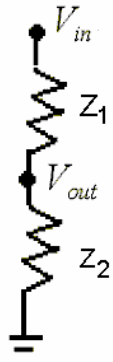
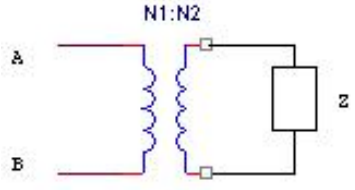
ENGR-4300 **Crib Sheet** **Quiz 1**

components	Resistors	Capacitors	Inductors
symbol	**R**	**C**	**L**
general equation	$V_R = I_R R$	$I_C = C\frac{dV_C}{dt}$	$V_L = L\frac{dI_L}{dt}$
combining in series	$R_T = R_1 + R_2 + \ldots + R_n$	$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$	$L_T = L_1 + L_2 + \ldots + L_n$
combining in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$	$C_T = C_1 + C_2 + \ldots + C_n$	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}$
impedance	$Z_R = R$	$Z_C = \frac{1}{j\omega C}$	$Z_L = j\omega L$
frequency$\rightarrow 0$	R	open circuit	short circuit
frequency$\rightarrow \infty$	R	short circuit	open circuit

Laws and Rules		
Ohm's Law	$V = IR$ $\quad V_T = I_T R_T$	
Kirchoff's Voltage Law	Sum of voltages in a loop is zero.	
Kirchoff's Current Law	Sum of currents entering junction equals the sum of currents leaving junction.	
Reading Resistors	$XYZ = XY \times 10^Z$ ohms	black-brown-R-O-Y-G-B-V-grey-white 0 1 2 3 4 5 6 7 8 9
Reading Capacitors	$XYZ = XY \times 10^Z$ picofarads $= XY \times 10^{(Z-6)}$ microfarads	
Logarithmic Scales	log(f)=[decade].[percent across]	$f = 10^{[\text{decade}].[\text{percent across}]}$
suffixes	K (10^3) Meg(10^6) G(10^9) T(10^{12})	m(10^{-3}) μ(10^{-6}) n(10^{-9}) p(10^{-12})
Euler's Identity $e^{j\theta} = \cos\theta + j\sin\theta$	parallel combination shortcut $R_{12} = \frac{R_1 R_2}{R_1 + R_2}$	Power Equation $P = VI = I^2 R$

Voltage Dividers	**Sine Waves**
 $V_{out} = \left(\frac{Z_2}{Z_1 + Z_2}\right) V_{in}$ $V_1 = \left(\frac{Z_1}{Z_1 + Z_2}\right) V_{in}$ $V_2 = \left(\frac{Z_2}{Z_1 + Z_2}\right) V_{in}$	$v(t) = A\sin(\omega t + \phi) + V_{DC}$ $\omega = 2\pi f \qquad f = \frac{1}{T}$ $\phi = -\omega t_0 = -2\pi \frac{t_0}{T}$ $V_{p-p} = 2A \qquad V_{rms} = \frac{A}{\sqrt{2}}$

Transformers		
	ideal equations	input impedance
	$a = \frac{N_2}{N_1} = \frac{V_2}{V_1} = \frac{I_1}{I_2} = \sqrt{\frac{L_2}{L_1}}$	$Z_{in} = Z_{AB} = \frac{Z}{a^2}$

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Calculating Inductance		Calculating Resistance
Long Coil	Ring shaped Coil	
$L = \frac{\mu N^2 \pi r_c^2}{d}$	$L = \mu N^2 r_c \left[\ln(\frac{8r_c}{r_w}) - 2 \right]$	$R = \frac{l}{\sigma A}$

Complex Polar Coordinates

Complex numbers: $z = x + jy = re^{j\theta}$ ($j = \sqrt{-1}$, 1/j = -j)

Polar to Cartesian transform: $x = r\cos\theta$, $y = r\sin\theta$

Cartesian to Polar transform: $r = \sqrt{x^2 + y^2}$ $\theta = \tan^{-1}\left(\frac{y}{x}\right)$

$$\vec{V} = \frac{x_1 + jy_1}{x_2 + jy_2} \quad |\vec{V}| = \frac{\sqrt{x_1^2 + y_1^2}}{\sqrt{x_2^2 + y_2^2}} \quad \angle\vec{V} = \tan^{-1}\left(\frac{y_1}{x_1}\right) - \tan^{-1}\left(\frac{y_2}{x_2}\right)$$

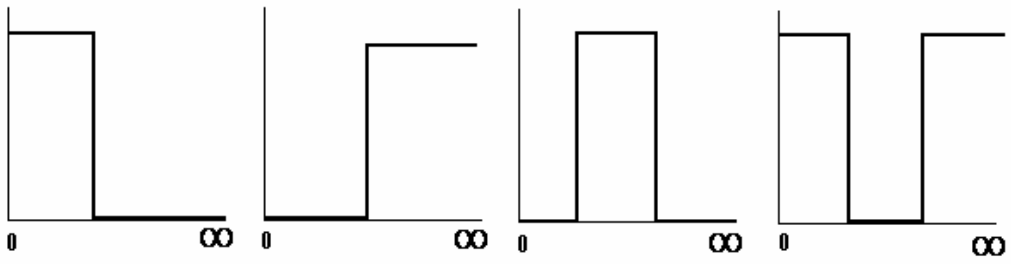
$$\vec{V} = Ae^{j(\omega t + \phi)} = A\cos(\omega t + \phi) + jA\sin(\omega t + \phi)$$

phases	
A	0
-A	π or -π
jA	$\pi/2$
-jA	$-\pi/2$
1	$\pi/4$ or $3\pi/4$
-1	$-\pi/4$ or $-3\pi/4$
x+jy	$\tan^{-1}(y/x)$

where A is a constant

Transfer Functions

$\vec{V} = \vec{I}\,Z$	$H(j\omega) = \frac{\vec{V}_{out}}{\vec{V}_{in}}$	$H(j\omega) = \frac{Z_2}{Z_1 + Z_2}$ *series circuit only*
Combining Impedances	$Z_{eq} = Z_1 + Z_2 + \ldots + Z_N$ *series*	$\frac{1}{Z_{eq}} = \frac{1}{Z_1} + \frac{1}{Z_2} + \ldots + \frac{1}{Z_N}$ *parallel*
Low Frequency Approximation	$\frac{A_n\omega^n + A_{n-1}\omega^{n-1} + \ldots + A_k\omega^k}{A_m\omega^m + A_{m-1}\omega^{m-1} + \ldots + A_r\omega^r} \approx \frac{A_k\omega^k}{A_r\omega^r} = \frac{A_k}{A_r}\omega^{k-r}$	
High Frequency Approximation	$\frac{A_n\omega^n + A_{n-1}\omega^{n-1} + \ldots + A_k\omega^k}{A_m\omega^m + A_{m-1}\omega^{m-1} + \ldots + A_r\omega^r} \approx \frac{A_n\omega^n}{A_m\omega^m} = \frac{A_n}{A_m}\omega^{n-m}$	
Using Transfer Functions	$A_{out} = \lvert H \rvert \cdot A_{in}$	$\phi_{out} = \angle H + \phi_{in}$

Filters

RC Circuit (corner)	RL Circuit (corner)	RLC Circuit (resonant)
$\omega_C = \frac{1}{RC}$ $f_C = \frac{1}{2\pi RC}$	$\omega_C = \frac{R}{L}$ $f_C = \frac{R}{2\pi L}$	$\omega_0 = \frac{1}{\sqrt{LC}}$ $f_C = \frac{1}{2\pi\sqrt{LC}}$