Announcements

- Homework 11 due Monday!
- Final Chapter write-ups due on Monday morning
  - Email me a pdf copy of your paper without your name on it
  - We will meet on Discord for some initial instructions, and then I'll temporarily co-op the HW Solutions website for it to become the Papers and Peer Evaluations site
- Final will be going out a week from Saturday.
- Responses: `rembold-class.ddns.net`

Today's Objectives

- Build up ideas of how to linearize equations of motion
- Reinforce ideas of how all these normal frequencies and modes come together to form a general solution

Q1

Last class, we had found that for a pendulum attached to a mass attached via spring to a wall, we got equations of motions that looked like:

$$-kx = 2m\ddot{x} + m\ell\cos(\phi)\ddot{\phi} - m\ell\dot{\phi}^2\sin(\phi)$$
$$-mg\ell\sin(\phi) = m\ell^2\ddot{\phi} + m\ell\cos(\phi)\ddot{x}$$

Where does this system have equilibrium points?

A) $x = 0$ and $\phi = 0$
B) $x = \ell$ and $\phi = 0$
C) $x = \ell$ and $\phi = \ell/x$
D) $x = k/m$ and $\phi = 0$

Q2

What overall dependence on the normal frequencies have on the mass?

A) Zero dependence, it all cancels out
B) As the mass increases, both normal frequencies increase
C) As the mass increases, both normal frequencies decrease
D) None of the above

Q3

For a particular set of constants, the two pairs of normal modes and frequencies are:

$$\omega_1 = 1.95, \quad \vec{\mathbf{e}}_1 = \begin{bmatrix} 1.58 \\ 1 \end{bmatrix} \quad \text{and} \quad \omega_2 = 5.08, \quad \vec{\mathbf{e}}_2 = \begin{bmatrix} -0.62 \\ 1 \end{bmatrix}$$

What can you conclude about the motion of the pendulum when the upper mass is traveling to the right?

A) It is stationary
B) It is moving right
C) It is moving left
D) It is impossible to say

Q4

Suppose we knew that the system started with both masses at their equilibrium point. The pendulum mass is is stationary, but the upper mass is traveling to the right at 20 cm/s. Take both $m = \ell = 1$. What is the position of the top mass after 2 seconds?

$$\omega_1 = 1.95, \quad \vec{\mathbf{e}}_1 = \begin{bmatrix} 1.58 \\ 1 \end{bmatrix} \quad \text{and} \quad \omega_2 = 5.08, \quad \vec{\mathbf{e}}_2 = \begin{bmatrix} -0.62 \\ 1 \end{bmatrix}$$

A) 4.3 cm
B) 0 cm
C) -1.95 cm
D) -5.7 cm