a) The purpose and applications of the circuit,
b) Function and specifications of key building blocks,
c) Questions you have about the circuit. For each question, indicate where you would expect to find the answer (course number, book, deriving it yourself, etc).

Keep your answer to two pages.

2. Design a 2nd order (i.e. single biquad) bandpass filter with 1MHz center frequency and 200kHz 3dB-bandwidth.
   a) Calculate $\omega_p$ and $Q_p$.
   b) Plot a 3D perspective view of the magnitude and phase response of the filter.
   c) Implement the filter with a 2nd order Sallen-Key section (see next page). Calculate all element values and the amplifier gain $K$. For simplicity (not the lowest sensitivity design!) make all capacitors 1pF and choose all resistors equal size. Calculate also the resulting filter gain $G$.
   d) Verify the transfer function with SPICE for nominal values and with a 5% variation of $K$. By how much are $\omega_p$ and $Q_p$ changing?
   e) Calculate the sensitivity $S_{Kp}$ and compare the analytical and simulation results.
   f) Return to nominal component values but add a 5% shunt capacitor to ground to both terminals of $C_1$ and $C_2$. By how much are $\omega_p$ and $Q_p$ changing?
Second-order Sallen-Key bandpass section:

\[ H_{bp}(s) = \frac{G \frac{\omega_o}{Q} s}{s^2 + \frac{\omega_o}{Q} s + \omega_o^2} \]

Center frequency
\[ \omega_o = \sqrt{\frac{R_1 + R_2}{R_1 R_2 R_3 C_1 C_2}} \]

Quality factor
\[ Q = \frac{\omega_o}{R_2 C_1 + \frac{1}{R_1 C_1} + \frac{1}{R_3 C_2} + \frac{1}{R_3 C_1} + 1 - K} \]

Gain
\[ G = \frac{1}{R_2 C_1 + \frac{1}{R_1 C_1} + \frac{1}{R_3 C_2} + \frac{1}{R_3 C_1} + 1 - K} \]