Quiz 1-B Solutions

1. Consider two identical masses hanging from identical springs. One system is lightly damped by air resistance, while the other is heavily damped by a nearby magnet (just like in lecture). Both springs are stretched and released, and they proceed to oscillate up and down.

(a) Which of the above plots of displacement vs. time (A or B) corresponds to the heavily damped system?

Plot A corresponds to the heavily damped system.

(b) Using motors, we can drive both spring systems at a variety of frequencies. For each driving frequency, we record the amplitude of the response, resulting in the resonance curves below:

Unfortunately, we neglected to label the plots and have since forgotten which is which. Using what you know about resonances, identify which plot (C or D) corresponds to the heavily damped system, and clearly explain how you know which one it is (continue on the next page if you run out of room).

Plot C corresponds to the heavily damped system. See next page for explanation.
Heavily damped systems will oscillate moderately when driven at a wide range of frequencies surrounding resonance. Thus they have broad resonance curves (like C) and low “Q-factors.” Lightly damped systems oscillate with large amplitudes right around resonance but will respond very little to driving frequencies away from resonance. Therefore, their resonance curves are narrow and sharply peaked (like D), and we say that these systems have a high “Q-factor.”

2. You pluck a guitar string and hear the note A₂, whose frequency is 110 Hz.

(a) What are the frequencies of the next three harmonics present in the string’s sound?

For a vibrating string, both even and odd harmonics are present, and these are simply whole-number multiples of the fundamental frequency. Since our fundamental frequency is \( f_1 = 110 \text{ Hz} \), the next three harmonics are:

\[ f_2 = 220 \text{ Hz}, \; f_3 = 330 \text{ Hz}, \; f_4 = 440 \text{ Hz} \]

(b) The string is 0.65 m long. What is the speed of waves along the string?

\[
f_1 = \frac{v}{2L} \Rightarrow v = 2Lf_1
\]

\[
v = 2(0.65 \text{ m})(110 \text{ Hz})
\]

\[
v = 143 \text{ m/s}
\]

(c) Are the waves along the string transverse or longitudinal?

Waves traveling along a string are **transverse** waves.