EE 42
Midterm Exam No. 1
27 February 2002

Put your name (printed, signed), your student identification number, and the number of the Discussion Section that you attend here:

Print Name (last, first) ______________________ Sign Name______________________
S. I. D. ______________________ Discussion Section No. ____________

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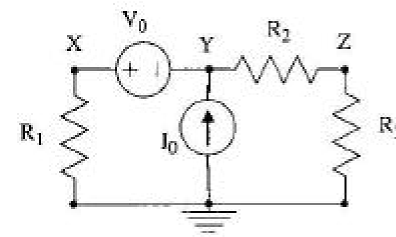
NOTE: THERE ARE SEVERAL DIFFERENT VERSIONS OF THIS EXAM IN THE ROOM. Your responses will be different from those of your neighbors. Keep you eyes on your own paper.

PLEASE DON'T OPEN THE TEST UNTIL THE PROCTOR SAYS YOU MAY BEGIN

Table 1:

Page	Points/ Possible
2	/15
3	/15
4	/35
5	/15
6	/10
7	/10
TOTAL	/100

1 (15 points). Write enough nodal equations to solve for all unknown currents and voltages in the circuit shown below. (IT IS NOT NECESSARY TO SOLVE THESE EQUATIONS.



Nodes X and Y

We have a supernode.

$$V_x - V_y = V_0 \quad (1)$$

$$\frac{V_x}{R_1} - I_0 + \frac{V_y - V_z}{R_2} = 0 \quad \text{or} \quad \frac{V_x}{R_1} - I_0 + \frac{V_y}{R_2 + R_3} = 0 \quad (2)$$

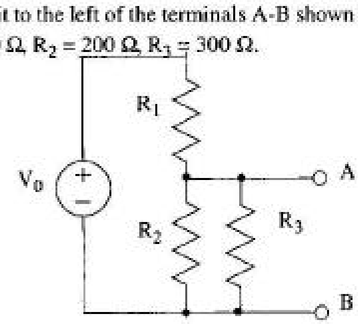
Node Z

$$\frac{V_z - V_y}{R_2} + \frac{V_z}{R_3} = 0 \quad (3)$$

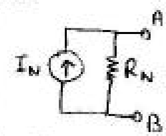
3 Unknown voltages : V_x, V_y, V_z

3 Equations.

2. (15 points). Draw the Norton equivalent circuit, and find its I_N and R_N, that is equivalent to the circuit to the left of the terminals A-B shown below. The values of the elements are: $V_0 = 6V$, $R_1 = 100\ \Omega$, $R_2 = 200\ \Omega$, $R_3 = 300\ \Omega$.



a. Draw Norton equivalent circuit here -->

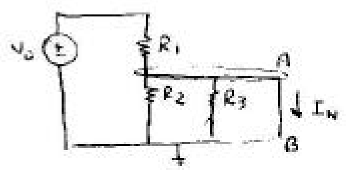


Norton Equivalent

b. I_N = 60mA

c. R_N = 54.5 Ω

I_N



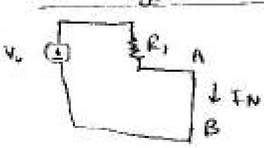
1st way: Nodal Analysis

$$\frac{V_A - V_0}{R_1} + \frac{V_A}{R_2} + \frac{V_A}{R_3} + I_N = 0$$

$V_A = 0$ (Goes to ground through a wire)

$\Rightarrow I_N = \frac{V_0}{R_1} = \frac{6\,V}{100\,\Omega} \Rightarrow \boxed{I_N = 60\,mA}$

2nd way: The wire takes out R_2, R_3

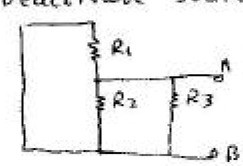


$\Rightarrow I_N = \frac{V_0}{R_1} = \frac{6\,V}{100\,\Omega} = 60\,mA$

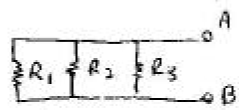
So $\boxed{I_N = 60\,mA}$

R_N

1) Deactivate sources



which is the same as



So, we have R_1, R_2, R_3 in parallel $\Rightarrow R_N = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = \frac{600}{11}\ \Omega$

$\Rightarrow \boxed{R_N = 54.5\ \Omega}$

True-False Questions:

3.(5 points) The equivalent resistance of six resistors connected in parallel is larger than the value of any of the individual resistors. True __ False ✓

4. (5 points) The equivalent resistance of six resistors connected in series is smaller than the value of any of the individual resistors. True __ False ✓

5. (5 points) The prefixes used to represent 1000, 1/1000, and 10^{-9}, respectively, are mezzo, milli, and nano, respectively. True __ False ✓

6. (5 points). To measure current flowing in a circuit element you connect an ammeter across the circuit element. False.

7. (5 points) An ideal voltmeter is electrically equivalent to a short circuit (zero resistance). True __ False ✓

8. (5 points) The electrical units for capacitance, inductance and voltage are henries, farads and volts. True __ False ✓

9. (5 points) If a 4-volt supply delivers current through a switch, resistor, and inductor connected in series, the voltage generated when the switch is operated cannot exceed 4 V. True __ False ✓

3. It should have been smaller than

4. It should have been larger than

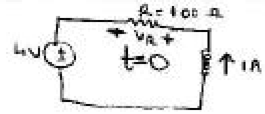
5. <u>kilo</u>, milli and nano

6. The ammeter is connected <u>in series</u> :

7. It is electrically equivalent to an open circuit

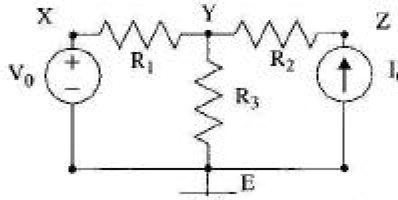
8. Farads, Henries, Volts

9. If the inductor had some initial current of 1A ~~flowing~~ stored in it then:

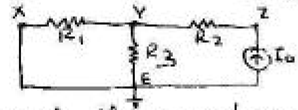


At t=0 this is what the circuit looks like, as the inductor holds on to its current value of 1A temporarily. Then at t=0, $V_R = (1A)(100\Omega) = 100V > 4V$

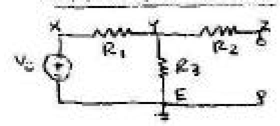
10. (5 points) Redraw the circuit below to show its electrical equivalent afrter you have "turned off" the independent sources (which you might do in order to find the Thevenin equivalent resistance, R_T, or in order to use superposition to analyze the circuit).



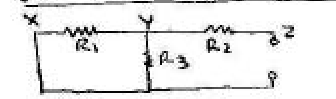
with the voltage source off



with the current source off



OR with both of them off

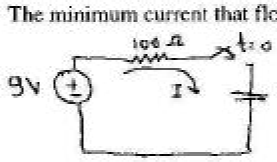


Note
R_2 does not really affect voltage calculation
But it does affect Thevenin resistance calculat. so it is not removed

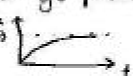
11. (5 points) An uncharged 60 µF capacitor is suddently connected to a 9V battery in series with a 100 Ω resistor, at time t = 0.

a. The maximum current that flows is 90 (give units mA) and it occurs at time t = 0.

b. The minimum current that flows is 0 (give units mA) and it occurs at time t = ∞.



After switching, V_c will go from ØV to 9V like so:



The current I flowing through is $\frac{9 - V_c(t)}{100}$ (By applying Ohm's Law on the 100 Ω resistor)

So: $I = \frac{9 - V_c(t)}{100}$

MAX I: when $V_c(t) = 0$ which happens at $t = 0$ (Initially uncharged capacitor)

$\Rightarrow I_{max} = \frac{9V}{100\,\Omega} = 90\,mA$

MIN I: when $V_c(t) = 9V$ which happens at $t = \infty$ (capacitor behaves like an open circuit)

$\Rightarrow I_{min} = 0\,mA$

12. (5 points) When analyzing a first-order transient circuit problem, which of these quantities cannot change instantaneously (check all that apply)::

a. Voltage across a resistor __
b. Current flowing through a capacitor __
c. Voltage across a capacitor ✓
d. Energy stored in an inductor ✓
e. Current flowing in an inductor ✓
f. Charge in a capacitor ✓
g. None of these __

13. (6 points) A 120V supply is connected to a 500 Ω and a 700 Ω resistor connected in series. What is the rate of energy dissipation in

a. The 500 Ω resistor: 5 (give units W).
b. The 700 Ω resistor: 7 (give units: W).
c. The 120-V supply: -12 (give units: W)

$I = \frac{120V}{500\,\Omega + 700\,\Omega} = 0.1\,A$

$Power_{500\Omega} = I^2 (R_{500\Omega}) = (0.1A)^2 \cdot (500\,\Omega) = \boxed{5W}$

$Power_{700\Omega} = I^2 \cdot (R_{700\Omega}) = (0.1A)^2 \cdot (700\,\Omega) = \boxed{7W}$

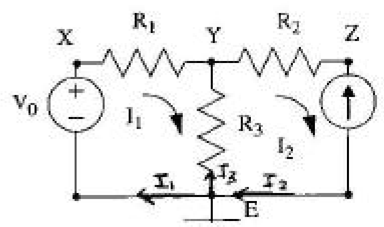
$Power_{source}$ = (Voltage across source) × (current flowing from its +ve term straight to the -ve.)

$= (120V)(-I) = (120V)(-0.1A) = \boxed{-12W}$

(so the source dissipates negative power so it actually produces power)

A quick check: The sum of all powers has to be zero. 5+7-12=0

14. (4 points) Write an equation for the voltage V_{EY} across resisistor R_3 in terms of the loop (mesh) currents indicated in this circuit:

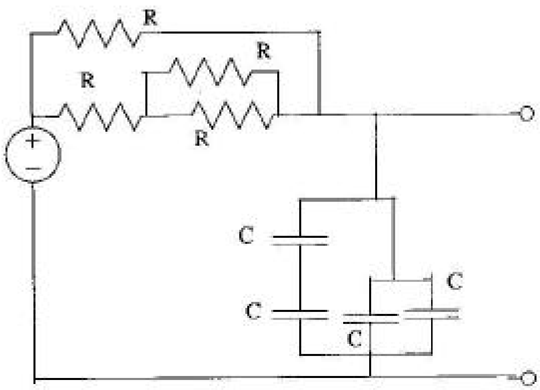


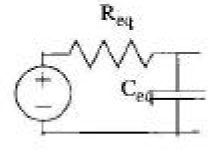
Apply Kirchoff's Law at E: $I_2 = I_3 + I_1 \Rightarrow I_3 = I_2 - I_1$

$V_{EY} = R_3 \cdot$ (current flowing through R_3 from E to Y) $= R_3 \cdot (I_2 - I_1)$

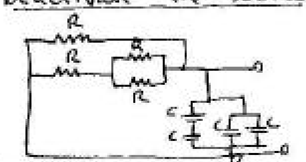
$\Rightarrow \boxed{V_{EY} = R_3 \cdot (I_2 - I_1)}$

15. (10 points) The circuit below shows a number of resistors and capacitors, in addition to an independent ideal voltage source. Combine the resistors into a single resistor R_{eq} that is in series with the voltage source and an equivalent capacitor C_{eq} (so that you could apply transient analysis to the circuit whose time constant would be $R_{eq}C_{eq}$). Note: all resistors are 1 kΩ and all capacitors are 2 μF.





Deactivate the source



a. R_{eq} = 600 Ω

b. C_{eq} = 5μ F

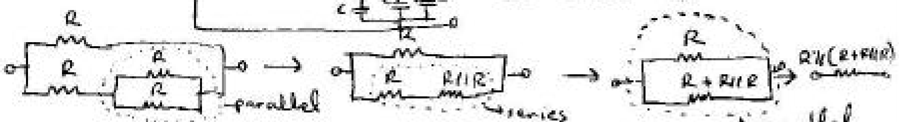
$R_{series} = R_1 + R_2 + R_3 + \cdots R_N$

$R_{//} = R_{parallel} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_N}\right)^{-1}$

$C_{series} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \cdots \frac{1}{C_N}\right)^{-1}$

$C_{//} = C_1 + C_2 + \cdots C_N$

Req

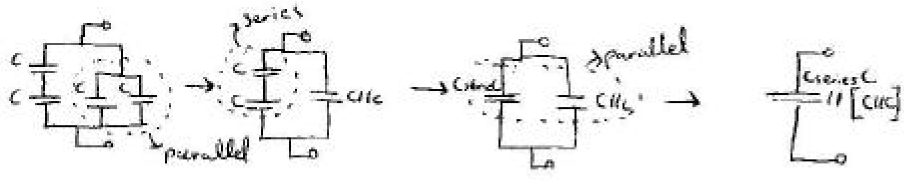


So $R//R = \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} = \frac{R}{2} = \frac{1k\Omega}{2} = 500\Omega$

$R + R//R = 1k\Omega + 500\Omega = 1500\Omega$

$R// (R + R//R) = \left(\frac{1}{1000\Omega} + \frac{1}{1500\Omega}\right)^{-1} = 600\Omega \Rightarrow$ $\boxed{R_{eq} = 600\Omega}$

Ceq:



$C//C = C + C = 4\mu F$

$C_{series}\,C = \left(\frac{1}{C} + \frac{1}{C}\right)^{-1} = 1\mu F$

$[C_{series}C] // [C//C] = 4\mu F + 1\mu F = 5\mu F \Rightarrow$ $\boxed{C_{eq} = 5\mu F}$