1. (20 pts) a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

\[ H(s) = \frac{X_{\text{out}}(s)}{X_{\text{in}}(s)} = ? \]

**SHOW YOUR WORK**
Simplify your expression for \( H(s) \) so that the denominator is a simple polynomial.

b) Find the value of \( F \) to make the transfer function critically damped.

c) If \( F \) is Greater than this value the system will be: underdamped or overdamped Circle one

d) Does the transfer function have a zero? Answer no or find the \( s \) value of the zero(s).
2. (24 pts) a) Draw the asymptotic Bode plot (the straight-line approximation) of the transfer function below.

\[ H(f) := \frac{200 \text{kHz} \cdot (10 \text{ Hz} + 0.5 \cdot j \cdot f)}{j \cdot f \cdot (10 \text{ kHz} + \frac{j \cdot f}{3})} \]

You must show and use the method from the class notes to get the Bode plot. That is, show things like the corner frequency(ies), the approximations of the transfer function in each frequency region, calculations of dB, etc..

Indicate which corner frequency(ies) are poles and/or zeroes.

b) The asymptotic Bode plot is not exact. Using a dotted line, sketch the actual magnitude of the transfer function \(|H(f)|\) on the plot above. Indicate the point(s) where the difference between the two lines is the biggest (draw arrow(s)) and write down the actual magnitude(s) at that (those) point(s).
3. (28 pts) The switch has been the upper position for a long time and is switched down (as shown) at time $t = 0$.

a) What are the final conditions of $i_L$ and the $v_C$?
$$i_L^{(\infty)} = ? \quad v_C^{(\infty)} = ?$$

b) Find the initial condition and initial slope of $i_L$ that you would need to have in order to find all the constants in $i_L(t)$. Don't find $i_L(t)$ or it's constants, just the initial conditions.

c) Find the initial condition and initial slope of $v_C$ that you would need to have in order to find all the constants in $v_C(t)$. Don't find $v_C(t)$ or it's constants, just the initial conditions.
Use constant-voltage-drop models for the diodes and LEDs on this exam.

4. (28 pts) Assume that diode $D_2$ does **NOT** conduct.
Assume that diodes $D_1$ and $D_3$ **DO** conduct.

a) Stick with these assumptions even if your answers come out absurd. Find the following:
$V_{D2} = ?$  $I_{D1} = ?$  $I_{D3} = ?$  $V_s = ?$

b) Based on the numbers above, was the assumption about $D_1$ correct?   Circle one:   yes  no
How do you know? (Specifically show a value which is or is not within a correct range.)

c) Based on the numbers above, was the assumption about $D_2$ correct?   Circle one:   yes  no
How do you know? (Show a value & range.)

d) Based on the numbers above, was the assumption about $D_3$ correct?
Circle one:   yes  no   How do you know?

**Answers**

1. a) $2s \frac{(-5(s+12))}{s^2 + 15s + 36 + 75}$
   b) 0.27
   c) underdamped
   d) -12 0

3. a) 10-V 200-mA 200-mA b) 300-mA -250- $\frac{A}{s}$ c) 15-V -15625- $\frac{V}{s}$

4. a) 1.8-V 42-mA 58-mA 88-mA  
   b) yes 42-mA > 0  
   c) no 1.8-V > 0.7V  
   d) yes 58-mA > 0