Quantum Physics, Preparation for Friday, Jan. 19

Study Q2.1 to Q2.3 from *Six Ideas*

It is a bit much to include Q2.4 (resonance) for one class. Moore only gives the resonance formula, Eq. Q2.9. He doesn't derive it because deriving it is decently tough. So just study Q2.1 to Q2.3. On the other hand, I am going to have you look ahead a bit to Q3 for the presentations....

Presentations

Thanks so much to those that were well enough, especially Ren, the only well person from Group 1 on Tuesday, for carrying out the coupled-harmonic oscillator presentations.

For the coming class I will again bring in the big TV. ***Just for simplicity, let's keep the same groups.***

Group 1: Collaborate on finding a video that demonstrates what Moore is showing in Figure Q3.2, p. 37. If you put "ripple tank diffraction" into your search terms, you will find lots of choices. You are looking for one that involves a single slit.

There are two very interesting cases even with the just a single slit: if the wavelength is short (compared to the width of the slit), and if the wavelength is long (compared to the width of the slit). Figure Q3.2 is showing the long wavelength case find a video (or videos) that demonstrate both cases.

Group 2: Collaborate on finding a video that shows what Moore is showing in Figure Q3.3, p. 37. A really good video and associated explanation will show what happens when the wavelength is greater than, about the same as, or less than the distance between the two slits.

For Problem Set 2

The same problem set that was originally due Tuesday, Jan. 16 before half the class got sick, just delayed in due date to Friday, Jan. 19.

Energy in Coupled Oscillators

1. Go back to "The Bridge." One of the problems that was considered in the bridge was the problem of two masses coupled with three springs.

As the most simplified version of this problem, we let all three springs have the same spring constant, k, we let both masses be the same, m, and we defined $\omega_0^2 = k/m$.

We argued that there are two solutions, one where the masses move back and forth together. A solution like this is called a “mode.” The first mode was:

$x_1(t) = A\cos\omega t$
$x_2(t) = A\cos\omega t$

and $\omega = \omega_0$. (The first mode also has the same thing but with sin instead of cos as another solution.)

The second mode had the two masses moving in opposite directions. *The second mode was:*

$x_1(t) = A\cos\omega t$
$x_2(t) = -A\cos\omega t$

and $\omega = \sqrt{3}\,\omega_0$. (The second mode also sine instead of cosine as another solution.)

In class on Friday, we studied the first mode. *For this problem use the second mode (with the cosine solution).*

(a) Using the second mode, how much is the left spring stretched at time t? The energy in a spring is $\frac{1}{2} k x^2$ where x is how much it is stretched (or compressed). What is the energy in the left spring?

(b) Repeat (a) for the right spring. You should get similar answers to (a).

(c) Repeat (a) for the center spring. This spring will be different than (a) or (b).

(d) All all of (a), (b), and (c) up and simplify. This is the potential energy stored in the springs.

(e) What is $v_1(t) = \frac{d}{dt} x_1(t)$? What is the kinetic energy of mass 1, which is $\frac{1}{2} m v_1^2$?

(f) Repeat (e), but for $v_2(t)$ and $\frac{1}{2} m v_2^2$?

(g) Now add all the energies you found in (d), (e), and (f) up. Use that for the second mode $\omega^2 = 3\,\omega_0^2 = 3\,k/m$ and use a trig identity. If you do it all right, you will get a very simple answer.

This problem was designed to help you see how energy can be traded back and forth between potential energy and kinetic energy such that total energy is conserved.

Energy in Coupled Oscillators

2. Moore Q2T.3 and Q2T.4, a couple of quick superposition problems.

3. Moore Q2B.2, a more detailed superposition problem.

Fundamental modes and harmonics of a string

4. Moore Q2M.2, a guitar string

5. Repeat Moore Q2M.2, but consider the "third harmonic" of the string. The third harmonic is the name for the harmonic with two nodes. There won't be a new tension! That was already determined in Q2M.2. But there will be new tones. The figures to look at are Figure Q2.7 and Figure Q2.8 with $n = 3$. What are the new frequencies corresponding to the third harmonic of E and the third harmonic of G? For the musicians only: the third harmonic is the perfect 5th but an octave up. Due to a pleasant numerical accident, the 5th differs only slightly from the perfect 5th.