4.32) One possible design: $C_1 = C_2 = 0.1 \text{nF}, R_1 = R_3 = R_4 = R_5 = 63.66 \text{k}, R/a = 553.9 \text{k}, R/(1-a) = \infty$. (Let $R/(1-a) = 100 \text{G}$ in LTSpice).

LM741 based response in rust versus theoretical response in blue. There are differences in the midband gain and in the center frequency ($f_o$).

5.2) 

a) One possible design: $a = 1$, $b = 1/Q = 0.2083$, $c = 1$, $d = 0$, $k = 1$. Let $R_o = R_A = 10 \text{k}$. Use $C = 10 \text{nF}$, so $R = 11.11 \text{k}$. Then $R_o/a = R_o/c = 10 \text{k}$, $R_o/b = 48 \text{k}$, $R_o/d = \infty$, $QR = 53.32 \text{k}$, $R/k = 11.11 \text{k}$

Simulation results for LM741 (rust) and desired response are shown below. The 741 design performs well for frequencies below 100 kHz.


e) $q = 5.623 \Rightarrow Q = 1.3553$. One possible design: $a = b = 1$, $c = d = 0$, $k = 1/Q = 0.73784$. Let $C = 0.1 \text{nF}$, $R = 66.31 \text{k}$, $QR = 89.876 \text{k}$, $R/k = 89.876 \text{k}$, $R_o = 10 \text{k}$, $R_o/a = R_o/b = 10 \text{k}$, $R_o/c = R_o/d = \infty$, $R_A = 10 \text{k}$
Simulation results for LM741 (rust) and desired response are shown below. The center frequency is off slightly. The 741 response falls off at around 100 kHz. The second figure below shows the response for the OPA 300. It completely overlaps the desired response up to 1 MHz.

One possible Ack-Moss w/FF Design:

\[ T(s) \text{ parameters: } p = 0.39811, \ H = 1.2589, \ q = 1.4125, \ Q = 16.578, \ \omega_0 = 2\pi \times 40k \]

Ack-Moss w/FF parameters: \( a = c = 1.2589, \ b = 0, \ k = 0.030232 \)

Ack-Moss w/FF components: \( C = 0.1 \text{ nF}, \ R = 39.789 \text{ k}, \ aC = 0.12589 \text{ nF}, \ R/c = 31.606 \text{ k}, \ R/b = \infty, \ R/k = 1.3161 \text{ M}, \ Q R = 659.6 \text{ k} \)

Here are LTSpice simulation results for a 741 based implementation. Simulation in rust, theoretical in blue. Implementation results are terrible. This may be due to the large R/k resistance. Switching to an OPA300 implementation (simulation in second graph) yields very good results. The simulation results almost completely overlap the desired theoretical results.
5.15 (g)

Write transfer function as:

\[ T(s) = \frac{s^2 + \omega_0^2}{s^2 + s\omega_0/Q + \omega_0^2} = \frac{k^2\omega_0^2}{s^2 + s\omega_0/Q + \omega_0^2} = k^2\left(\frac{1/k^2}{s^2 + s\omega_0/Q + \omega_0^2}\right) \]

and implement term in parenthesis using GIC w/FF. Add a noninverting amp with gain \( k^2 \) to implement the complete transfer function.

\( T(s) \) parameters: \( k^2 = 7.6436, \ Q = 1.778 \)

GIC w/FF parameters: \( a = 0.56541, \ b = 0.5, \ c = 1 \)

GIC w/FF components: \( C = 1 \ \text{nF}, \ R = 58.823 \ \text{k}, \ aC = 0.56541 \ \text{nF}, \ (1 - a)C = 0.43459 \ \text{nF}, \ R/c = 58.823k, \ R/(1-c) = \infty, \ Q \ R/b = 209.17 \ \text{k}, \ Q \ R/(1 - b) = 209.17 \ \text{k} \)

Follow GIC with noninv amp with \( RF = 66.436k, \ R1 = 10 \ \text{k} \).

LTSpice 741-based simulation (rust) vs theoretical blue is shown below. The 741-based implementation looks pretty good.