Lindsey Paul – Notes for EGB120, also called ENB120

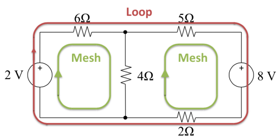
Units:

Charge, q, $1.6022 \cdot 10^{-19}\ C$, Coulombs	Voltage, v, Volt
Current, i, Amperes	Energy, w, Watt
Power, p – w/t Watt = J/s	Inductance, L - Henrys
Resistance, R - Ohms	Capacitance, C - Farads

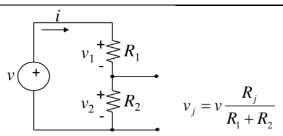
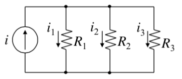
Prefixes:

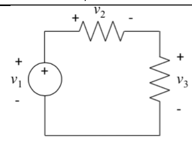
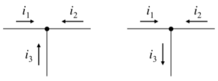
Giga	G	^9
Mega	M	^6
Kilo	K	^3
Milli	m	^-3
Micro	μ	^-6
Nano	n	^-9
Pico	p	^-12
Femto	f	^-15

Terms

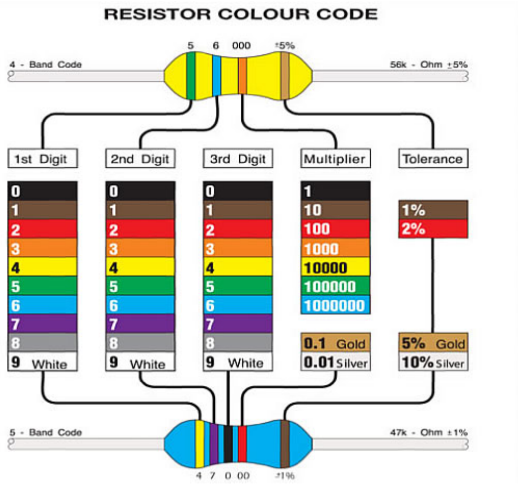
Passive Element	Cannot generate energy
Impedance, Z	Complex resistance, Ohms. Captures the magnitude and phase change associated with the circuit element.
Attenuation	Gain of less than 1
Node	A point where two or more circuit elements join
Essential Node	A point where three or more elements join
Earth	An earthed ground is literally attached to the ground
Loop	A path with the same start and end node
Mesh	A loop that does not enclose any other loops. 

Main Formulae:

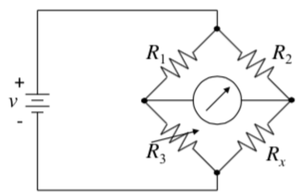
Current:	$i = \frac{dq}{dt}, 1A = \frac{1C}{s}$
Voltage:	$v = \frac{dw}{dq}, 1V = \frac{1J}{C}$
Power:	$p = \frac{dw}{dt}, 1W = \frac{1J}{s}$
Ohms Law:	$v = iR$
Voltage Divider	 $v_j = v\frac{R_j}{R_1 + R_2}$
Current Divider	 $i_j = \frac{v}{R_j} = i\frac{(R_1 \Vert R_2 \Vert R_3)}{R_j}$
Capacitor Equation:	$q = Cv, i = C\frac{dv}{dt}$, 1F = 1C/v
Inductor Equation:	$v = L\frac{di}{dt}$

Decibels, dB	gain in dB $= 20\log_{10}\lvert H \rvert$ H=Vout/Vin
KVL	 $v_1 - v_2 - v_3 = 0$ $v_1 = v_2 + v_3$
KCL	 $i_1 + i_2 + i_3 = 0$, $i_1 + i_2 = -i_3$ $i_1 + i_2 - i_3 = 0$, $i_1 + i_2 = i_3$

Resistors:

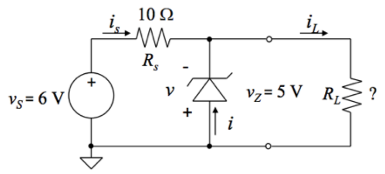


Wheatstone Bridge Circuit:

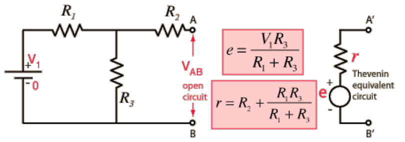
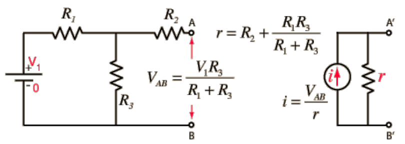
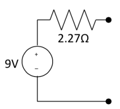
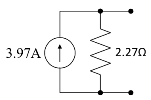
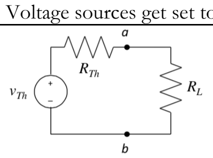
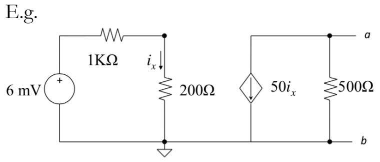
What is it?	-Can be used as a strain gauge -Bridge is said to be balanced when no current flows through the ammeter -Balance by adjusting R3
Diagram:	 $R_x = \frac{R_2}{R_1}R_3$

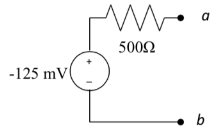
Mesh Analysis:

What is it?	Complex circuit analysis method -must choose a ground
Steps:	-Label unknown mesh currents -Find v across each of the circuit elements in terms of mesh currents -Use KVL to create simultaneous equations -Solve for mesh currents

	 $i_s R_s < (v_s - v_z)$ For a small negative i, $i_s \approx i_L$ $\therefore i_L R_s < (v_s - v_z)$ $i_L < \frac{(v_s - v_z)}{R_s}$ $i_L < 100\text{ mA}$

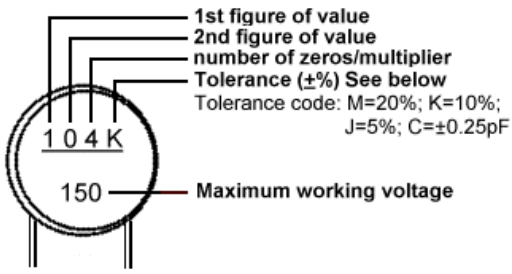
Equivalent Circuits:

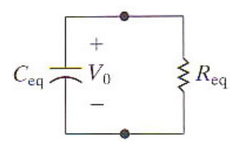
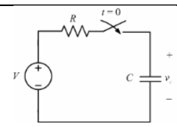
Thevenin Equivalent Circuit	
Norton Equivalent Circuit	
N.B.	The r values are the same for Norton and Thevenin  $i_{sc} = \frac{v_{OC}}{R_{th}}$, $R_{Th} = R_p$ 
Super-position	Calculate for each invididual element. Current sources get set to open circuits Voltage sources get set to short circuits
Getting Maximum Power From a Thevenin Source	 $i_L = \frac{v_{Th}}{R_{Th} + R_L}$ $P_L = i_L^2 R_L = \frac{v_{Th}^2}{(R_{Th} + R_L)^2}.R_L$
Thevenin Dependant Source	E.g.  Find the Thevenin equivalent $i_x = \frac{6\times10^{-3}}{1200} = 5\times10^{-6} = 5\mu A$ $v_{Th} = v_a - v_b = -50\times5\mu A\times500\Omega = -125mV$ $i_{sc} = -50 i_x = -50\frac{6\times10^{-3}}{1200} = -250\mu A$ $R_{Th} = \frac{-125mV}{-250\mu A} = 500\Omega$ Which produces the following:

Capacitors:

What do they do?	-Caps store energy as voltage
$C = \frac{\varepsilon A}{d}$	A = Area of Plates Epsilon = Dielectric Constant d = Distance Between Plates
Series/Parallel	$C_{parallel} = C_1 + C_2$ $C_{Series} = (C^{-1} + C^{-1})^{-1}$
DC Steady State	$i = C\frac{dV}{dT} = 0$ v is constant = open circuit
NB	Discharged Caps are at 0V
Relationship to vi	$v(t) = \frac{1}{C}\int_0^t i\, d\tau + v(0)$
Energy in a Cap	$w = \frac{1}{2}Cv^2, Watts$



Natural Response of RC Circuit – Discharging $v(t) = v(0)e^{\frac{-t}{RC}}$ Tau = RC = time constant	
Step Response of and RC – charging $v(t) = I_sR + (V_0 - I_sR)e^{\frac{-t}{RC}}$ $t \ge 0$	

Inductor:

What do they do?	-Store energy as current -Cannot generate energy, passive element
Series/Parallel	$L_{Series} = L_1 + L_2$ $L_{Parallel} = (L^{-1} + L^{-1})^{-1}$
DC Steady State	$v = L\frac{di}{dT} = 0$ I is constant, short circuit