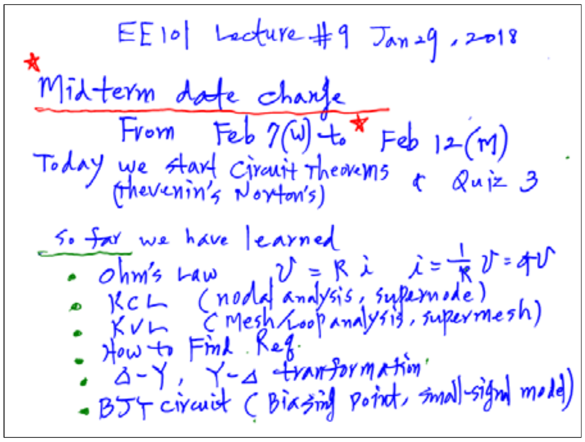
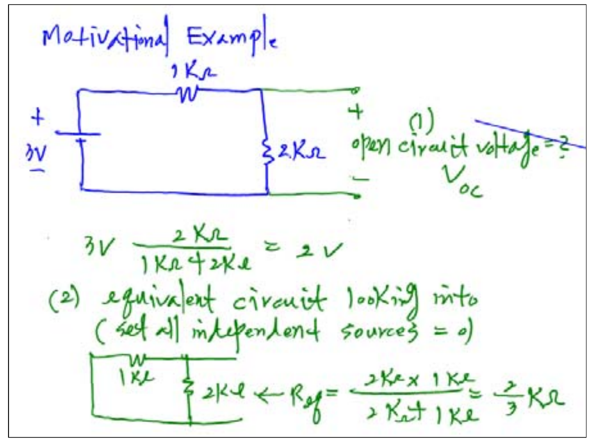
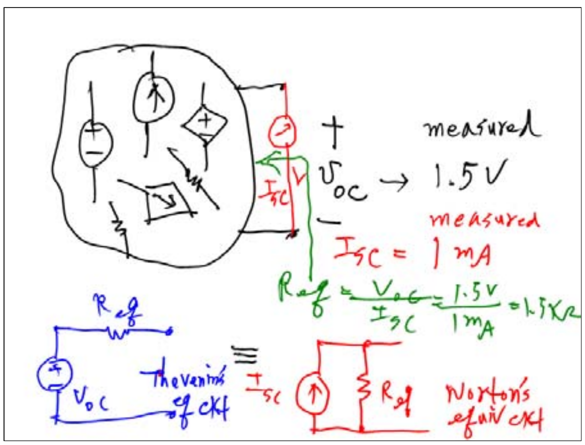
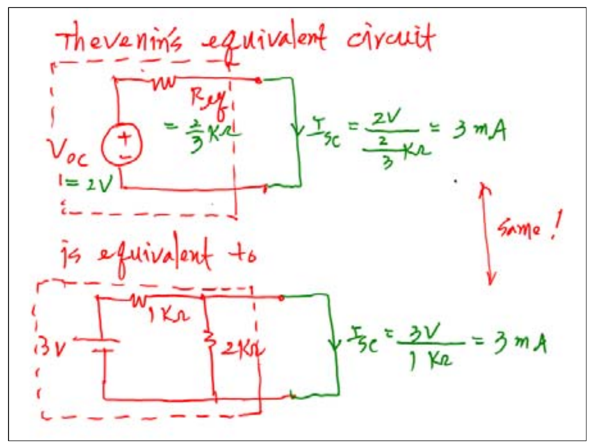
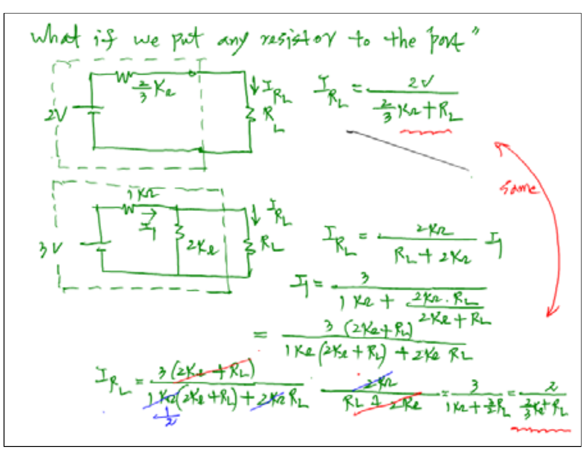
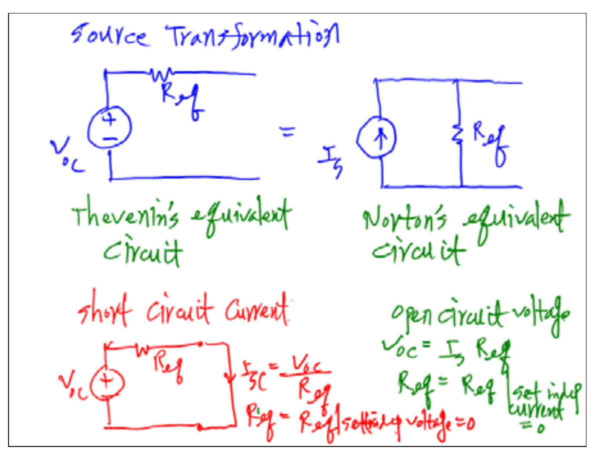

EE101 Lecture #9 Jan 29, 2018
Midterm date change
From Feb 7(W) to Feb 12(M)
Today we start circuit theorems & Quiz 3
(thevenin's Norton's)
so far we have learned
• Ohm's Law v = R i i = 1/R v = Gv
• KCL (nodal analysis, supernode)
• KVL (Mesh/Loop analysis, supermesh)
• How to Find Req
• Δ-Y, Y-Δ transformation
• BJT circuit (Biasing point, small-signal model)

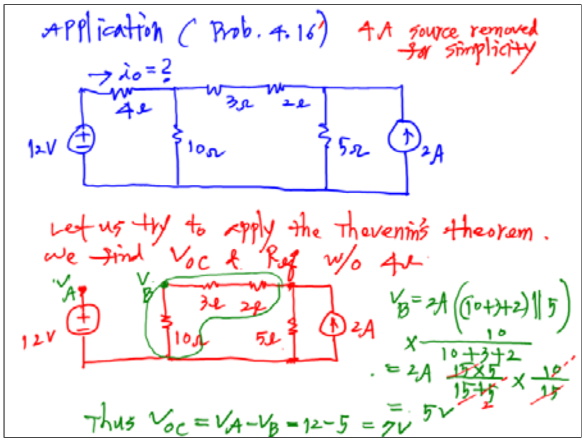

Motivational Example
1 KΩ
+
3V
−
2KΩ
+
(1) open circuit voltage = ?
Voc
−
3V · 2KΩ / (1KΩ + 2KΩ) = 2V
(2) equivalent circuit looking into
(set all independent sources = 0)
1KΩ
2KΩ ← Req = 2KΩ × 1KΩ / (2KΩ + 1KΩ) = 2/3 KΩ

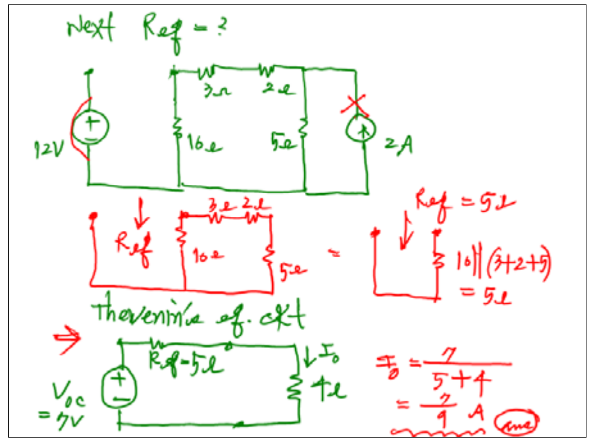

+
voc → 1.5V
measured
−
Isc
measured
Isc = 1 mA
Req = Voc / Isc = 1.5V / 1mA = 1.5KΩ
Req
Voc
Thevenin's eq ckt
≡
Isc
Req
Norton's equiv ckt

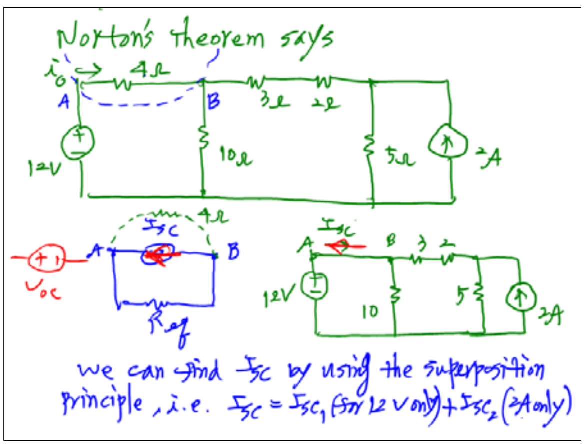

Thevenin's equivalent circuit
Req = 2/3 KΩ
Voc = 2V
Isc = 2V / (2/3 KΩ) = 3 mA
Same!
is equivalent to
1KΩ
3V
2KΩ
Isc = 3V / 1KΩ = 3 mA

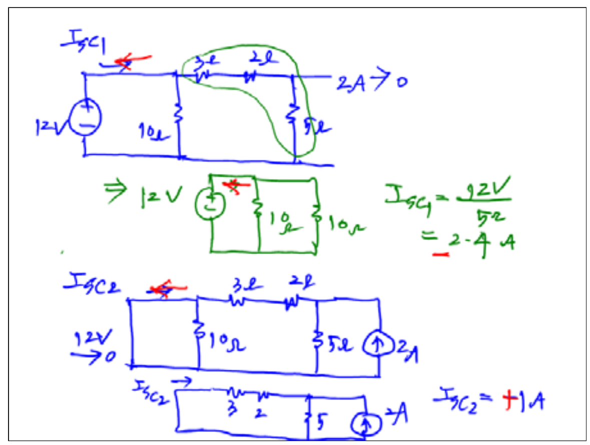

What if we put any resistor to the port?
2/3 KΩ
2V
IRL
RL
IRL = 2V / (2/3 KΩ + RL)
Same
1KΩ
I1
3V
2KΩ
IRL
RL
IRL = 2KΩ / (RL + 2KΩ) · I1
I1 = 3 / (1KΩ + 2KΩ·RL / (2KΩ + RL))
= 3(2KΩ + RL) / (1KΩ(2KΩ + RL) + 2KΩ RL)
IRL = 3(2KΩ + RL) / (1KΩ(2KΩ + RL) + 2KΩ RL) · 2KΩ / (RL + 2KΩ) = 3 / (1KΩ + 3/2 RL) = 2 / (2/3 KΩ + RL)

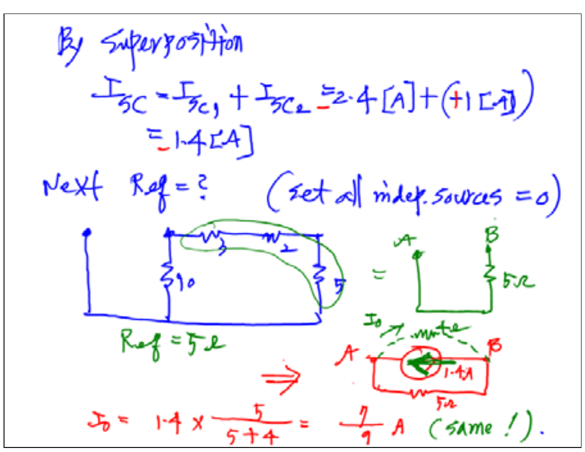

Source Transformation
Req
Voc
=
Is
Req
Thevenin's equivalent circuit
Norton's equivalent circuit
short circuit current
Voc
Req
Isc = Voc / Req
Req = Req | setting voltage = 0
open circuit voltage
Voc = Is Req
Req = Req | set indep current = 0

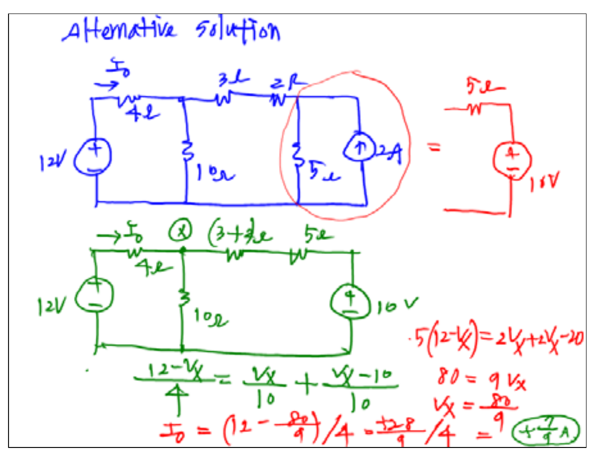

Application (Prob. 4.16)
4A source removed for simplicity
$i_o = ?$
4Ω 3Ω 2Ω
12V 10Ω 5Ω 2A
Let us try to apply the Thevenin's theorem.
We find V_{oc} & R_{eq} w/o 4Ω
V_A V_B
$V_B = 2A\left((10+3+2)\parallel 5\right) \times \frac{10}{10+3+2}$
$= 2A \frac{15\times5}{15+5} \times \frac{10}{15}$
$= 5V$
Thus $V_{oc} = V_A - V_B = 12 - 5 = 7V$


Next $R_{eq} = ?$
3Ω 2Ω
12V 10Ω 5Ω 2A
$R_{eq} = 5Ω$
$10 \parallel (3+2+5) = 5Ω$
Thevenin's eq. ckt
$R_{eq} = 5Ω$
$V_{oc} = 7V$
I_o 4Ω
$I_o = \frac{7}{5+4} = \frac{7}{9}$ A


Norton's theorem says
i_o 4Ω
A B 3Ω 2Ω
12V 10Ω 5Ω 2A
V_{oc} I_{SC} R_{eq}
12V 10 5 2A
We can find I_{SC} by using the superposition principle, i.e. $I_{SC} = I_{SC_1}$ (for 12V only) $+ I_{SC_2}$ (2A only)


I_{SC1}
3Ω 2Ω
2A → 0
12V 10Ω 5Ω
12V 10Ω 10Ω
$I_{SC_1} = \frac{12V}{5Ω} = 2.4$ A
I_{SC2}
3Ω 2Ω
12V → 0
10Ω 5Ω 2A
$I_{SC_2} = +1$ A


By superposition
$I_{SC} = I_{SC_1} + I_{SC_2} = 2.4$ [A] $+ (+1$ [A]$)$
$= 1.4$ [A]
Next $R_{eq} = ?$ (set all indep. sources = 0)
10 3 2 5
A B 5Ω
$R_{eq} = 5Ω$
I_o 4Ω 1.4A 5Ω
$I_o = 1.4 \times \frac{5}{5+4} = \frac{7}{9}$ A (same!).


Alternative solution
I_o 4Ω 3Ω 2Ω
12V 10Ω 5Ω 2A
5Ω 10V
I_o $(3+2)Ω$ 5Ω
12V 10Ω 10V
$\frac{12-V_x}{4} = \frac{V_x}{10} + \frac{V_x - 10}{10}$
$5(12 - V_x) = 2V_x + 2V_x - 20$
$80 = 9V_x$
$V_x = \frac{80}{9}$
$I_o = (12 - \frac{80}{9})/4 = \frac{28}{9}/4 = \frac{7}{9}$ A