PHY221 Classical Physics **Homework 2** *Waves*

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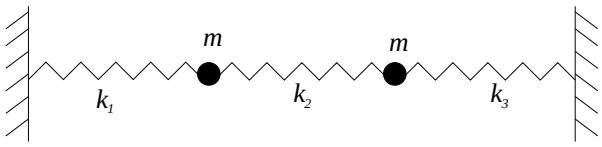
Deadline: 4pm Monday 23rd November 2015

1. Two balls of equal mass m are attached to each other and to two walls by horizontal springs. A spring of spring constant k_1 connects one mass to the wall on the left. A spring, of spring constant k_2 connects the two balls to each other. Finally a third spring connects the second ball to the wall on the right. All the springs remain horizontal. Assume there is no damping.

   (a) What are the two equations of motion of the system? [4]



   (b) Solve these equations of motion to obtain the angular frequencies of the normal modes. [8]

   (c) For the case of equal spring constants $k_1 = k_2 = k_3 = k$, find the relationship between the amplitudes for the highest frequency mode. [6]

   (d) Describe the motion of each mode. [2]

——————— *Please turn over* ———————

2. You hear someone shout and then an echo. The sound has reflected off the wall of a building.

   (a) Write down the wave equation for the sound waves in terms of the pressure P, defining the symbols you use. [1]

   (b) What is the phase velocity, c, of sound? [1]

   (c) Given that air has a density $\rho_{\text{air}} = 1.18\,\text{kg}\,\text{m}^{-3}$ and compressibility $\kappa_{\text{air}} = 6.72 \times 10^{-6}\,\text{Pa}^{-1}$ and the brick wall has a density $\rho_{\text{wall}} = 363\,\text{kg}\,\text{m}^{-3}$ and compressibility $\kappa_{\text{wall}} = 4.91 \times 10^{-10}\,\text{Pa}^{-1}$, calculate the ratio of the reflected sound intensity to the incident intensity, given that the reflection coefficient, r is:

   $$r = \frac{(Z_2 - Z_1)^2}{(Z_1 + Z_2)^2}$$

   where Z_1 and Z_2 are the impedances of the different media the sound travels in. [6]

   (d) Explain in words why the echo sounds quieter than the initial shout. [2]

   (e) Show that

   $$P(x,t) = A_1 \sin(kx - \omega t) + A_2 \cos(kx - \omega t)$$

   is a solution to the wave equation from part (a). [6]

   (f) Given the frequency of the person's voice is $f = 526\,\text{Hz}$, what is the value of the wavelength of the sound in air? [4]