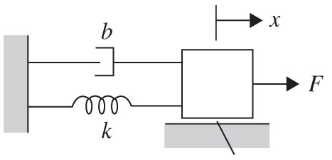
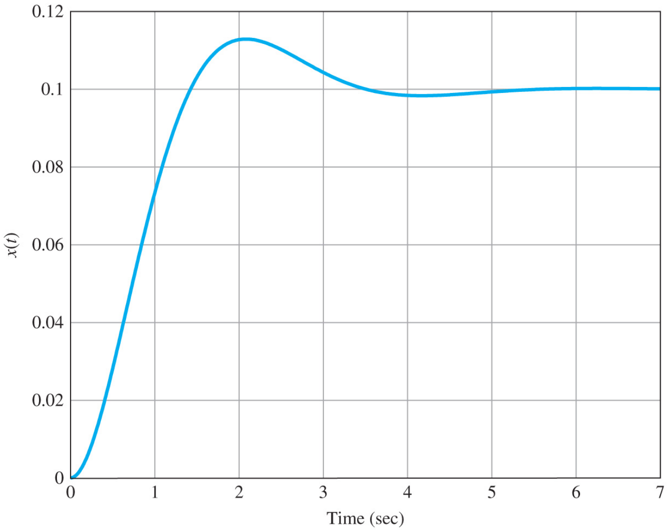
Control Systems : Set 4 : PID (3)

Prob 1 | A simple mechanical system is shown in the figure below. The parameters are k = spring constant, b = viscous friction constant and m = mass. A step of 2 Newtons force is applied and the resulting step response is shown below. What are the values of the system parameters k, b, and m?

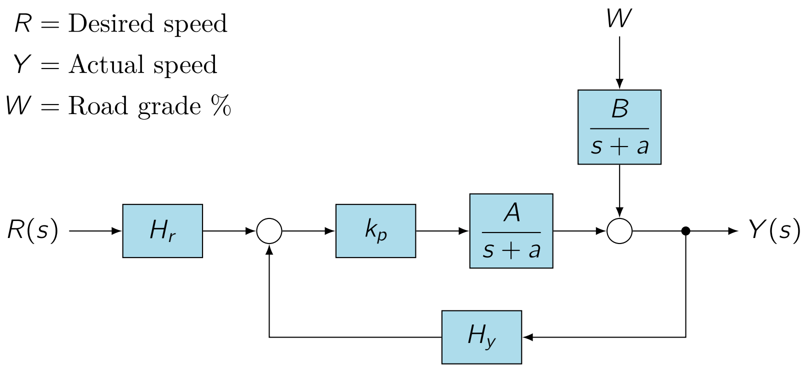
Hi





Prob 2 | Consider the automobile speed control system depicted in the figure below.

R = Desired speed
Y = Actual speed
W = Road grade %



a) Find the transfer functions from $W(s)$ and from $R(s)$ to $Y(s)$.

b) Assume that the desired speed is a constant reference r_o, so that $R(s) = r_o/s$. Assume that the road is level, so $w(t) = 0$. Compute values of the feedforward gain H_r to guarantee that

$$\lim_{t\to\infty} y(t) = r_o$$

Consider two cases

(i) $H_y = 0$. This is an open-loop feed-forward controller, as there is no feedback.

(ii) $H_y \neq 0$. This is now a closed-loop feedback controller.

c) Now assume that a constant grade disturbance $W(s) = w_o/s$ is present in addition to the reference input. Find the variation in speed Y due to the grade change for both the feed-forward and feedback cases, using the values for H_r computed in part (b). Use your results to explain (i) why feedback control is necessary and (ii) how the gain k_p should be chosen to reduce steady-state error.

d) Assume that $w(t) = 0$ and that the gain A undergoes the perturbation $A + \delta A$. Determine the error in speed due to the gain change for both the feed forward and feedback cases (use the values for H_r derived in (b)). How should the gains be chosen in this case to reduce the effects of δA?

Note that the controller gains have to be chosen as a function of A, and not of $A + \delta A$, as the control engineer does not know that the system gains will change during operation.

Prob 3 | The open-loop transfer function of a unity feedback system (i.e., a system whose controller is a proportional gain equal to one) is

$$G(s) = \frac{K}{s(s+5)}$$

The desired system response to a step input is specified as having a peak time less than $t_p = 2$sec and an overshoot less than $M_p = 10\%$.

a) Determine whether both specifications can be met simultaneously by selecting the right value of K.

b) Sketch the associated region in the s-plane where both specifications are met, and indicate what root locations are possible for some likely values of K.

c) Find the maximum value for K for the system to oscillate.