Why are we here?

-Learn circuit analysis

-Learn to be critical thinkers

-Learn to ask "why?", "how?", ...

-Learn to answer your own questions by exploiting all of the resources at your disposal: Where are the clues? Where is the knowledge?

(hint: books, colleagues, experiments, etc.)

-Begin the transition from highly structured middle school to the unconstrained real world

What do engineers do?

Problem solvers

Sleuths

Designers

Creators

Planners

Innovators

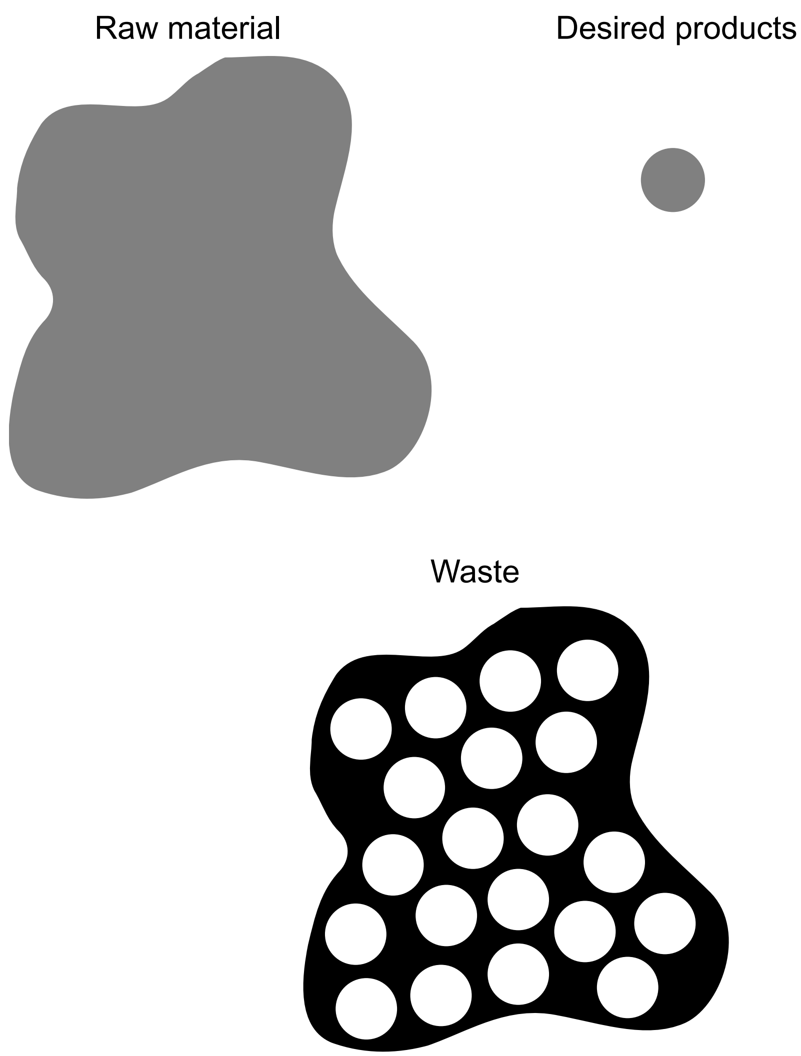
You are the individuals who will craft tomorrow

Much of engineering is just taking a big problem and repeatedly chipping off small bits until nothing is left of the problem.

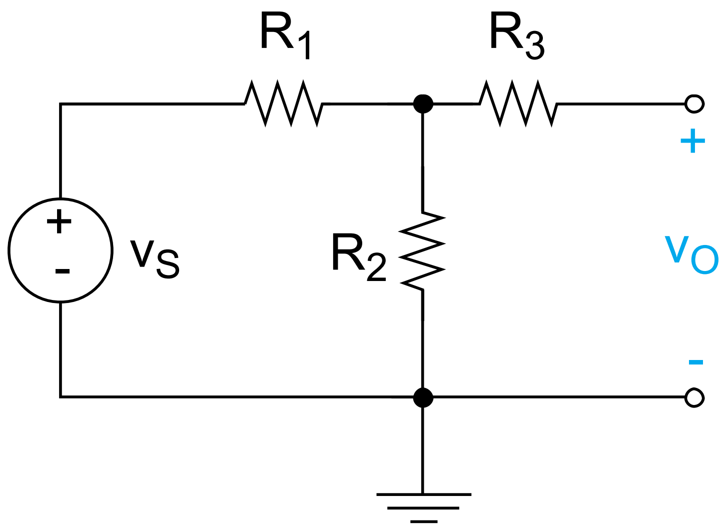
Learn how to make the small chips intuitively rather than memorizing large operations.

E.g., how do you separate X from Y?

Cost of the control- discard some of the desired item and/or keep some of the undesired material

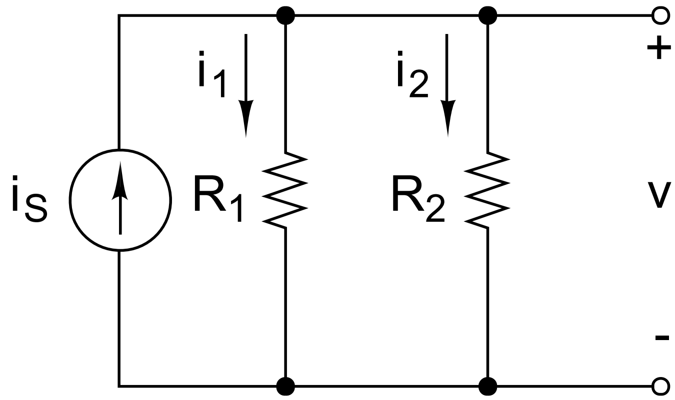


Ye old voltage division



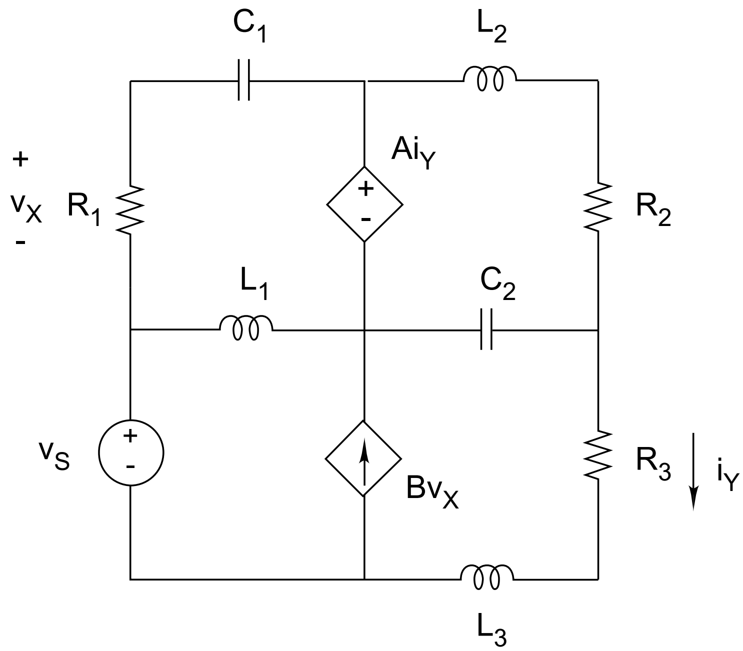
Based on: Ohm's Law

And it's pal, current division...



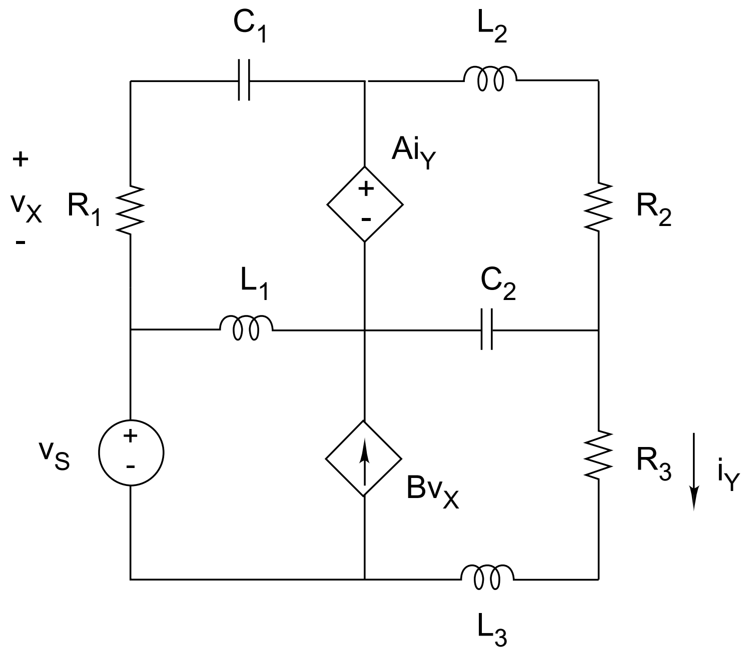
Based on: Ohm's Law

Node Voltage Analysis



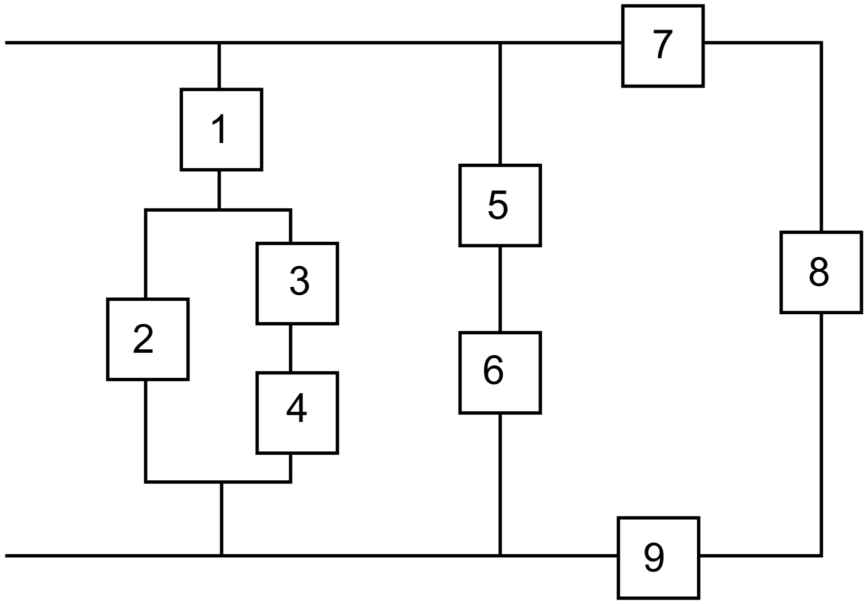
Based on: applying KCL then Ohm's Law... what do you find?
Warning: method defines direction of current and you must address voltage sources as special cases (why?). Also, don't confuse with mesh analysis

Mesh Current Analysis



Based on: applying <u>KVL</u> then Ohm's Law... what do you find?
Warning: method defines direction of current and you must address <u>current</u> sources as special cases (why?). Also, don't confuse with node analysis

If that's a parallelogram, where's my pen?



Serial connections: one line, no external branches (may have internal branches)

Parallel connections: multiple routes between the same pair of nodes

Serial and Parallel

R: can prove with Ohm's law and KVL (P) or KCL (S)

C: can prove with capacitor laws and KVL (P) or KCL (S)

L: can prove with inductor laws and KVL (P) or KCL (S)

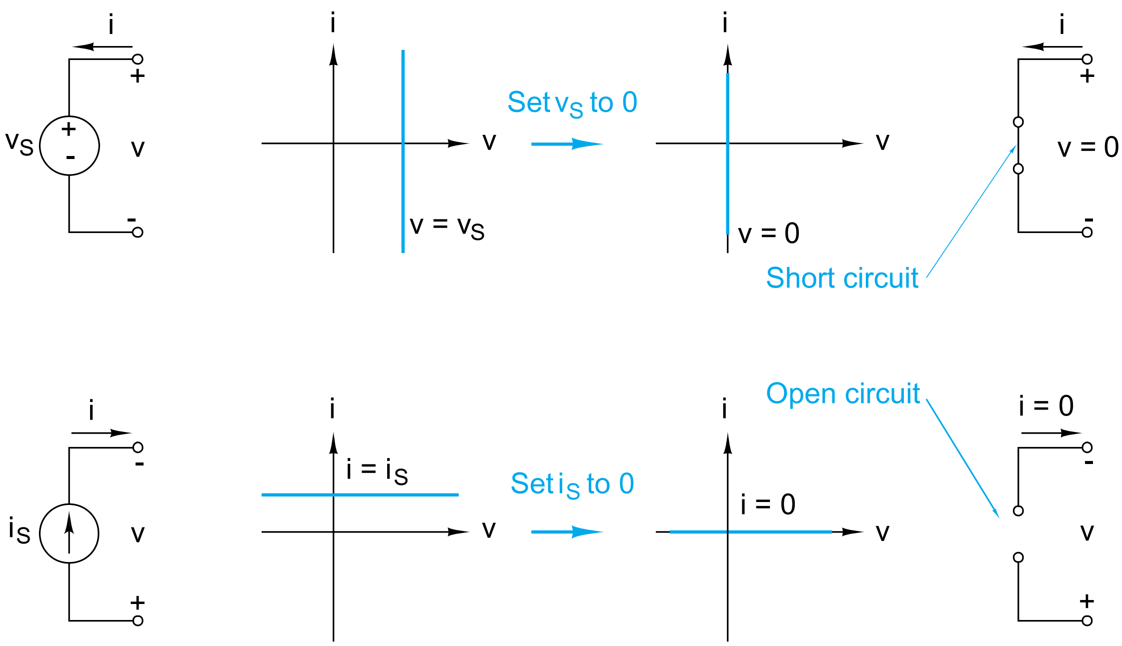
Z: like R, but you can also use impedance to back figure for L & C

I'm Superman... no, just the superposition principle

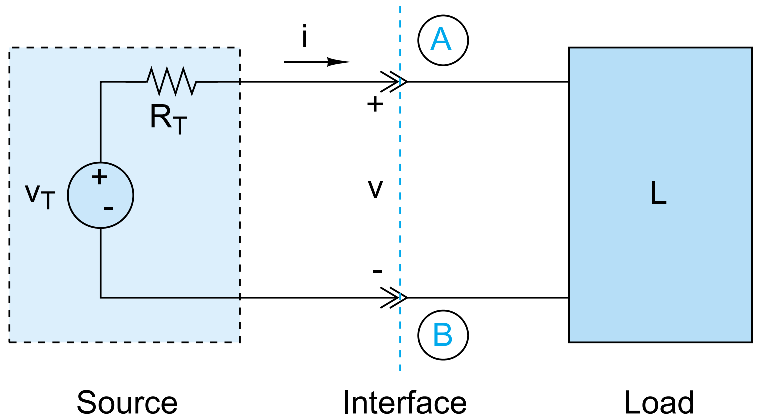
In linear circuits, the contribution of each input is independent of all other inputs. So one can solve a linear circuit by successively turning off all but one of the inputs.

1. "Turn off" all <u>independent</u> sources except one and find the resulting output.
2. Repeat step 1 for each of the remaining independent sources.
3. The net output with all of the sources turned on is the algebraic sum of the outputs caused by each source acting alone.

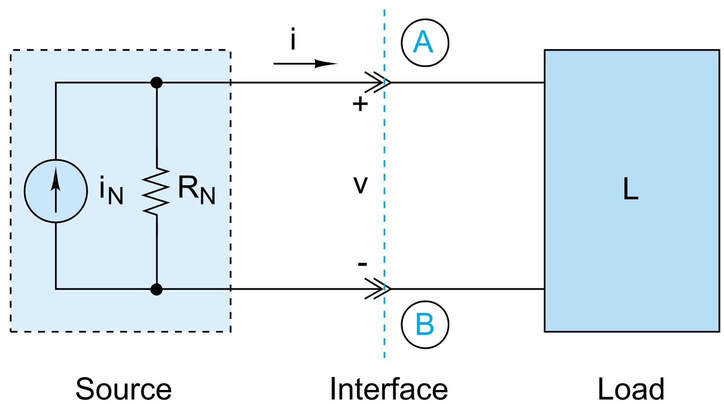
But what do you mean by "turn off"?



Thevenin equivalent



Norton equivalent



Pick two:

1) remove load and measure v_{oc} -> v_T

2) replace load with short and measure i_{sc} -> i_N

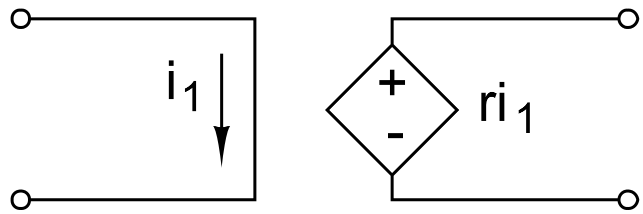
3) turn off all independent sources and measure the resistance as "seen" by the load.

$$v = v_T - iR_N$$

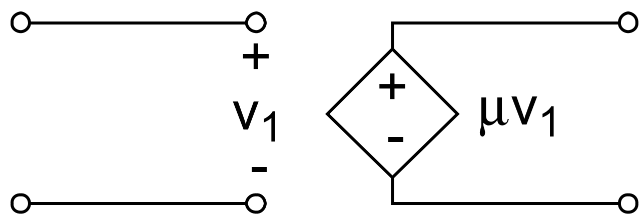
$$i = i_N - \frac{v}{R_N}$$

See lecture 10 for load lines

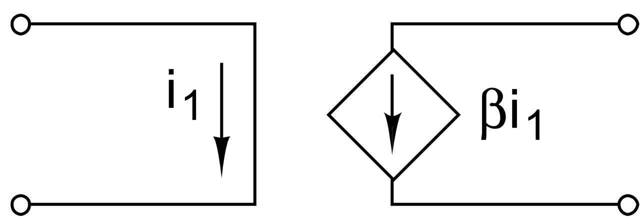
Linear dependent sources:



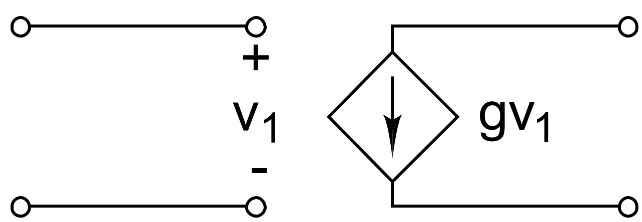
(a) CCVS



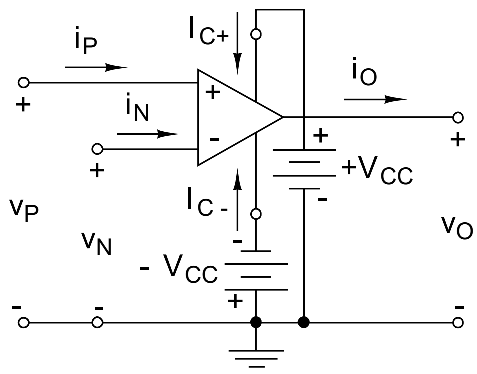
(b)VCVS

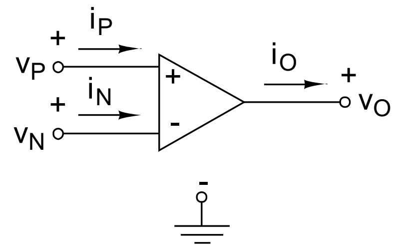


(c) CCCS



(d) VCCS





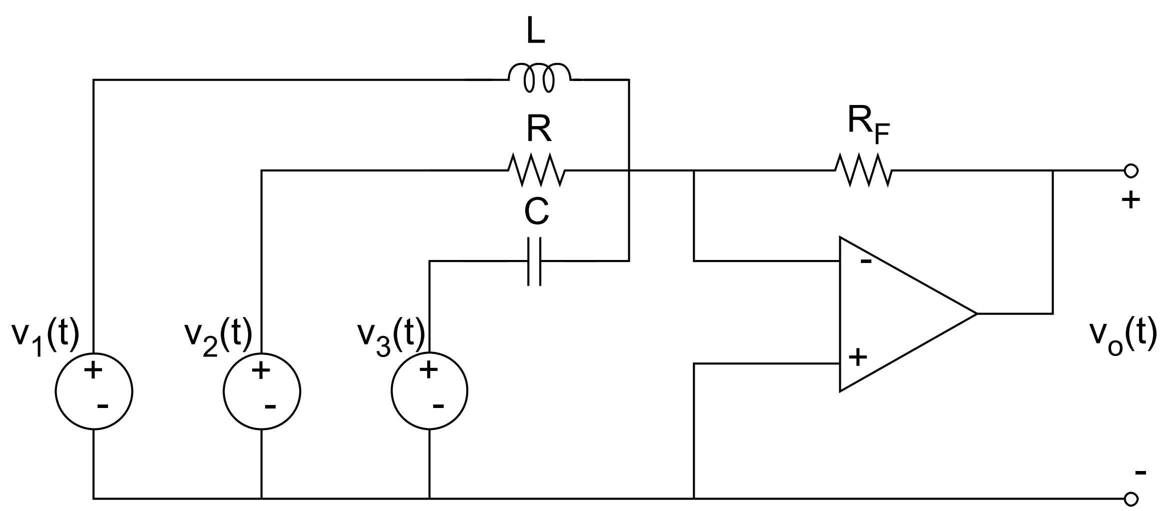
the "ideal model" of the Op Amp:

$v_P = v_N$

$i_P = i_N = 0$

What do we know about v_O and i_O?

What about KCL and Op Amps?



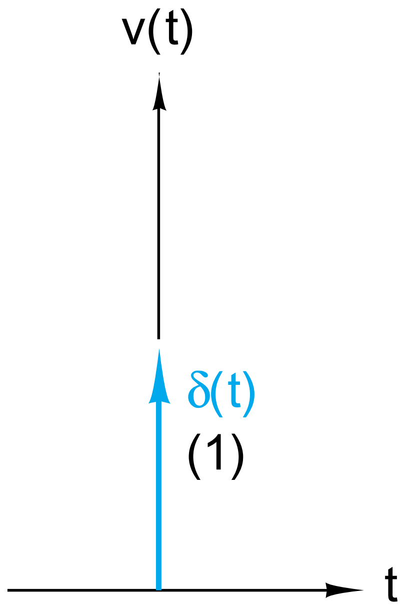
Oh them blasted waveforms...

$$u(t) = \begin{cases} 0, & t < 0 \\ 1, & t \geq 0 \end{cases}$$

count your transitions

$$\delta(t) = \begin{cases} 0, & t \neq 0 \\ 1, & t = 0 \end{cases} \quad \text{and} \quad \int_{-\infty}^{t} \delta(x)dx = u(t)$$

watch your notation



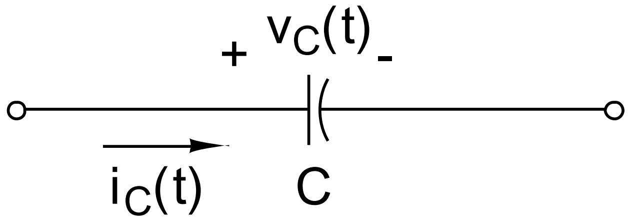
$$r(t) = \int_{-\infty}^{t} u(x)dx = t \cdot u(t) \quad [\text{sec}]$$

If you can't integrate or differentiate graphically, then perhaps you can do it analytically.

$$u(t) = \int_{-\infty}^{t} \delta(x)dx \qquad \delta(t) = \frac{du(t)}{dt}$$

$$r(t) = \int_{-\infty}^{t} u(x)dx \qquad u(t) = \frac{dr(t)}{dt}$$

Capacitance, C: relates voltage and stored charge in a capacitor. The unit of capacitance is the farad (F).



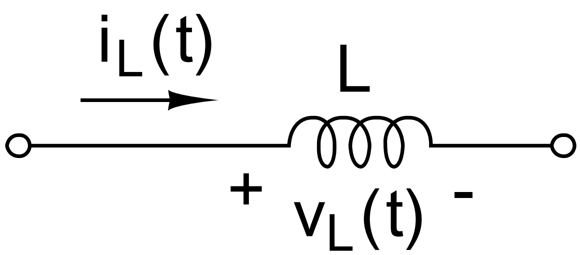
$$q(t) = Cv_C(t)$$

$$i_C(t) = \frac{dq(t)}{dt} = C\frac{dv_C(t)}{dt}$$

$$v_C(t) = v_C(t_o) + \frac{1}{C}\int_{t_o}^{t} i_C(x)dx$$

(parallel menomic)

Inductance, L: relates voltage and stored energy in an inductor. The unit of inductance is the henry (H).



$$v_L(t) = \frac{d\lambda(t)}{dt} = L\frac{di_L(t)}{dt}$$

$$i_L(t) = i_L(t_o) + \frac{1}{L}\int_{t_o}^{t} v_L(x)dx$$

(serial menomic)

Not everything is phasors and impedance

RC (series)

$$R_T C \frac{dv(t)}{dt} + v(t) = v_T(t)$$

RL (parallel)

$$G_N L \frac{di(t)}{dt} + i(t) = i_N(t)$$

"zero-input" or "natural" response

$$R_T C \frac{dv(t)}{dt} + v(t) = 0$$

Only one family of functions satisfy this condition:

$$v(t) = Ke^{st}$$

$$s = \frac{1}{\text{time constant}};$$

$$\text{time constant} = R_{eq} C_{eq} \ or\ G_{eq} L_{eq}$$

Find K using initial state, but be careful if final state is non-zero.

Phasors are great! But they don't belong everywhere...

Which of the following are phasors? Why or why not?

$V_A \cos(\omega t + \phi)$ $V_A \cos(\phi)$ $V_A e^{j(\omega t + \phi)}$

Euler's relationship is handy:

$$e^{j\theta} = \cos\theta + j\sin\theta$$

thus,

j=

Know the difference between phasor domain and time domain.

given v(t)=

$\mathbf{V} =$

$v(t) = \text{Re}\{\mathbf{V} \cdot e^{j\omega t}\}$

note presence/absence of t and ω

What do phasors assume and what do they remove from analysis:

Impedance:

When can you use it?

When is it not appropriate?

What are the two forms?

Resistor impedance:

Capacitor impedance:

Inductor impedance:

Once you find the circuit response, can you find how it changes relative to frequency?

What is characteristic of:

a Low Pass Filter

a High Pass Filter

a Band Pass Filter