Guide to: circuits involving resistors, capacitors, inductors

Applications: DC circuits (with time dependence).

Basic idea: Current is conserved (splits and rejoins); Voltage drops add up in loops to zero.
Each passive element (R, C, L) has its voltage-current relationship.
Kirchhoff's rules lead to differential equations for charge or current.

Derivations: 1) parallel resistors: current splits and rejoins, voltage drop is the same;
series resistors: current is the same, voltage drops add.

2) series capacitors: transient current is the same - same charge Q on both C's; voltage drops depend on Q/C for each capacitor and adds up to total voltage drop.

3) parallel/series inductors: analogous to resistors, since the voltage drop formula is similar to Ohm's law (even though it involves the time derivative of the current instead of the current itself)

Equations: $\Delta V_R = -R\ I(t)$ $\Delta V_C = \frac{Q(t)}{C}$ $\Delta V_L = -L\frac{dI}{dt}$ time dependence is transient

Current definition: $I(t) = \frac{dQ}{dt}$ sometimes we use a minus sign (discharging capacitor)!

Time constants: $\tau = RC$ $\tau = \frac{L}{R}$ $\omega = \frac{2\pi}{T} = \frac{1}{\sqrt{LC}}$

Understand the differential equations for RC, RL, and LC circuits and their solutions!

Energy storage in L and C: $PE_L = \frac{1}{2}L\ I(t)^2$ $PE_C = \frac{1}{2C}\ Q(t)^2$

Problems: 19.22-68; 21.38-49; 62-68; 22.41-47

Always begin with an intuitive understanding how the current flows (from high potential to low), how it splits and re-joins. Group elements together for equivalent R, C, L where necessary and simplify the circuit (re-draw with equivalent elements if it helps you).

Circuits with L and C elements will have transient and steady-state behavior that is different.

Understand the role of switches (simple on/off, vs toggle switch). Circuits with C or L in addition to R always have a charge vs discharge transient regime.

Capacitors allow current to flow until fully charged (exponentially dying current)

Inductors initially inhibit current flow (counter-EMF); pass current in steady state without voltage drop.

LC circuits: energy exchange: simple oscillations; realistic circuit: RLC has damping.