1. Consider the 2-loop circuit configuration shown below, with input voltage $v_i(t)$, output voltage $v_o(t)$, two resistors, and two one capacitors, so that

$$z_1(s) = R_1, \quad z_2(s) = 1/sC_1, \quad z_3(s) = R_2, \quad z_4(s) = 1/sC_2.$$ 

\[ 
\begin{array}{c}
\begin{array}{c}
+ \\
\scriptstyle v_i(t) \\
- \\
\end{array}
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\begin{array}{c}
\begin{array}{c}
\scriptstyle z_1(s) \\
\scriptstyle z_2(s) + \\
\scriptstyle z_3(s) \\
\scriptstyle z_4(s) \\
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
\scriptstyle + \\
\scriptstyle v_o(t) \\
\scriptstyle - \\
\end{array}
\end{array}
\] 

i. Define loop currents $I_1(s)$ and $I_2(s)$, and determine the transfer function, $H(s) = \frac{V_o(s)}{V_i(s)}$, in terms of $z_1(s), z_2(s), z_3(s),$ and $z_4(s)$. Then specialize to the specific components listed above, and express the transfer function in terms of $R_1, R_2, C_1, C_2$.

ii. Design the circuit (select the values of $R_1, R_2, C_1, C_2$) to meet the following specifications:
   a. The dc gain is unity (zero dB);
   b. The gain is no smaller than -3 dB for frequencies between 0 and 1 kHz; and
   c. The gain is no larger than -40 dB for frequencies larger than 20 kHz.

iii. Present the design with Bode plots of the filter magnitude and phase response and verify on your plots that the design specifications are satisfied.

2. Design a second-order Butterworth low-pass filter to satisfy the specifications
   a. The dc gain is unity (zero dB);
   b. The gain is no smaller than -1 dB for frequencies between 0 and 2,000 Hz; and
   c. The gain is no larger than -40 dB for frequencies larger than 40 kHz.
   Determine a circuit realization as a series RLC low-pass filter. Pick reasonable values of $R$, $L$, and $C$.

3. Design a Butterworth low-pass filter (that is, find the required number of poles, $N$, and -3 dB cutoff frequency, $\omega_c$) to satisfy the following specifications.
   a. The gain is no less than -1 dB for frequencies less than or equal to 10,000 Hz.
   b. The gain is no larger than -40 dB for frequencies greater than or equal to 25,000 Hz.
   Plot the magnitude frequency response (in units of decibels) and verify in the plot that your design satisfies the specifications.

3. Text, problem 13.23.
5. Text, problem 13.34.