16-299 Assignment 2: Scaling rules for stiffness and damping.

It is interesting to think about how stiffness and damping should change as the desired movement gets faster, or a load is carried in the hand.

1) Let's consider a very simple system with a mass, with stiffness and damping such that the system is critically damped and gets 90% of the way to a desired position in a step response in 1 second. How should the stiffness and damping scale with speed, such that the system remains critically damped, and gets to 90% of the way to the desired position twice as fast (0.5s) or half as fast (2s)? What about an arbitrary speed scaling factor f_s times as fast (f_s = 2 means the velocities are twice as big, and the duration is half as long. f_s = 1 generates the original step response of 1 second.). Verify your scaling law using simulations at several values of f_s.

2) Let's consider the same system with added mass (a mass scaling factor of f_m). Does adding mass make the system faster or slower with the same stiffness and damping? More or less oscillatory with the same stiffness and damping? If the system has f_m times the mass, how should the stiffness and damping scale with f_m to keep the system critically damped, and reaching 90% of the distance to the desired position in a step response in 1s? Verify your scaling law using simulations at several values of f_m.

3) If we scale both the speed and the mass, what should the stiffness and damping be in terms of f_s and f_m simultaneously? Verify your scaling law using simulations at several combinations of values of f_s and f_m.