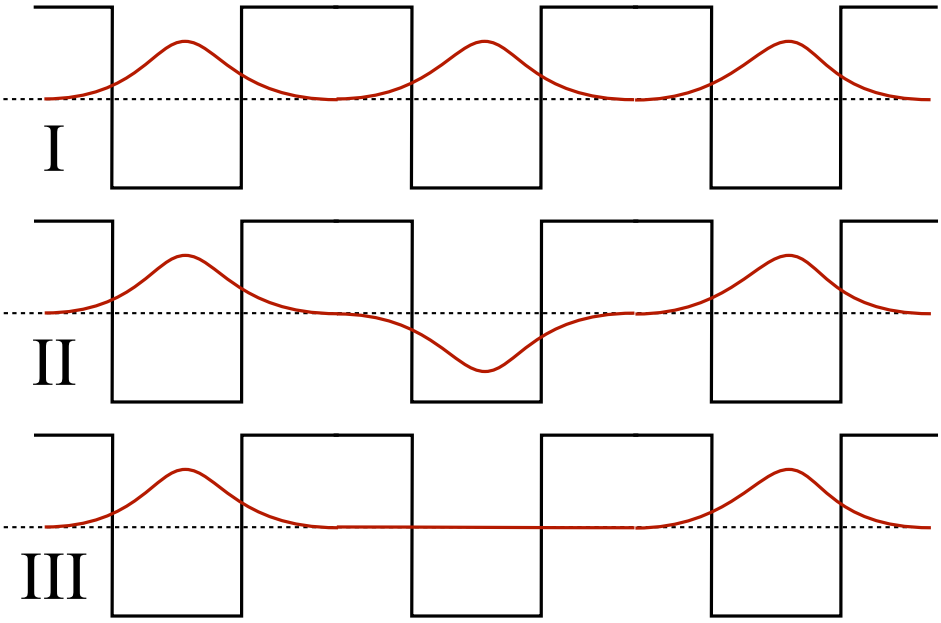
Physics 370 Homework #11 v2

9 problems

Due by Monday, November 28

▷ **1.**

(Harris 10.26) The diagrams below represent the three lowest energy wave functions for three "atoms". As in all truly molecular states we consider, these states are shared among the atoms. At such large atomic separation, however, the energies are practically equal, so an electron would be just as happy occupying any combination.



(a) Identify algebraic combinations of the states (for instance, $\mathrm{I}+\frac{1}{2}\mathrm{II}+\frac{1}{2}\mathrm{III}$) that would place the electron in each of the three atoms.

(b) Were the atoms closer together, the energies of states I, II, and III would spread out and an electron would occupy the lowest energy one. Rank them in order of increasing energy as the atoms draw closer together. Explain your reasoning.

▷ **2.**

(Harris 10.50) Assuming an interatomic spacing of 0.15 nm, obtain a rough value for the width (in eV) of the $n = 2$ band in a one-dimensional crystal.

▷ **3.**

(Harris 10.52) Carbon (diamond) and silicon have the same covalent crystal structure, yet diamond is transparent while silicon is opaque to visible light. Argue that this should be the case based only on the difference in band gaps—roughly 5 eV for diamond and 1 eV for silicon.

▷ **4.**
(Harris 10.57) Show that for a room-temperature semiconductor with a band gap of 1 eV, a temperature rise of 4 K would raise the conductivity by about 30%.

▷ **5.**
(Harris 11.5) The semiempirical binding energy formula has four terms. Suppose we have a nucleus with 18 protons and 22 neutrons. For each term in the formula, indicate (without calculation) whether adding one more proton would cause an increase or a decrease, and explain why it should have this effect. Focus on the underlying idea.

▷ **6.**
(Harris 11.20) By classical, hard-sphere assumptions, what smallest value of A would make one nucleon surrounded? Relate your answer to Figure 11.14.

▷ **7.**
(Harris 11.40) How much energy is released, and what is the daughter nucleus, in the β^+ decay of nitrogen-13?

▷ **8.**
(Harris 11.50) Given initially 100 g of plutonium–239, how much time must pass for the amount to drop to 1 g?

▷ **9.**
(Harris 11.30) The semiempirical binding energy formula predices the binding energies of neon–20, iron–56, and uranium–238 within about 1%. Fill in the following table (on a separate piece of paper) for the four terms of the formula. Discuss what the table reveals.

	Volume	Area	Coulomb	Asym.	Volume ÷ A	Area ÷ A	Coulomb ÷ A	Asym. ÷ A	Total ÷A
Ne20									
Fe 56									
U 238									