ECE 3510 Exam 2 Information

This sheet and the Exam 1 Information sheet are the only reference materials allowed at exam. Bring this page.

You **may add** whatever you want to this page.

Sinusoidal responses, effects of poles & zeros, etc. Find: $|\mathbf{H}(j\cdot\omega)|$ and $\angle\mathbf{H}(j\omega)$

Steady-state AC analysis to get $y_{ss}(t)$ $\mathbf{Y}(\omega) = \mathbf{X}(\omega)\cdot\mathbf{H}(j\cdot\omega)$

Control system characteristics and the objectives of a "good" control system.
- Stable
- Tracking fast smooth minimum error (often measured in steady state)
- Reject disturbances
- Insensitive to plant variations
- Tolerant of noise

Poles on the 45° line (4% overshoot & $\zeta = 0.707$). Know regions where $\zeta >$ or < 0.7071.

Elimination of DC steady-state error, p. 61 - 63.

1	Closed-loop system stable	
AND 2	$C(s)$ or $P(s)$	has pole @ 0
AND 3	$C(s)$ and $P(s)$	No zero @ 0

Rejection of constant (DC) disturbances, p. 63 - 65.

1	Closed-loop system stable	
AND 2	$C(s)$	has pole @ 0
OR 3	$P(s)$	has zero @ 0 But bad for DC response

For all the roots of a polynomial to be in the LHP, all of the coefficients must be greater than 0. (This is sufficient for a second-order polynomial.)

Root - Locus Plots

a) **Main rules**

1. Root-locus plots are symmetric about the real axis.
2. On the real axis, spaces left of an odd number of O-L poles and zeros are always part of the locus. (Essentially, every other space on the real axis (counting leftward) is part of the plot.)
3. Each O-L pole originates ($k = 0$) one branch. (n)

   Each O-L zero terminates ($k = \infty$) one branch. (m)

   All remaining branches go to ∞. $(n - m)$

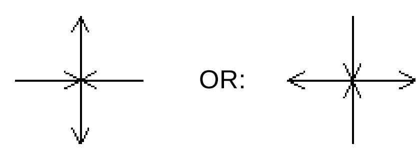
   These remaining branches approach asymptotes as they go to ∞.
4. The origin of the asymptotes is the *centroid*.

$$\text{centroid} = \sigma = \frac{\sum_{all} OLpoles - \sum_{all} OLzeros}{n - m}$$

(# poles - # zeros)

5. The angles of the asymptotes

n - m	angles (degrees)			
2	90	270		
3	60	180	300	
4	45	135	225	315

6. The angles of departure (and arrival) of the locus are almost always: 

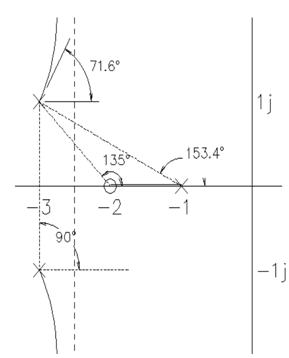
b) Additional rules.

Gain at any point on the root locus: $k = \frac{1}{|G(s)|}$

Phase angle of $G(s)$ at any point on the root locus: $\arg(G(s)) = \arg(N(s)) - \arg(D(s)) = \pm 180^o, \pm 540^o, \ldots$

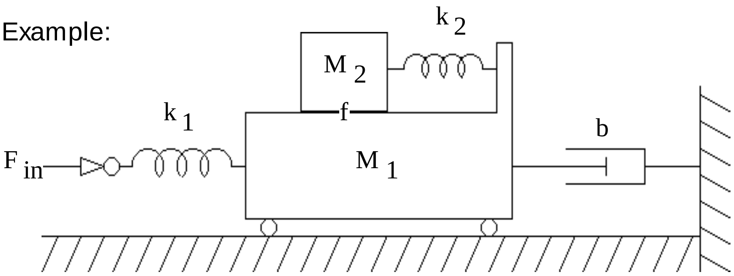
The breakaway/in points are also solutions to: $\sum_{all} \frac{1}{(s + - p_i)} = \sum_{all} \frac{1}{(s + - z_i)}$

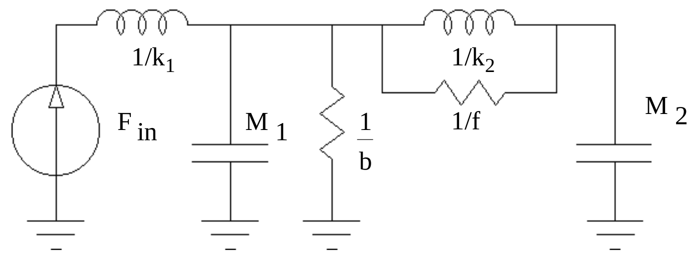
Departure angles from complex poles: Example. $180 - 90 - 153.4 + 135 = 71.6\,\text{deg}$



	Mechanical translational	**Mechanical rotational**
Through Variable (I):	F = Force (N)	T = Torque (N·m)
Across Variable (V):	v = velocity $\left(\frac{m}{sec}\right)$	ω = angular velocity $\left(\frac{rad}{sec}\right)$

Example:



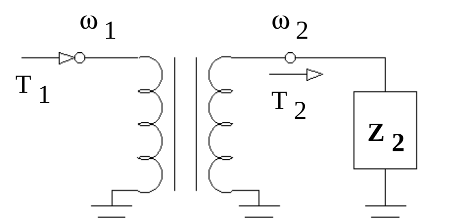


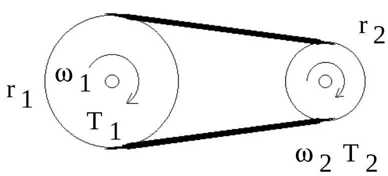
Transformers

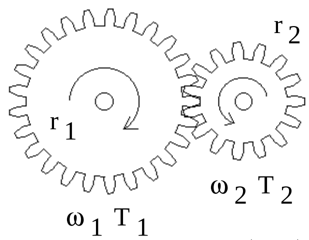
Equivalent impedance in primary: $\mathbf{Z}_{eq} = N^2 \cdot \mathbf{Z}_2 = \left(\frac{N_1}{N_2}\right)^2 \cdot \mathbf{Z}_2$

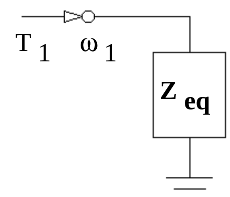
Belts, chains, & gears

r = radius of pulley or pitch radius of gears







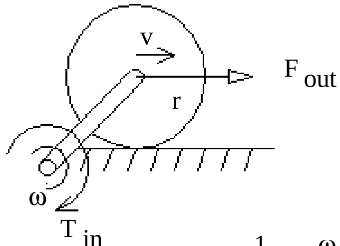


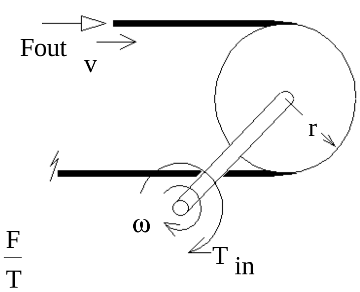
$\mathbf{Z}_{eq} = N^2 \cdot \mathbf{Z}_2 = \left(\frac{r_2}{r_1}\right)^2 \cdot \mathbf{Z}_2$

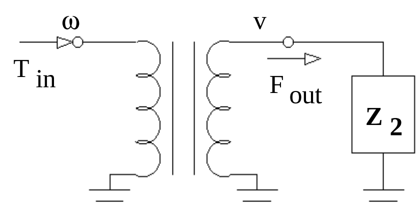
$N = \frac{r_2}{r_1} = \frac{\omega_1}{\omega_2} = \frac{T_2}{T_1}$ = gear tooth ratio $\left(\frac{N_2}{N_1}\right)$

Tires, racks, & conveyors

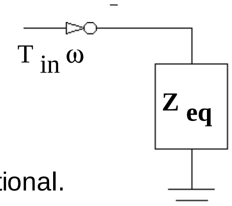
r = radius of wheel or pitch radius of pinion gear







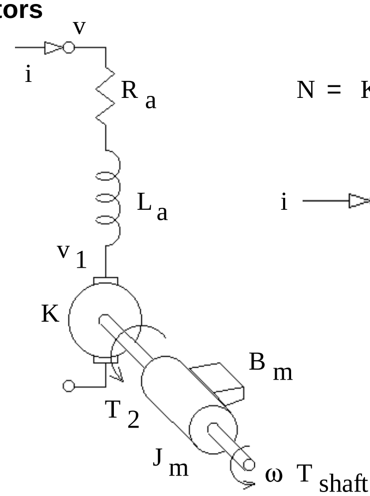
$N = \frac{1}{r} = \frac{\omega}{v} = \frac{F}{T}$



$\mathbf{Z}_{eq} = N^2 \cdot \mathbf{Z}_2 = \left(\frac{1}{r}\right)^2 \cdot \mathbf{Z}_2$

Note: N = r if the input is linear motion and output is rotational.

DC Motors



$N = K = \frac{v_1}{\omega} = \frac{T_2}{i}$