Problem set 6

Ge 108

Due 14 November 2001

1 Bumpy cars

The springs of a car of mass 1200 kg give it a bounce period of 0.5 seconds for small vertical oscillations. The oscillation, unfortunately for the passengers, is not damped at all.

(a) How far does the car sink when a driver a 3 passengers, each of mass 75 kg, get into the car?

(b) The car with passengers hits a sudden rise in the pavement of 5 cm. The effect is to instantantaneously raise the wheels and the bottom of the springs by 5 cm. By computing the maximum acceleration from the resulting simple harmonic motion, determine if the passengers fly clear of their seats (they are, unfortunately, not wearing seat belts.)

2 Buoys

An object floating in a fluid is buoyed up by a force equal to the weight of the displaced fluid. A uniform cylinder of density ρ and length l is floating with its axis vertical in a fluid of denisty ρ_0. What is the frequency of vertical oscillation?

3 Coupled springs

Two spings are attached to a mass m, which moves without friction, as shown in Figure 3. In each case, write down the equation of motion and derive the frequency of oscillation.

4 Seriously coupled springs

Program `springs.m` calculates the position of a set of n masses connected by $n + 1$ springs which are eventually connected to the wall. As the program is currently set up, the number of masses is 19, the number of springs is 20,

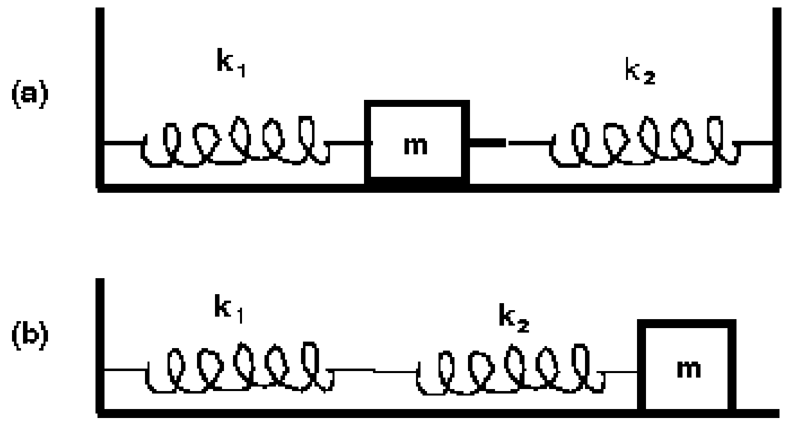

Figure 1: Springs

all masses are the same, all springs are the same, and the system is initially perturbed by moving the first mass away from the wall.

The program works by calculating the acceleration felt by each mass, first from the spring on the left, then from the spring on the right, and keeping track of the changing velocity and position of the mass.

(a) Figure out how the program works (or, alternatively, if you prefer, write your own program from scratch).

(b) Run the program. The initial perturbation eventually travels all the way to the right wall. How long does it take for this signal to reach the right wall? Modify the program so that all of the spring constants are 10 times higher. How long does the signal take to reach the right wall now? What do you think the velocity of signal propagation is, in terms of k, m, and l (just use m and l to make the units come out correctly).

(c) Modify the program so that the motions are now damped. Use a damping constant of 1, in the units of the problem. How long does it take for most of the motion to die away? What if the damping constant is 0.1?