Useful Information

**Bode Plots**

- Look for places in $|H(s)|$ where a real number and a $j\omega$ or $jf$ term are added.
- Set real = |imaginary| to find poles and zeroes.
- Poles come from denominator of transfer function, zeroes from numerator.
- Divide frequencies into regions & find approx $|H(s)|$ in each region by simplifying each (real + imaginary) to just the largest part.

Slopes: -20, 0, or +20 dB/decade

\[ dB = 20 \log_{10} \left| H(\omega) \right| \]

Cut corners by 3-dB

**2nd order tran.**

- **Overdamped** $b^2 - 4k > 0$
  
  \[ s_1 \text{ and } s_2 \text{ are real and negative} \]

  \[ X(t) = X(\infty) + B \cdot e^{s_1 t} + D \cdot e^{s_2 t} \]

  \[ \frac{d}{dt} X(0) = B \cdot s_1 + D \cdot s_2 \]

- **Critically damped** $b^2 - 4k = 0$
  
  \[ s_1 = s_2 = \frac{b}{2} \]
  
  \[ s_1 \text{ and } s_2 \text{ are real, equal and negative} \]

  \[ X(t) = X(\infty) + B \cdot e^{s_1 t} + D \cdot t \cdot e^{s_1 t} \]

  \[ B = X(0) - X(\infty) \]

  \[ D = \frac{d}{dt} X(0) - B \cdot s \]

- **Underdamped** $b^2 - 4k < 0$
  
  \[ s = \alpha + j\omega \text{ complex} \]
  
  \[ s_1 \text{ and } s_2 \]

  \[ X(t) = X(\infty) + e^{\alpha t} \cdot (B \cdot \cos(\omega t) + D \cdot \sin(\omega t)) \]

  \[ B = X(0) - X(\infty) \]

  \[ D = \frac{d}{dt} X(0) - B \cdot \alpha \]

**Final Conditions, or "after a long time"**

- $V_C \rightarrow V_{c(\infty)}$
- $i_L(0) \rightarrow i_L(\infty)$

Replace capacitors with opens

Replace inductors with wires

Capacitor voltage cannot change instantaneously

Inductor current cannot change instantaneously

**System Block Diagrams**

- Standard feedback loop transfer function

\[ \frac{A(s)}{1 - A(s) \cdot B(s)} \]

**Diodes**

- Conducting

\[ \begin{align*}
  V_{d} &< 0.7V \\
  \text{Check} \quad \text{LEDs: 2V}
\end{align*} \]

- Not conducting

Use these models for the diodes and LEDs on this exam.