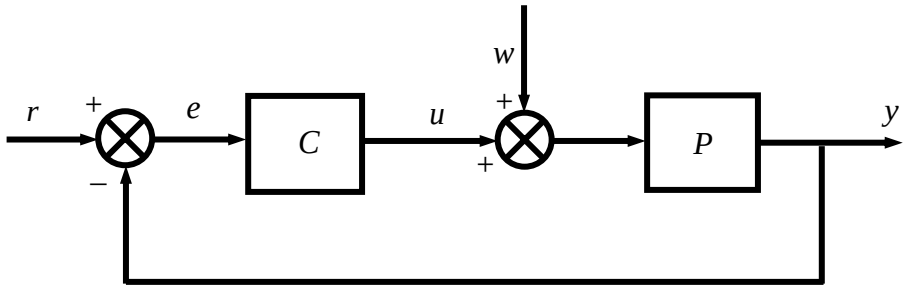
ENME 585 – Assignment 2

1. A mass of $m = 2$ is attached to the ground by a spring of stiffness $k = 10$ and a damper of $b = 4$, acting in parallel. An external force $f(t)$ applied to the mass produces a displacement $x(t)$. If a unit step f is applied, find the maximum displacement of the mass and the time at which it occurs.

2. For the mass-spring-damper of question 1, find the largest value of stiffness k that will not produce an overshoot. Assume that $m = 2$ and $b = 4$, as before.

Questions 3-8 refer to the feedback system shown below, where the transfer function of the plant P is $P(D) = \frac{4}{2D+1}$.



3. Suppose proportional control $C = 2$ is used. If $r = h$ and $w = 0$, find the steady-state error e_{ss}.

4. If $C = 2$, $r = 0$, and $w = h$, find e_{ss}. Compare this to the e_{ss} that would result without any feedback (i.e. $C = 0$).

5. If $C = 2$, what is the time constant of the closed-loop system? Compare this to the time constant of the plant $P(D)$ itself. Is the response of the closed-loop system faster or slower than that of the open-loop system (i.e. the plant)?

6. Suppose integral control $C = k_I h$ is used (with $k_I > 0$). If $r = w = h$, find e_{ss}.

7. If $C = k_I h$, choose the integral gain k_I so that $e_{ss} = 0.1$ when $r = [t]$ and $w = 0$.

8. For the value of k_I found in Question 7, design k_P so that the PI-control $C = k_P + k_I h$ makes the closed-loop system critically damped.