Name: Answer Key

EXAM 1
EECS 215
Introduction to Electronic Circuits
Wednesday, February 8, 6:00pm-8:00pm

Lecture Section (circle 1):	001 Finelli	002 Phillips

This test consists of 6 problems with points as indicated to total 60 points.

Read through the entire exam before beginning.
Show all work (on the pages provided in this booklet) to earn partial credit.
Briefly explain major steps, include units, and write your final answers in the areas provided.
Do not unstaple the pages.

No credit will be given if no work is shown.

Exam Policies

- No food allowed during exam.
- No books allowed (closed book exam).
- One, 8.5 x 11 inch notes page (ONE SIDED) allowed
- Only scientific calculators allowed (**graphing calculators not permitted**).
- No communication of any kind is allowed. No use of cell phones, computers, or any devices besides calculators. Violation of this will be treated as an honor code violation.
- No credit will be given for this exam without a signed honor pledge.

Write out the honor pledge and sign below.

"I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code"

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Signature: ______________________________

Do not write in this space

Problem 1: [ ]/10	Problem 4: [ ]/10
Problem 2: [ ]/10	Problem 5: [ ]/10
Problem 3: [ ]/10	Problem 6: [ ]/10

Total score [ ]/60

1. The current entering the positive terminal of a device and the corresponding voltage across the device are defined as follows:

$$i(t) = 20\, e^{-5t}\text{mA} = .020\, e^{-5t}\text{ A}$$

$$v(t) = 100(1 - e^{-5t})\text{V}$$

a. Find the charge delivered to the device between $t = 0$ and $t = 30$ ms.

b. Calculate the instantaneous power absorbed by the device at $t = 0$ and $t = 30$ ms.

c. Determine the total energy absorbed by the device from $t = 0$ to $t = \infty$.

a) $Q = \int_0^{.03} i(t)dt = \int_0^{.03} .02\, e^{-5t} dt = \frac{.02}{-5} e^{-5t}\Big|_0^{.03} = \frac{0.02}{-5}\left(e^{-.15} - 1\right) = \boxed{5.57\times10^{-4}C}$

b) $p(0) = i(0)v(0) = (0.02\, e^0)(100)(1 - e^0) = \boxed{0\text{ W}}$

$p(.03) = .020\, e^{-.15}(100)(1 - e^{-.15}) = \boxed{240\text{mW}}$

c) $W_{total} = \int_0^{\infty} i(t)v(t)dt = (.02)(100)\int_0^{\infty}\left(e^{-5t} - e^{-10t}\right)dt$

$= \frac{2}{-5} e^{-5t}\Big|_0^{\infty} - \frac{2}{-10} e^{-10t}\Big|_0^{\infty}$

$= -\frac{2}{5}(0-1) + \frac{2}{10}(0-1) = \boxed{200\text{mJ}}$

Write your answer here:

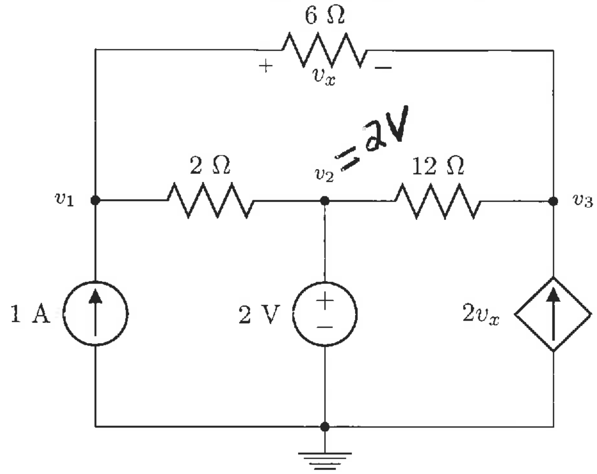
a. Charge = $5.57\times10^{-4}C$

b. $p(0)$ = 0 W $\qquad p(30\ ms)$ = 240 mW

c. Total energy = 200 J

Problem 1 score: [ ]/10

2. Find the node voltages v_1, v_2, and v_3 for the circuit below using **NODAL ANALYSIS**.



① $1 = \frac{v_1 - v_3}{6} + \frac{v_1 - v_2}{2}$ → $v_2 = 2V$

③ $2v_x = \frac{v_3 - v_1}{6} + \frac{v_3 - 2}{12}$

$v_x = v_1 - v_3$

From ①, $v_1\left(\frac{1}{6}+\frac{1}{2}\right) + v_3\left(-\frac{1}{6}\right) = 2$

$4v_1 - v_3 = 12 \rightarrow v_3 = 4v_1 - 12$

③ $2(v_1 - v_3) = \frac{v_3 - v_1}{6} + \frac{v_3}{12} - \frac{1}{6}$

$v_1\left(2+\frac{1}{6}\right) + v_3\left(-2 - \frac{1}{6} - \frac{1}{12}\right) = -\frac{1}{6}$

$26v_1 - 27v_3 = -2$

Sub $v_3 = 4v_1 - 12$:

$26v_1 - 27(4v_1 - 12) = -2$

$-82v_1 = -326$

$\boxed{v_1 = \frac{326}{82} = \frac{163}{41} = 3.9756\ V}$

$v_3 = 4\left(\frac{163}{41}\right) - 12$

$\boxed{v_3 = \frac{160}{41} = 3.9024\ V}$

Write your answer here:

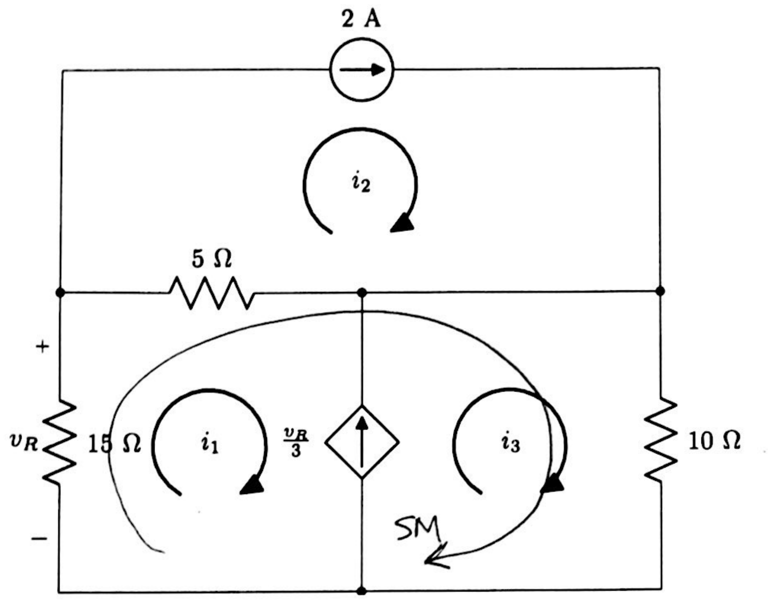
$v_1 =$ 3.9756 V

$v_2 =$ 2 V

$v_3 =$ 3.9024 V

Problem 2 score: [ ]/10

3. Find the mesh currents $i_1, i_2,$ *and* i_3 in the circuit below using **MESH ANALYSIS**.



$i_2 = 2A$

supermesh

$15i_1 + 5(i_1 - \cancel{i_2}^{\,2}) + 10 i_3 = 0$

$2i_1 + i_3 = 1$

also $\frac{v_R}{3} = i_3 - i_1$

and $v_R = -15i_1$

$4i_1 + i_3 = 0$

$\Rightarrow \boxed{i_1 = -\frac{1}{2}A,\ i_2 = 2A,\ i_3 = 2A}$

Write your answer here:

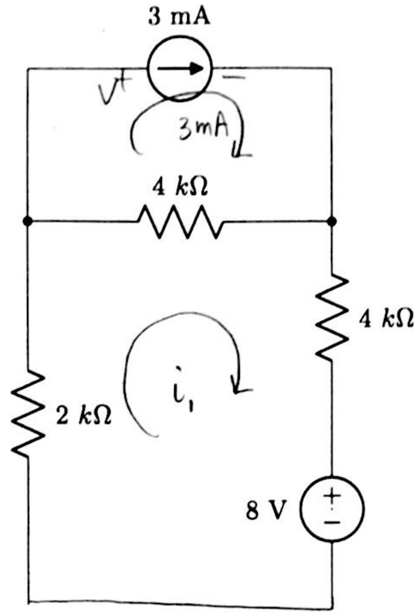
$i_1 =$ $-0.5A$

$i_2 =$ $2A$

$i_3 =$ $2A$

Problem 3 score: [ ]/10

4. For the circuit below, determine the power absorbed by each element and confirm that power is conserved in the circuit.



KVL around bottom

$$2k\Omega(i_1) + 4k\Omega(i_1 - 3mA) + 4k\Omega(i_1) + 8V = 0$$

$$10k\, i_1 = 4V \Rightarrow i_1 = 0.4mA$$

3mA source

$$p = +(3mA)(V) = 3mA\overbrace{(4k\Omega)(i_1 - 3mA)}^{V} = -31.2\,W$$

8V source

$$p = 8\, i_1 = 3.2W$$

2kΩ resistor

$$p = (i_1^2)(2k\Omega) = 0.32\,W$$

4kΩ resistor in middle

$$p = (i_1 - 3mA)^2(4k\Omega) = 27.04$$

4kΩ resistor on right

$$p = (i_1^2)(4k\Omega) = 0.64$$

check: $-31.2 + 3.2 + .32 + 27.04 + .64 = 0$ ✓

Write your answer here:

Power absorbed by 3 mA source = −31.2 mW

Power absorbed by 8V source = 3.2mW

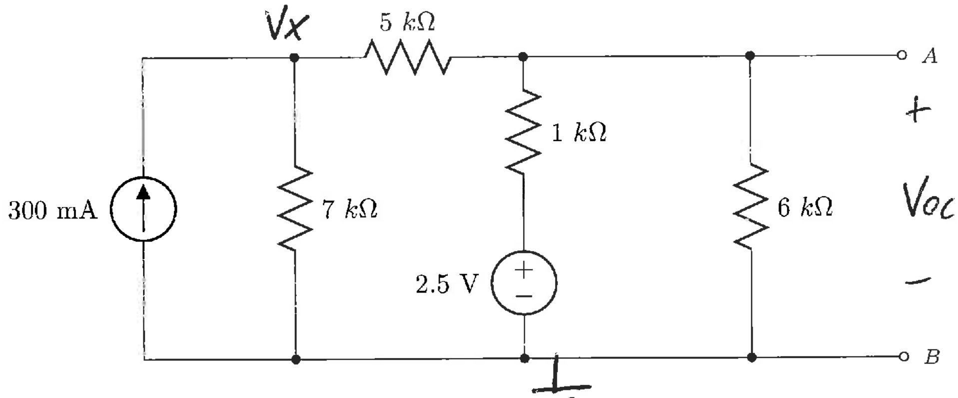
Power absorbed by 2 kΩ resistor = 0.32 mW

Power absorbed by 4 kΩ resistor in middle = 27.04 mW

Power absorbed by 2 kΩ resistor on right side = 0.64 mW

Problem 4 score: [ ]/10

5. Find both the Thévenin and Norton equivalent circuits for the network connected at nodes A and B below.



$V_{oc} = V_{TH}$, nodal analysis @ V_x, V_{oc}

V_x: $0.3 = \frac{V_x}{7k} + \frac{V_x - V_{oc}}{5k}$

$V_x\left(\frac{1}{7k} + \frac{1}{5k}\right) - V_{oc}\left(\frac{1}{5k}\right) = 0.3$

$12V_x - 7V_{oc} = 10.5k$

$V_x = \frac{7}{12}V_{oc} + 875$

V_{oc}: $\frac{V_{oc} - V_x}{5k} + \frac{V_{oc} - 2.5}{1k} + \frac{V_{oc}}{6k} = 0$

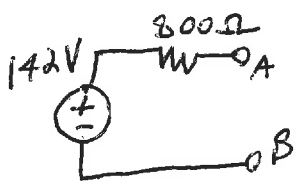
$V_{oc}\left(\frac{1}{5k} + \frac{1}{1k} + \frac{1}{6k}\right) - V_x\left(\frac{1}{5k}\right) = \frac{2.5}{1k}$

$41 V_{oc} - 6 V_x = 75$

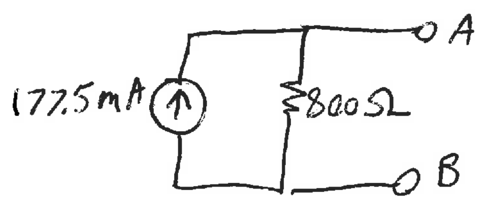
sub V_x; $41 V_{oc} - 6\left(\frac{7}{12}V_{oc} + 875\right) = 75$

$\boxed{V_{oc} = 142\text{ V}}$

Sketch the Thevenin equivalent circuit here:

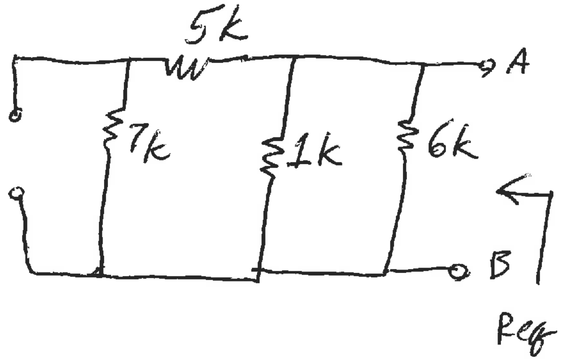


Sketch the Norton equivalent circuit here:



Problem 5 score: [ ]/10

R_{eq}:



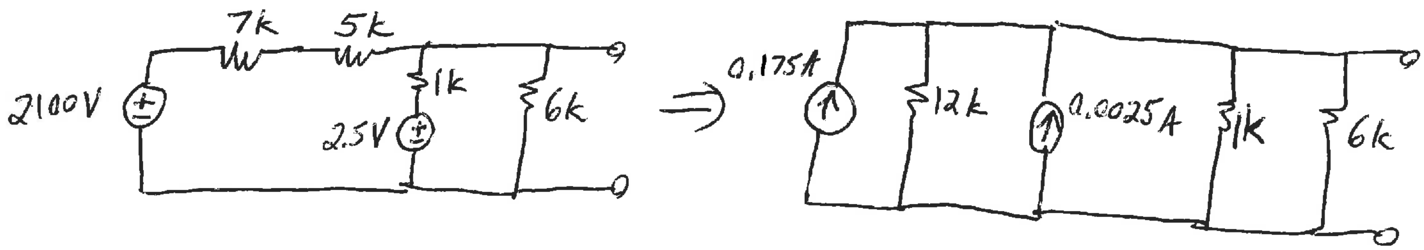
$R_{eq} = \left[\left(7k + 5k\right) // 1k\right] // 6k$

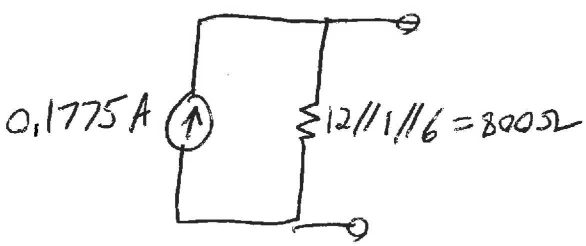
$12k // 1k \rightarrow \left(\frac{1}{12} + 1\right)^{-1} = \frac{12}{13} k$

$\frac{12}{13} k // 6k \rightarrow \left(\frac{13}{12} + \frac{1}{6}\right)^{-1} = \frac{4}{5} k = \boxed{800\,\Omega}$

$I_N = \frac{V_{TH}}{R_{TH}} = \frac{142}{800} = \boxed{177.5\ mA}$

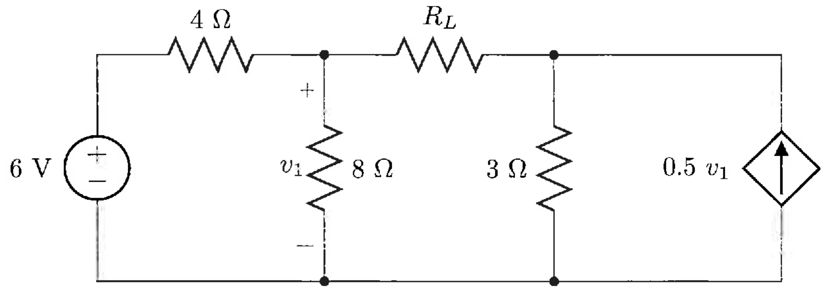
Alternative: Source transformation





Done!

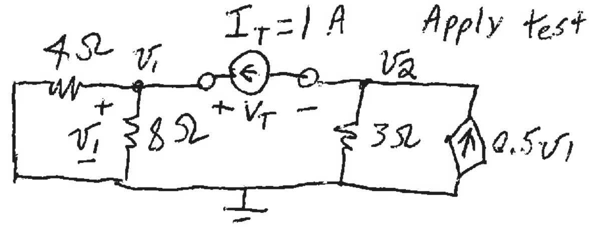
6. Find the maximum power that can be delivered to the resistor R_L in the circuit below.



P_{max} when $R_L = R_{TH}$

Find thevenin equiv.

R_{eq}:



Apply test source $I_T = 1A$, calc. V_T

Nodal analysis, assign v_1, v_2

$V_T = v_1 - v_2$

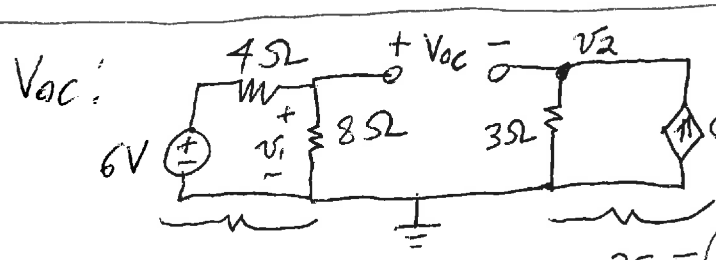
v_1: $1 = \frac{v_1}{4} + \frac{v_1}{8} \rightarrow v_1 = \frac{8}{3}\,V = 2.667\,V$

v_2: $0.5 v_1 = \frac{v_2}{3} + 1 \rightarrow v_2 = 1\,V$

sub $v_1 = \frac{8}{3}\,V$

$R_{eq} = \frac{V_T}{I_T} = \frac{8/3 - 1}{1} = \frac{5}{3}\,\Omega = 1.667\,\Omega$

V_{oc}:



$v_1 = 6V\left(\frac{8}{4+8}\right) = 4\,V$

$V_{oc} = v_1 - v_2 = -2\,V$

$v_2 = (0.5 v_1)(3) = (0.5)(4)(3)$
$= 6\,V$

$P_{max} = I^2 R_L = \left(\frac{V_{TH}}{2R_{TH}}\right)^2 R_{TH} = \frac{V_{TH}^2}{4R_{TH}}$

$P_{max} = (2)^2/4(5/3) = 3/5\,W = 0.6\,W$

Write your answer here:

The maximum power that can be transferred = 0.6 W

Problem 6 score: [ ]/10