Output Stage and power amplifiers (Ch. 12)
Sections: 12.5, 12.6, 12.9, 12.10

Bias a class-AB output stage either using diodes, or using $V_{BE}$ multiplier.
Know each circuit configuration, design rules and their pros and cons.
Understand the basic operation principle and circuit diagram of class-D output stage
Class-D power amplifiers: operation principle, circuit configuration,
Why class-D output stage has high power efficiency?

Power transistors
Junction temperature limit, Junction thermal resistance, maximum allowed power
dissipation, BJT safe operation area.

Filters and tunable amplifiers (Ch. 17)
Sections: 17.1, 17.2, 17.3, 17.4, 17.5, 17.7, 17.11, and class notes on Bessel filter and frequency transformation (lowpass to highpass and bandpass)

Filter specifications:
Pass-band ripple (as small as possible),
Stop-band attenuation (as large as possible)
Transition between pass-band and stop-band (as quick as possible)

Polynomial representation of filter transfer functions: with clearly defined zeros and poles (easily to evaluate filter characteristics).

Butterworth filters: (maximally flat gain at low frequencies)
\[ |T(j\omega)|^2 = \frac{1}{1 + \varepsilon^2 (\omega/\omega_p)^{2N}}, \]
Locations of poles?
How to relate parameters to filter performance specifications?

Chebyshev filters:
\[ |T(j\omega)|^2 = \begin{cases} 
\frac{1}{1 + \varepsilon^2 \cos^2[N \cos^{-1}(\omega/\omega_p)]} & \omega \leq \omega_p \\
\frac{1}{1 + \varepsilon^2 \cosh^2[N \cosh^{-1}(\omega/\omega_p)]} & \omega \geq \omega_p 
\end{cases} \]
Locations of poles?
How to relate parameters to filter performance specifications?

Bessel-Thomson filters:
Maximally flat group delay at low frequencies
No analytical expression, but there is an equation to find coefficients. A lookup table is usually used.
Comparison between Butterworth, Chebyshev and Bessel filters.

Transform from a low-pass filter into a high-pass or a band-pass filter

1\textsuperscript{st} order filters: \( T(s) = \frac{a_1s + a_0}{s + \omega_0} \)

Low-pass, high-pass and all-pass (not possible to make band-pass).

2\textsuperscript{nd} order filters (Biquad): \( T(s) = K \frac{k_2s^2 + k_1(\omega_0/Q)s + k_0\omega_0^2}{s^2 + (\omega_0/Q)s + \omega_0^2} \)

Low-pass: \( k_0 = 1, k_1 = 0, k_2 = 0. \)
High-pass: \( k_0 = 0, k_1 = 0, k_2 = 1. \)
Band-pass: \( k_0 = 0, k_1 = 1, k_2 = 0. \)
Notch filter: \( k_0 = 1, k_1 = 0, k_2 = 1. \)

\( \omega_0 \): resonance frequency
\( B = \omega_0/Q, \) 3-dB bandwidth (for band-pass or notch filters)

Poles: \( s_{1,2} = -\frac{\omega_0}{2Q} \pm j\omega_0 \sqrt{1 - \frac{1}{4Q^2}} \), Damping rate of resonance: \( \sigma = -\frac{\omega_0}{2Q} \).

1\textsuperscript{st} and 2\textsuperscript{nd} order filters are fundamental building blocks to make more sophisticated filters.

All filters can be expressed in polynomial form according to the locations of zeros and poles. Then a transfer function can always be decomposed into a combination of 1\textsuperscript{st} and 2\textsuperscript{nd} order functions. So, biquad (2\textsuperscript{nd} order) filter is a fundamental building block with major parameters: \( \omega_0 \) and \( Q \).

How to realize biquad filters:
Traditional way: use RLC circuit
IC circuit: avoid using inductors, but use more op-amps.
Two-integrator-loop, Switched-capacitor filter