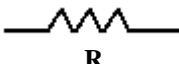
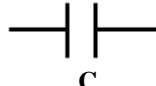
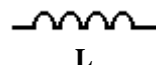
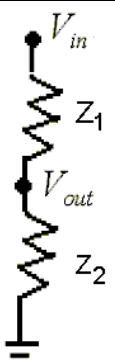


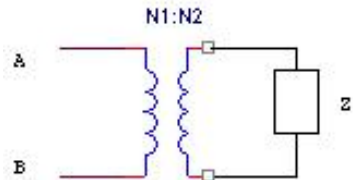
DO NOT WRITE ON THIS SHEET

RETURN SHEET AFTER QUIZ

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	$R_T = R_1 + R_2 + \dots + R_n$	$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}$	$L_T = L_1 + L_2 + \dots + L_n$
combining in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$	$C_T = C_1 + C_2 + \dots + C_n$	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \dots + \frac{1}{L_n}$
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 x 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 x 10 ^Z picofarads = XY x 10 ^(Z-6) microfarads	
Logarithmic Scales	log(f)=[decade].[percent across]	f = 10 ^{[decade].[percent across]}
suffices	K (10 ³) Meg(10 ⁶) G(10 ⁹) T(10 ¹²)	m(10 ⁻³) μ(10 ⁻⁶) n(10 ⁻⁹) p(10 ⁻¹²)
<u>Euler's Identity</u> $e^{j\theta} = \cos \theta + j \sin \theta$	<u>parallel combination shortcut</u> $R_{12} = \frac{R_1 R_2}{R_1 + R_2}$	<u>Power Equation</u> $P = VI = I^2 R$

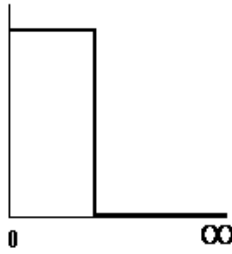
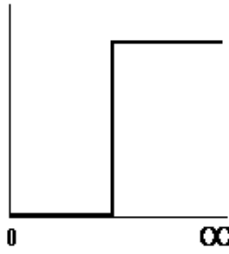
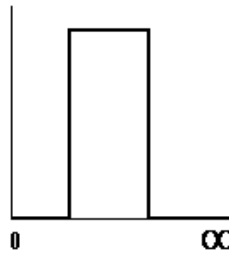
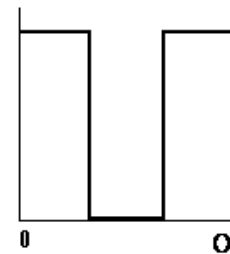
Voltage Dividers	Sine Waves
 $V_{out} = \left(\frac{Z_2}{Z_1 + Z_2} \right) V_{in}$ $V_1 = \left(\frac{Z_1}{Z_1 + Z_2} \right) V_{in}$ $V_2 = \left(\frac{Z_2}{Z_1 + Z_2} \right) V_{in}$	$v(t) = A \sin(\omega t + \phi) + V_{DC}$ $\omega = 2\pi f \quad f = \frac{1}{T}$ $\phi = -\omega t_0 = -2\pi \frac{t_0}{T}$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

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

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

Complex Polar Coordinates																	
Complex numbers: $z = x + jy = re^{j\theta}$ ($j = \sqrt{-1}$, $1/j = -j$)	<table border="1"> <thead> <tr> <th colspan="2">phases</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>0</td> </tr> <tr> <td>-A</td> <td>π or $-\pi$</td> </tr> <tr> <td>jA</td> <td>$\pi/2$</td> </tr> <tr> <td>-jA</td> <td>$-\pi/2$</td> </tr> <tr> <td>$\tan^{-1}(1)$</td> <td>$\pi/4$ or $-3\pi/4$</td> </tr> <tr> <td>$\tan^{-1}(-1)$</td> <td>$-\pi/4$ or $3\pi/4$</td> </tr> <tr> <td>x+jy</td> <td>$\tan^{-1}(y/x)$</td> </tr> </tbody> </table> <p>where A is a constant</p>	phases		A	0	-A	π or $-\pi$	jA	$\pi/2$	-jA	$-\pi/2$	$\tan^{-1}(1)$	$\pi/4$ or $-3\pi/4$	$\tan^{-1}(-1)$	$-\pi/4$ or $3\pi/4$	x+jy	$\tan^{-1}(y/x)$
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Polar to Cartesian transform: $x = r \cos \theta$, $y = r \sin \theta$																	
Cartesian to Polar transform: $r = \sqrt{x^2 + y^2}$ $\theta = \tan^{-1}\left(\frac{y}{x}\right)$																	
$\vec{V} = \frac{x_1 + jy_1}{x_2 + jy_2}$ $ \vec{V} = \frac{\sqrt{x_1^2 + y_1^2}}{\sqrt{x_2^2 + y_2^2}}$ $\angle \vec{V} = \tan^{-1}\left(\frac{y_1}{x_1}\right) - \tan^{-1}\left(\frac{y_2}{x_2}\right)$																	
$\vec{V} = Ae^{j(\omega t + \phi)} = A \cos(\omega t + \phi) + jA \sin(\omega t + \phi)$																	

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

Filters			
RC Circuit (corner)	RL Circuit (corner)	RLC Circuit (resonant)	
$\omega_c = \frac{1}{RC}$ $f_c = \frac{1}{2\pi RC}$	$\omega_c = \frac{R}{L}$ $f_c = \frac{R}{2\pi L}$	$\omega_0 = \frac{1}{\sqrt{LC}}$	$f_c = \frac{1}{2\pi \sqrt{LC}}$
			
low pass filter	high pass filter	band pass filter	band reject filter