Your name: _____

EECS 215
Midterm Exam #1
October 19, 2016

This exam consists of 6 problems with points as indicated to total 80 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, 8.5x11 inch notes page (ONE SIDED) allowed
  - Calculators allowed (But **you may not use the following functions: graphs, integrals, derivatives**).
  - Full credit will not be awarded if you do not show your work.
  - 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.

In which section are you enrolled? ☐**EECS 215-001 (Finelli)** ☐**EECS 215-002 (Zhang)**

Write and sign the honor pledge:

Answer key

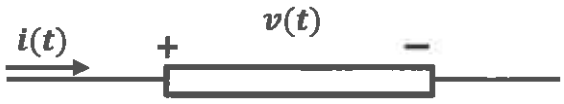
Signed: _____

Do not write in this space

Problem 1: [ ]/10
Problem 2: [ ]/5
Problem 3: [ ]/20
Problem 4: [ ]/15
Problem 5: [ ]/25
Problem 6: [ ]/5

Total score [ ]/80

1. (10 points total) A circuit device is defined as shown below:



The current and voltage for the device are:

$$i(t) = \begin{cases} 0\,A, t < 0 \\ (25e^{-12t} + 25)mA, t \geq 0 \end{cases} \qquad v(t) = \begin{cases} 0\,V, t < 0 \\ (2e^{-12t} - 2)V, t \geq 0 \end{cases}$$

a. (4 points) Find the total charge entering the device between 0 and 10 milliseconds

b. (2 points) Calculate the power dissipated by the device at $t = 10$ milliseconds

c. (4 points) Determine the total energy dissipated by the device between 0 and 10 milliseconds

Note: By signing the honor code, you agreed not to use the integral function of your calculator. Please show your work.

a) $Q = \int_0^{.01} (25e^{-12t} + 25) \times 10^{-3}\, dt = \left(\frac{-25}{12} e^{-12t} \Big|_0^{.01} + 25t \Big|_0^{.01} \right) \times 10^{-3} = \boxed{485\,mC}$

b) $p(.01) = \left(25e^{-12(.01)} + 25\right) \times 10^{-3} \left(2e^{-12(.01)} - 2\right) = \boxed{-10.67\,mW}$

c) $w = \int_0^{.01} 50\left(e^{-12t} + 1\right)\left(e^{-12t} - 1\right) \times 10^{-3}\, dt$

$= .05 \int_0^{.01} \left(e^{-24t} - 1\right) dt = .05 \left(-\frac{1}{24} e^{-24t} \Big|_0^{.01} - t \Big|_0^{.01} \right)$

$= \frac{-.05}{24} \left(e^{-.24} - 1\right) - (.05)(.01) = \boxed{-55.47\,\mu J}$

Write your answer here:

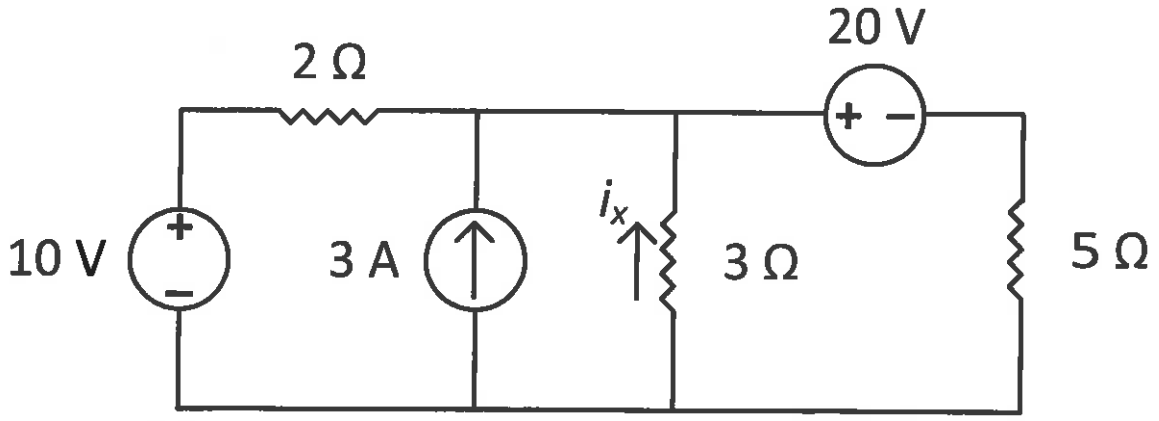
Total charge = 485 mC

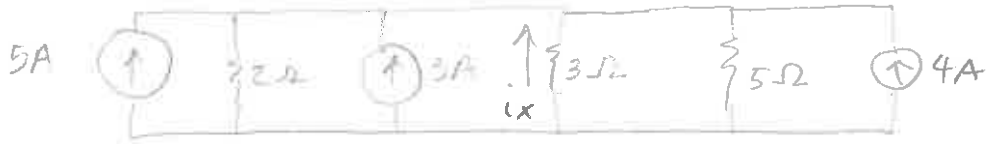
Power dissipated = −10.67 mW

Total energy dissipated = −55.47 μJ

Problem 1 score: [ ]/10

2. (5 points) For the circuit shown below, use any approach you wish to find the current i_x





Current ÷

$i_x = -12\left(\frac{10/7}{10/7+3}\right)$

$= -3.87A$

Write your answer here:

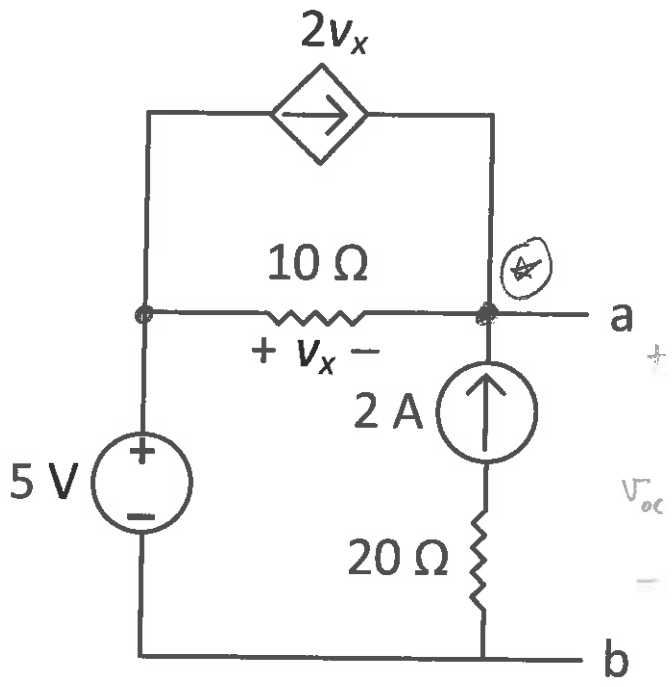
$i_x =$ $i = -3.87A$

Problem 2 score: [ ]/5

3. (20 points total) Determine the Thevenin equivalent circuit between nodes (a, b) for the circuit shown below, by:

   a. (10 points) Finding the open-circuit voltage v_{oc}

   b. (10 points) Finding the Thevenin resistance R_{TH}



KCL @ ★

a) $\frac{v_{oc}-5}{10} - 2v_x - 2 = 0$

$v_x = 5 - v_{oc}$

$\frac{v_{oc}-5}{10} + 2(v_{oc}-5) = 2$

$21 v_{oc} = 125$

$v_{oc} = \boxed{5.95\ V}$

b) R_{TH}: deactivate sources and apply v_t

KCL at top ($v_x = -v_t$)

$-2v_x + \frac{v_t}{10} - i_t = 0$

$2v_t + \frac{v_t}{10} = i_t$

$\frac{21}{10} v_t = i_t$

$R_{th} = v_t / i_t = \boxed{0.48\ \Omega}$

Write your answer here:

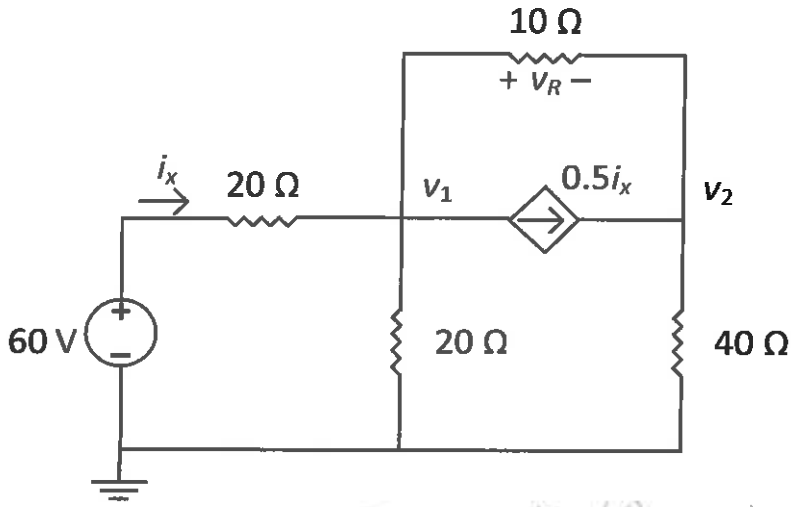
v_{oc}= 5.95 V

R_{TH} = 0.48 Ω

Problem 3 score: [ ]/20

4. (15 points total). Use nodal analysis (with the node voltages as defined in the circuit) to solve for v_1 and v_2

Note: You must use nodal analysis for full credit. You will lose 5 points if you use a different method.



KCL @ 1 $\quad \frac{v_1-60}{20} + \frac{v_1}{20} + \frac{v_1-v_2}{10} + .5\,i_x = 0$

$$i_x = \frac{60-v_1}{20}$$

$$v_1 - 60 + v_1 + 2v_1 - 2v_2 + 30 - \frac{v_1}{2} = 0$$

$$\boxed{7v_1 - 4v_2 = 60}$$

KCL at ② $\quad \frac{v_2-v_1}{10} - .5\left(\frac{60-v_1}{20}\right) + \frac{v_2}{40} = 0$

$$4v_2 - 4v_1 - 60 + v_1 + v_2 = 0$$

$$\boxed{-3v_1 + 5v_2 = 60}$$

solving simultaneously ⇒ $\boxed{v_1 = 23.5\ V}$ $\boxed{v_2 = 26.1\ V}$

Write your answer here:

v_1= 23.5V

v_2= 26.1V

Problem 4 score: [ ]/15

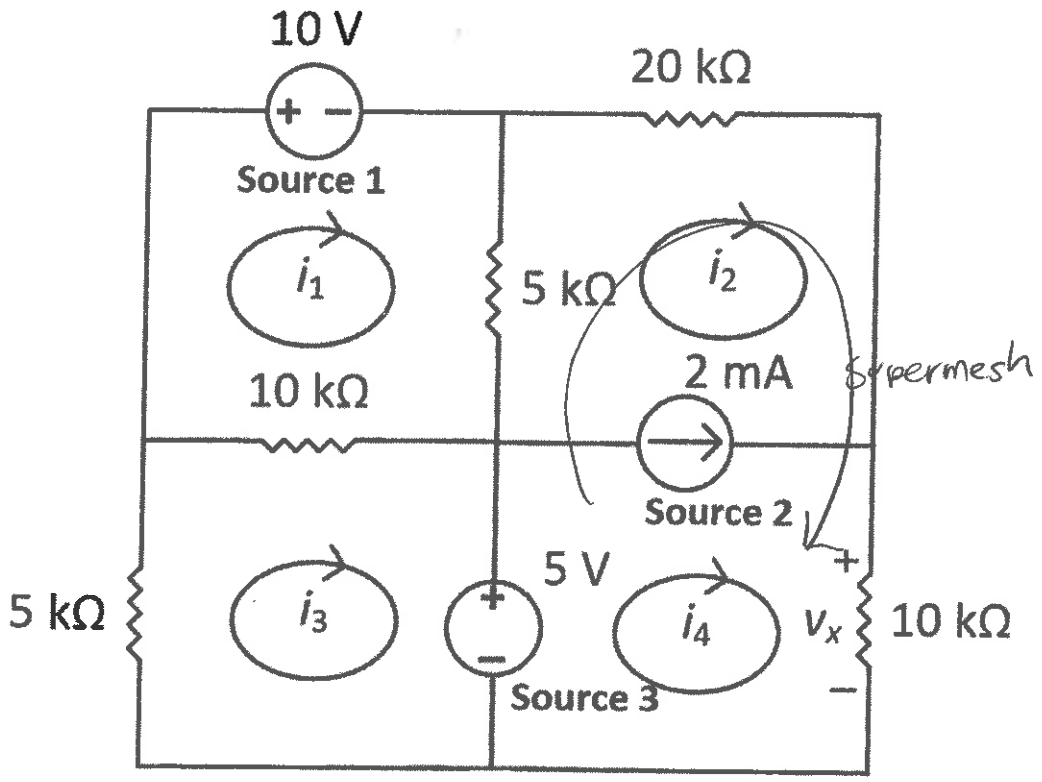
5. (25 points total) Apply mesh analysis to:

   a. (17 points) Solve for the mesh currents labeled in the circuit

   b. (2 points) Find the voltage v_x

   c. (6 points) Solve for the power supplied by each of the three sources

   Note: You must use mesh analysis for full credit. You will lose 5 points if you use a different method.



Write your answer here:

i_1 = −2.03 mA

i_2 = −0.72 mA

i_3 = −1.69 mA

i_4 = 1.28 mA

v_x = 12.8 V

$p_{source1}$ = 20.3 mW

$p_{source2}$ = 15.6 mW

$p_{source3}$ = 14.8 mW

Problem 5 score: [ ]/25

KVL
mesh 1:

$$10 + 15k i_1 - 5k i_2 - 10k i_3 = 0$$

KVL Supermesh

$$-5k i_1 + 25k i_2 + 10k i_4 - 5 = 0$$

KVL mesh 3

$$-10k i_1 + 5 + 15k i_3 = 0$$

Constraint eqn:

$$i_4 - i_2 = 2mA$$

$$\Rightarrow \quad 3i_1 - i_2 - 2i_3 = -2mA$$
$$-i_1 + 5i_2 + 2i_4 = 1mA$$
$$-2i_1 + 3i_3 = -1mA$$
$$-i_2 + i_4 = 2mA$$

$$\Downarrow$$

$i_1 = -2.03mA$
$i_2 = -.72\,mA$
$i_3 = -1.69\,mA$
$i_4 = 1.28mA$

$$\Rightarrow v_x = 10k\, i_4 = \boxed{12.8\,V}$$

$p_{absorbed} = -p_{supplied}$

$p_{s1} = 10 i_1 = \boxed{-20.3mW}$

$p_{s2} = 2mA\,(5 - 10\, i_4) = \boxed{-15.6mW}$

$p_{s3} = 5(i_3 - i_4) = \boxed{-14.8mW}$

note: $p_{20k} = i_2^2 (20k) = 10.3\,mW$

$p_{10k\text{-}left} = (i_1 - i_3)^2\, 10k = 1.2mW$

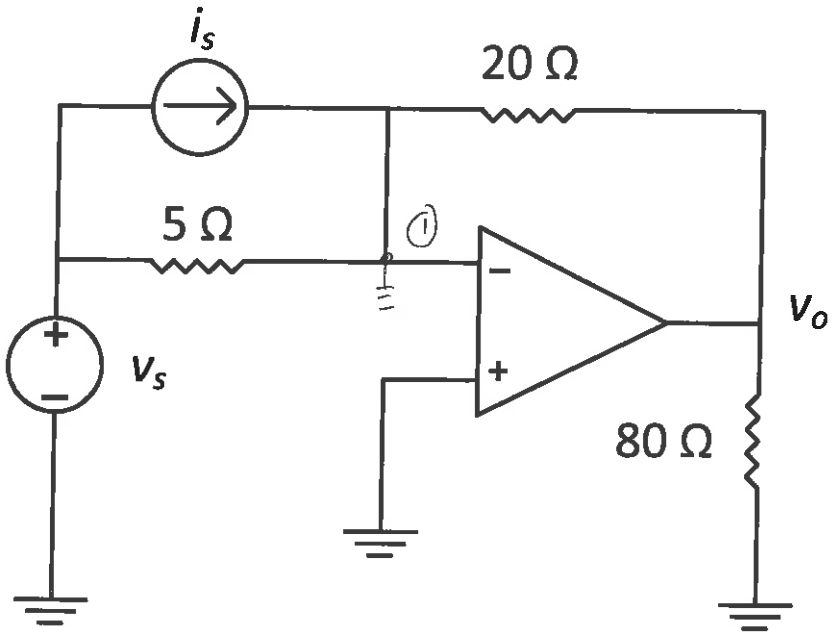
$p_{5k\text{-}mid} = (i_1 - i_2)^2\, 5k = 8.6mW$

$p_{5k\text{-}left} = (i_s^2)\, 5k = 14.2mW$

$p_{10k\text{-}right} = i_4^2\, 10k = 16.4\,mW$

$\Big\} \quad 50.7\,mW$

6. (5 points) For the circuit below, calculate v_o as a function of v_s and i_s



KCL @ ①

$$\frac{0-v_s}{5} - i_s + \frac{0-v_s}{20} = 0$$

$$-4v_s - 20i_s - v_o = 0$$

$$v_o = \boxed{-4v_s - 20i_s}$$

Write your answer here:

$v_o =$ $-4v_s - 20i_s$

Problem 6 score: [ ]/5