Active Second-order Low-pass Filter
KCL at A: \[
\frac{V_a - V_{in}}{R} + \frac{V_a - V_{out}}{1/C_s} + \frac{V_a - V_b}{R} = 0
\]

Voltage division: \[
V_b = \frac{1/C_s}{R + 1/C_s} V_a = \frac{1}{1 + RC_s} V_a \implies V_a = (1 + RC_s)V_b
\]

Voltage division: \[
V_b = \frac{R_1}{R_1 + R_2} V_{out} = \frac{1}{K} V_{out}, \quad K = 1 + \frac{R_2}{R_1}
\]
Filter Transfer Function

\[ T(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{K}{R^2C^2s^2 + (3 - K)RCs + 1} \]

\[ \lim_{s \to 0} T(s) = \text{DC gain} = K = 1 + \frac{R2}{R1}, \quad 1 \leq K < 3 \]

\[ \lim_{s \to \infty} T(s) = 0 \]
Bode Diagram

The Bode Diagram shows the frequency response of a system with different resistor values. The graphs represent the magnitude (dB) and phase (degree) of the system's transfer function. The frequency range spans from 10^0 Hz to 10^7 Hz. The magnitude graph indicates a decrease in amplitude with increasing frequency, while the phase graph shows a decrease in phase shift. The diagrams are labeled with resistor values of 1k, 10k, 50k, and 100k.
New circuit components

- LM324 OpAmp, Capacitors and dual potentiometer
Constructed Circuit

- Audio mixer + Active filter
Constructed Circuit, with connectors, and volume and cut-off frequency controllers