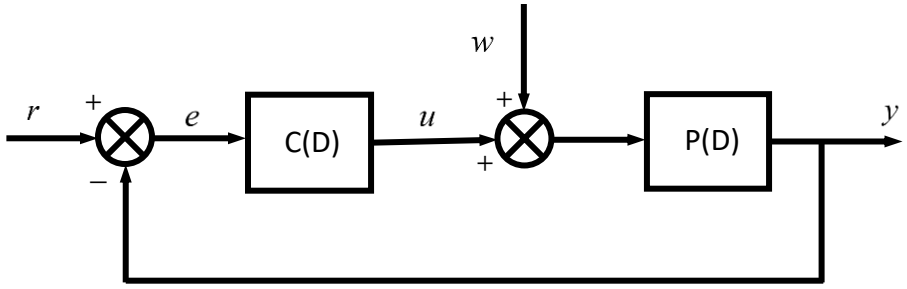
ENME 585 – Quiz 2 2022

Closed book and closed notes. Schulich calculators allowed. Please show your work.

All questions refer to the following feedback loop.



1. In the above feedback loop, the PI control $u(t) = k\left(e(t) + 4\int_{-\infty}^{t} e(\tau)\, d\tau\right)$ is applied to the second-order plant $\ddot{y}(t) + 2\dot{y}(t) + y(t) = u(t)$.

   a) Sketch the loci of the closed-loop poles as $k > 0$ varies. Show any asymptotes and indicate where they intersect the real axis.

   b) Find the values of any imaginary axis crossings in the root locus and the range of k for closed-loop stability.

   c) Design k to achieve a steady-state error of $e_{ss} = 1$ when $r = [t]$ and $w = 0$.

   d) For $r = [t]$ and $w = 0$, why is it not possible to design k to achieve $e_{ss} = 0.1$? For these values of r and w, find the greatest lower bound on the achievable e_{ss}.

2. In the above feedback loop, proportional control $C(D) = k$ is applied to the plant $P(D) = \frac{1}{D(D+2)}$.

   a) Sketch the loci of the closed-loop poles as $k > 0$ varies.

   b) Design k for critically-damped closed-loop poles.

   c) Find the steady-state error e_{ss} if $k = 5,\ w = [1]$, and $r = 0$.

   d) For the conditions of (2c), find the peak magnitude of the error $|e(t)|$.