open-loop:

$$E_{OL} = [1 - GD_{OL}]R - GW$$

$$\downarrow$$

$$R - Y_{OL}$$

closed loop:

$$E_{CL} = \frac{R - GW + GD_{CL}W}{1 + GD_{CL}}$$

$$\downarrow$$

$$R - Y_{CL}$$

- Disturbance rejection = $(R=0, V>0)$
- sensor ~~rejection~~ noise = $(R=0, W>0)$

- sensitivity to parameter changes
  - $\frac{dT}{dG}$ where T = transfer fnc $\frac{Y}{R}$

PID controller on unit feedback loop:

proportional: $D = K_p$ → system response

proportional & integral: $D = K_p + \frac{K_I}{s}$ → eliminates steady state error

PID: prop. integ. deriv.: $K_p + \frac{K_I}{s} + K_D s$

$E = R - Y$: if only P:

$$\rightarrow E = R - Y: \quad \frac{R}{1+DG} = \frac{R}{1+K_pG} \rightarrow \frac{E}{R} = \frac{1}{1+K_pG} = T(s)$$

$$\lim_{t\to\infty} e(t) = \lim_{s\to 0} sE(s) = \lim_{s\to 0} s \underbrace{R \cdot T(s)}_{E}$$

← REMEMBER TO TEST FOR STABILITY FIRST!!

LECTURE 7-8 skipped

LECTURE #9

RLOCUS: $\{s\} \mid 1 + KL(s) = 0$ as $K \rightarrow [0 \rightarrow +\infty]$

assume denominator $D(s)$ numerator $N(s)$ transfer fnc. (n poles m zeros)

RULE #1: n branches start @ poles. m end at zeros

RULE #2: loci on $\mathbb{R}$ axis left of odd # of poles, zeros.

RULE #3: asymptotes @ $\angle$ angles $\phi_\ell = \frac{180^\circ + 360(\ell - 1)}{n-m}$ $\ell = 1, 2, 3 \ldots n-m$

radiating from α where $\alpha = \frac{\sum p_i - \sum z_i}{n-m}$

ϕ = $\angle$ from poles ψ = $\angle$ from zeros.

$L(s)$ is plants