3.2.1: Driven Springs Simulation

The following simulation shows five different masses, each attached to a spring of the same stiffness. The springs are mounted on a mechanical device that shakes the springs and attached masses. You can adjust the driving frequency, f in Hz, of the shaking mechanism, the amplitude of the driving force, F_o, in Newtons, the amount of friction, b in $\mathrm{Ns/m}$, and the stiffness of the springs, κ, measured in $\mathrm{N/m}$.

Simulation Questions:

1. Start the simulation. Do any of the masses have a very large amplitude?
2. Increase the amplitude of the driving force, F_o. Now do any of the masses have a very large amplitude?
3. Reset the simulation and change the driving frequency, f, to $0.5\ \mathrm{Hz}$. Wait a few seconds. What do you see now?
4. Why is the oscillation of mass number five much larger than the other ones now?
5. Reset the simulation and change the driving frequency to $2.0\ \mathrm{Hz}$. What do you notice now?
6. See if you can determine the resonance frequency of the center mass by trial and error. What is its resonance frequency?
7. In the previous simulation we saw that the natural frequency, written as f_o is given by the stiffness of the spring, κ, and the mass; $f_o = (\kappa/m)^{1/2}/(2\pi)$. In this simulation the large mass is $10\ \mathrm{kg}$ and the spring constant is initially $100\ \mathrm{N/m}$ so $f_o = 0.5\ \mathrm{Hz}$. This is why it has a large oscillation when driven at $0.5\ \mathrm{Hz}$; it will resonate with a driving frequency equal to its natural frequency. The center mass (number three) is $2.5\ \mathrm{kg}$ so the natural frequency is $1.0\ \mathrm{Hz}$. Did you find a resonance frequency of $1.0\ \mathrm{Hz}$ for this mass?
8. Mass number two is $1.25\ \mathrm{kg}$. Calculate its natural frequency. Verify your result by trying it out in the simulation.
9. Reset the simulation so that none of the masses are in resonance. Why doesn't the driving amplitude have much of an effect on the oscillation of the masses?
10. Change the spring stiffness, κ to $150\ \mathrm{N/m}$. (This changes the stiffness of all the springs.) Do the masses have the same resonance frequencies? Explain.
11. Use the formula for the natural frequency to calculate the natural frequency of the $10\ \mathrm{kg}$ mass (mass number five) with a spring constant of $150\ \mathrm{N/m}$. Verify your result using the simulation.