PH 427/PH527 PERIODIC SYSTEMS

OSU Department of Physics — Homework #1
Spring 2008 — Assigned: Monday 3/31/08
Instructor: William Warren — Due: Friday 4/4/06 1:00 pm

Collaboration on homework is encouraged, but write-ups must be completely and absolutely independent. This applies also to (and especially to) any computer-generated material. If you intend to use Maple or Mathematica as the means to present your solution, you must be VERY particular about your presentation. Well-presented solutions can be excellent, but if you don't take care, they can be impossible to decipher. Discuss with me if you need guidance. If you turn in a solution that is too similar to someone else's, all of us will discuss the matter, and you and the other party or parties will be asked to generate new, independent solutions.

Solutions distributed in previous offerings of this course are strictly off-limits.

PRACTICE PROBLEMS: Main, Problem 8.9, 12.4, 12.8

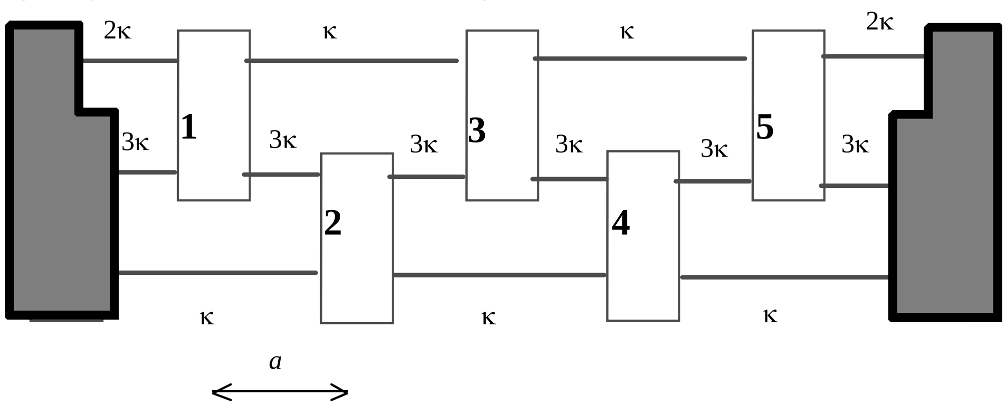
1. Two coupled pendulums

Two identical simple pendulums are connected by a light spring attached to the bobs. Each bob has a mass of 1.00 kg. For small oscillation amplitudes, the two normal modes of the system are found to have periods of 1.18 and 1.20 s, respectively. Use this information to determine the spring constant of the spring.

Note: You are to solve the general problem first, then do the numerical calculation.

2. Five coupled mechanical oscillators

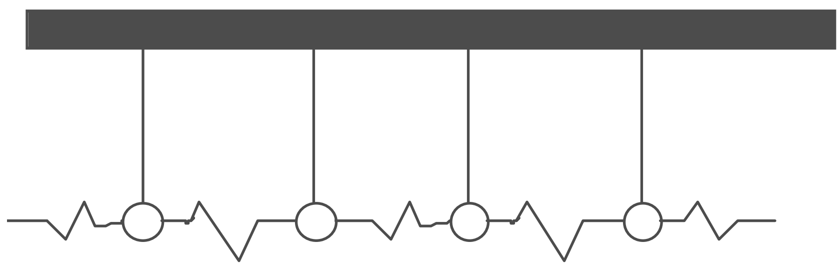
The boxes in the diagram below represent oscillators of identical masses *m* (numbered 1 – 5) constrained to move in the horizontal direction. (Imagine the masses are on a frictionless surface and you are looking down from the top, *i.e.* gravity plays no role in this problem). The lines joining the masses represent springs of the same material, and the number near each spring is its spring constant. The equilibrium distance between blocks is *a*. The heavy boxes on the sides represent immovable walls. Also, everything is symmetric, so that no twisting results.



Find the eigenfrequencies of longitudinal oscillations of the system, and plot the dispersion relation. (EXTRA: Plot the normal modes). There are two different ways to solve this problem; it is instructive to understand both of them. One involves setting up the coupled equations for this system and solving directly. The other involves viewing the system has a subset of an infinite system with appropriate boundary conditions.

3. A chain of coupled pendulums:

Consider a system of an infinite number of coupled pendulums each mass *m* and length *L*, a portion of which is shown below. The springs between them are identical and have spring constant κ.



(a) Find the dispersion relation for small longitudinal oscillations of this system.

(b) Explore the dispersion relation. (This question is deliberately open-ended in order to encourage you to start asking questions yourself. What are the interesting features? What is different about this system compared to others you have studied? Are there limits that you'd expect? How quantitative can you be?)