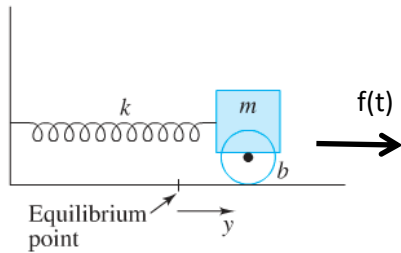


Given the Spring-Mass-Damper System and its differential equation with forcing function  $f(t)$



$$\frac{d^2 y}{dt^2} + \left(\frac{b}{m}\right) \frac{dy}{dt} + \left(\frac{k}{m}\right) y = f(t)$$

Create a published document with your name and section number. Address part in a separate cell.

- a) Write the equations in state space (matrix form)  $x'(t) = Ax(t) + Bf(t)$ . Let  $x_1 = y$  and  $x_2 = y'$ . Do this symbolically. Hint: see Lecture Week 3 notes.

For following parts use the values

m	b	k	f(t)	y(0)	y'(0)	Simulation range
1	8 Changes in part e	200	As indicated By part	63	0	[0, 2]

- b) Find the equilibrium point if

- The external force  $f(t) = 0$
- The external force  $f(t) = 50$
- The external force  $f(t) = -20$

Explain how a constant external force  $f(t)$ , can change the equilibrium point.

- c) What are the roots of the auxiliary equation? Are they real or complex, discuss why.
- d) Using ode45 simulate the system for the given initial conditions with  $f(t) = 0$ . Create component plots:  $y(t)$  vs.  $t$ ,  $y'(t)$  vs.  $t$  and phase plots  $y'(t)$  vs.  $y(t)$ . Use subplot to get all 3 plots on the same graph – components on left 2 panes and phase on right 2 panes. Annotate your axes properly. On the phase plot mark the initial conditions and equilibrium point with colored circles and stars, define using legend.
- e) It is desired that the system be modified so that the roots of the auxiliary equation are negative real and equal. Find the value of  $b$  that accomplishes this (do by hand with Matlab's help). What are the values of the roots? What is the value of  $b$ ?
- f) Redo part d using this new value of  $b$ . Hint make a new ode45 function for the D.E. Discuss if the time to get and stay at the equilibrium point is faster or slower than part d.

Note: Submit a published pdf file of your script with convention **lastname\_initials\_lab4.m** The published document must include all functions used. All figures must be annotated (labels, legends, markers, title, etc. Answers to questions asked should be printed as an output.