Latex Symbols: http://oeis.org/wiki/List of LaTeX mathematical symbols

Metric Prefixes:			
peta	Р	10^{15}	1 000 000 000 000 000
tera	Τ	10^{12}	1 000 000 000 000
giga	G	10^{9}	1 000 000 000
mega	Μ	10^{6}	1 000 000
kilo	k	10^{3}	1 000
hecto	h	10^{2}	100
deca	da	10^{1}	10
one		10^{0}	1
deci	d	10^{-1}	0.1
centi	С	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	μ	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	р	10^{-12}	0.000 000 000 001
femto	f	10^{-15}	0.000 000 000 000 001

Ohm's Law:
$$V = IR$$
, $I = \frac{V}{R}$, $R = \frac{V}{I}$

Power: $P = IV = I^2R = \frac{V^2}{R}$

Energy:

•
$$W = \int_0^t P(s)ds$$

• Unit: Watts,
$$W = \frac{J}{s} = \frac{V^2}{\Omega} = VA = A^2\Omega$$

KCL: Kirchoff's Current Law:

- All currents out of (or into) a point sum to 0
- be careful with signs with this!

KVL: Kirchoff's Voltage Law:

- The sum of voltages around a fixed loop is 0
- be careful with signs with this one too!

Exam 1 stuff:

Source Transformation:

• When you have a current source with a resistor in

parallel to its load or a voltage source with a resistor in series to it's load, you can use Ohm's Law to transform it into the opposite source type.

• The resistor value stays constant, the source type and value changes

Nodal Analysis:

- use KCL to sum all currents at each node to 0
- when in doubt, use more nodes
- remember to have a ground node for reference
- convention is to count current out of the node as positive
 - current sources pointing into the node are counted negative

Superposition:

- evaluate the circuit many times, killing all but one source each time
- sum the results to get the final result (be careful with signs)
- superposition only applies for linear circuits
 - which nearly all are. Notable exception: stuff Norton Equivalent: with diodes

Mesh:(current loop method)

- use KVL to sum all the voltages in each loop to 0
- convention is to loop clockwise
- when you hit a voltage terminal, use the sign of that terminal; e.g. hit negative terminal of V_x means append " $-V_x$ " to equation. (does not matter if V_s is source or component)
- When you hit a resistor, use V = IR to find voltage drop

Thevenin: Independent Only:

- always remove the load resistor (if present) first
- find V_{th} by assuming AB is an open circuit
- find R_{th} :
 - first deactivate all sources in the circuit
 - then determine the equivalent resistance from A to B

Thevenin: Dependent and Independent:

- Note: you can't kill independent sources
- find V_{th} the same way
- find R_{th} :
 - kill all independent sources
 - put a 1Amp independent current source across AB
 - find voltage across new independent source
 - use $R_{th} = \frac{V}{I} = \frac{V}{1 \text{Amp}}$

Thevenin: Dependent Only:

- can't find V_{th} regular way, so use 1Amp source method
- This means you will get $R_{th} = \frac{V_{th}}{1 \text{ Amp}}$

• just use Ohm's Law on the Thevenin Equivalent

Exam 2 stuff:

Ideal Op Amp:

- The output tries to do whatever is necessary to make the difference between the input voltages zero.
- Zero current in/out from the input pin
- For a real op amp, the output voltage is limited to $\pm V_{CC}$
 - Saturated when $|V_{out}| = V_{CC}$

Op Amp - Inverting:

- $V_o \to R_f \to -\text{input}$ $-\text{input} \to R_s \to V_s$ $+input \rightarrow ground$
- R_f : feedback resistor R_s : source resistor
- $V_o = -\frac{R_f}{R}V_s$
- linear region: $\left|\frac{R_f}{R_s}\right| \leq \left|\frac{V_{CC}}{V_s}\right|$

Op Amp - Summing:

- Adds voltages
- Similar to inverting op amp except that each input is wired as $V_x \to R_x \to -\text{input}$. (Only one R_f , but one $R_s = R_r$ for each input)
- $V_o = -\left(\frac{R_f}{R_a}V_a + \frac{R_f}{R_b}V_b + \ldots\right)$
- If $R_f = R_a = R_b \dots$ then $V_o = -(V_a + V_b + \dots)$

Op Amp - Non-inverting:

- +input $\rightarrow R_s \rightarrow V_q \rightarrow$ ground $-\text{input} \rightarrow R_s \rightarrow \text{ground}$ (two different resistors each with value R_s) same R_f feedback resistor as inverting amp
- R_f and R_s form an unloaded voltage divider across -input
- $V_o = \frac{R_s + R_f}{R_s} V_g$
- Linear region: $\frac{R_s + R_f}{R_s} < \left| \frac{V_{CC}}{V_a} \right|$

Op Amp - Difference:

• regular feedback resistor R_b

 R_a : from V_a to -input

 R_c : from V_b to +input

 R_d : from +input to ground

- $V_o = \frac{R_d(R_a + R_b)}{R_a(R_c + R_d)} V_b \frac{R_b}{R_a} V_a$
- if $\frac{R_a}{R_b} = \frac{R_c}{R_d}$ then $V_o = \frac{R_b}{R_a} (V_b V_a)$ Op Amp Integrator:

• Circuit: just like inverting op-amp except with a

- capacitor instead of the feedback resistor (R_f)
- The only resistor is R_s , between the source and the -input of the op amp
- $V_o = -\frac{1}{RC} \int V_{in} dt$
- can be used to turn square wave into sawtooth wave

Op Amp - Differentiator:

- Circuit: just like inverting op-amp except with a capacitor instead of the input resistor (R_s)
- $V_o = -R_f C \frac{dV_{in}}{dt}$
- Can be used to turn sawtooth wave into square Impedance: wave

Inductors:

- Series and parallel is the same as resistors
- Voltage: $V_L(t) = -L \frac{di_L(t)}{dt}$ Energy: $W(t) = \frac{1}{2}L * i(t)^2$
- $\tau = \frac{L}{R}$
- RL Charging: $i(t) = i_f + (i_o i_f)e^{-tR/L}$
- RL Discharging: $i(t) = i_0 e^{-tR/L}$

Capacitors:

- Series and parallel is the opposite as resistors
- Current: $I_c(t) = C \frac{dV_C(t)}{dt}$

Energy: $W(t) = \frac{1}{2}C * V_C(t)^2$

- $\tau = RC$
- V_f =final voltage

 $V_o = \text{initial voltage}$

- RC Charging: $V(t) = V_f + (V_o V_f)e^{-t/(RC)}$
- RC Discharging: $V(t) = V_0 e^{-t/(RC)}$

Exam 3 stuff:

RLC Circuits - Parallel:

- $s_{1,2} = \frac{1}{2/RC} \pm \sqrt{\left(\frac{1}{2RC}\right)^2 \frac{1}{LC}}$ $s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$
- $\alpha = \frac{1}{2RC}$
- resonant frequency: $\omega_0 = \frac{1}{\sqrt{IC}}$

- damping:
 - $\omega_0 < \alpha$: over damped
 - $* V(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$
 - $\omega_0 = \alpha$: critically damped
 - $*V(t) = B_1 t e^{\alpha t} + B_2 e^{\alpha t}$
 - $\omega_0 > \alpha$: under damped
 - * $V(t) = B_1 t e^{\alpha t} \cos(\omega_0 t) + B_2 e^{\alpha t} \sin(\omega_0 t)$
- $\omega_d = \sqrt{\omega_0^2 \alpha^2}$ damped frequency (only relevant for under damped)

- V = IZ
- $Z_R = R$
 - $\phi_R = 0^\circ$
- $Z_L = i\omega L$
 - Current lags 90° behind voltage
 - $\phi_I = -90^{\circ}$
- $Z_C = \frac{1}{i_{VC}}$
 - Current leads voltage by 90°
 - $\phi_C = 90^{\circ}$

Reactance:

- $X_L = \frac{V_L}{I_L} = \omega L = 2\pi f L$
- $X_C = -\frac{1}{\omega C} = -\frac{1}{2\pi f C}$

Complex Power:

- $S = P + iQ = \frac{(V_{RMS})^2}{\sigma^2}$
 - \bar{Z} is complex conjugate of Z
- $P = \frac{V_m I_m}{2} \cos(\theta_v \theta_i)$
- $Q = \frac{V_m I_m}{2} \sin(\theta_v \theta_i)$
- - * also means conjugate

Maximum Power Transfer:

- unrestricted: $Z_L = Z_{Th}$
- restricted: $|Z_L| = |Z_{Th}|$