**MoCChA BONUS Assignment**

You can earn extra credit for the final exam by filling out this bonus assignment:

* Create a one-page formulary to bring to the exam. The formulary can be double-sided. Turn in together with your exam for a 2-point bonus.
* Complete this MoCChA assignment for an 8-point bonus. Turn in together with your exam.

You can complete this assignment in teams, but every team member needs hand in their solution.

This assignment explores solutions and properties of the differential equation for the harmonic oscillator,

where m = mass of the oscillating object and k = spring constant.   
  
1. How do you expect the frequency and amplitude of oscillation to differ for the following two oscillators: (a) m = 0.001, k = 1 versus (b) m = 0.1, k = 1? Sketch the expected trajectories x(t) assuming initial conditions x(0) = 0 and x’(0) = 1.

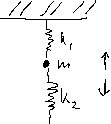
2. Compare your expectations with the numerical solutions from the MoCChA notebook <https://hub.crc.pitt.edu> -> Chem1000/ODE\_oscillator.ipynb.

Now consider a harmonic oscillator with friction:

is a coefficient describing friction resulting in energy dissipation.   
  
3. What do you expect the trajectory x(t) to look like when friction is small versus large friction, e.g. for   
(a) m = 0.001, , k = 1 versus (b) m = 0.001, , k = 1?

4. Compare your expectations to the numerical solutions from the MoCChA notebook <https://hub.crc.pitt.edu> -> Chem1000/ODE\_oscillator\_friction.ipynb.

5. When one connects a mass to two springs of opposing directions, then the oscillator can be described by



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Where k1 and k2 are the spring constants of the two opposing springs. What do  
you expect the trajectory x(t), frequency and amplitude to be under the following   
circumstances?  
x(0) = 0, x’(0) = 1, m = 0.001, and:  
(a) k1 = 1 and k2 = 0.001,  
(b) k1 = 1 and k2 = 0.9



6. Return to <https://hub.crc.pitt.edu> -> Chem1000/ODE\_oscillator.ipynb to compare your expectation with the numerical solution.