

Physics 171.201
Midterm Exam 2

November 13th, 2002

Answer all **three** problems. Be sure that you pace yourself so that you have enough time to work on each question. Partial credit will be given for partially correct answers. Be sure to **show your working**.

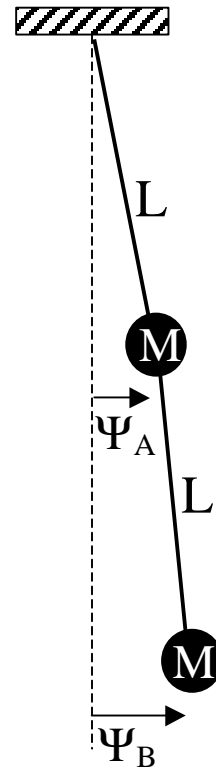
1. (40 points) Consider a compound pendulum consisting of two identical strings and two identical masses that are arranged as shown on the right.

Assume that the displacements Ψ_A and Ψ_B about the equilibrium position (dotted line) are both much smaller than L , and that the masses are free to move only in the plane of the paper.

(a) Write down the equation of motion for the system, making use of small-angle approximations where appropriate. (HINT: don't forget that the tension in the upper string is twice that in the lower string.)

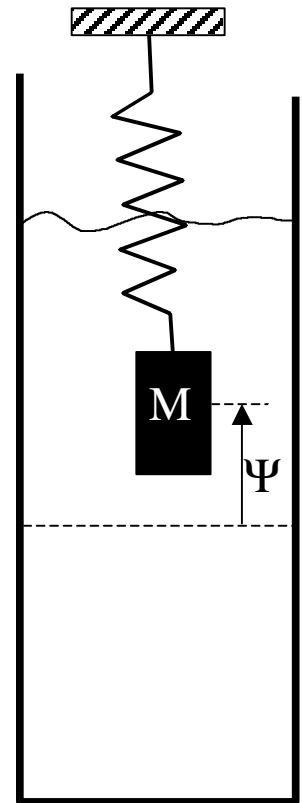
(b) Determine the frequencies for the two normal modes.

(c) Describe the normal modes of the system quantitatively and sketch them



2. (40 points). Consider a damped harmonic oscillator consisting of a mass on a spring that is immersed in a viscous liquid. The spring constant is K , the mass is M , and the viscous force on the mass is $-\Gamma Mv$, where v is the velocity. Ψ is the displacement relative to the equilibrium position.

The mass is driven at resonance by the application of an external driving force of the form $F = F_0 \cos(\omega_0 t)$, where $\omega_0 = (K/M)^{1/2}$ is the natural oscillation frequency in the absence of damping.



(a) Write down the equation of motion for system

(b) Roughly how long does it take the steady-state solution to be established, i.e. for any transient solution to die away? (Simply state the result without deriving it.)

(c) Show that the steady state solution for the displacement can be written in the form $\Psi = \Psi_0 \sin(\omega_0 t)$, and determine the relationship between Ψ_0 and F_0 .

(d) For the steady state solution, compute the velocity of the mass (as a function of time) and the rate of power input by the driving force. Where does this power go?

3. (20 points). Write a couple of paragraphs explaining why it sounds very noisy when your head is above water in a crowded indoor swimming pool, but very quiet when you put your head under water.

Your explanation should include a qualitative discussion of the laws governing the reflection and transmission of waves at interfaces between media, the impedance of sound waves in air, the impedance of sound waves in water, and the impedance of hard, tiled walls as dashpots.