Name: ______________________________ (please print)

Signature: ___________________________

ECE 2201 -- Exam #1
March 2, 2019

Keep this exam closed until you are told to begin.

1. This exam is closed book, closed notes. You may use one 8.5” x 11” crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution that is not given in a reasonable order will lose credit. Clearly indicate your answer (for example by enclosing it in a box).
3. It is assumed that your work will begin on the same page as the problem statement. If you choose to begin your work on another page, you must indicate this on the page with the problem statement, with a clear indication of where the work can be found. **If your work continues on to another page, indicate clearly where your work can be found. Failure to indicate this clearly will result in a loss of credit.**
4. Show all units in solutions, intermediate results, and figures. Units in the exam will be included between square brackets.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this exam.

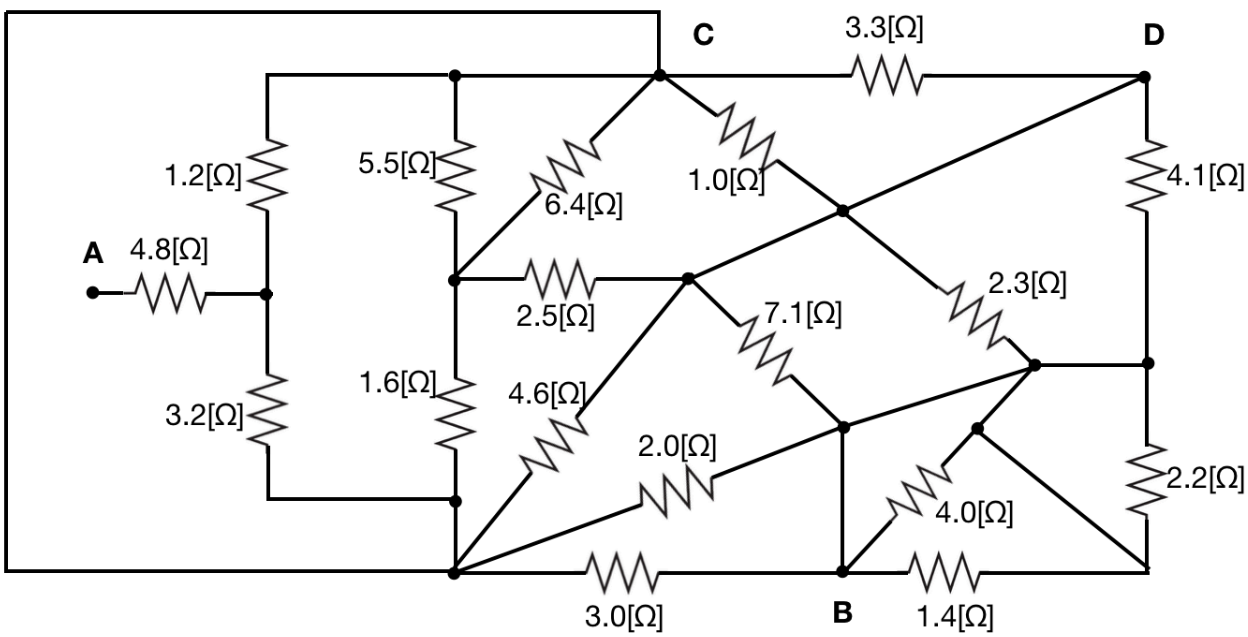
1. _______________/30
2. _______________/35
3. _______________/35

Total = 100

Room for extra work

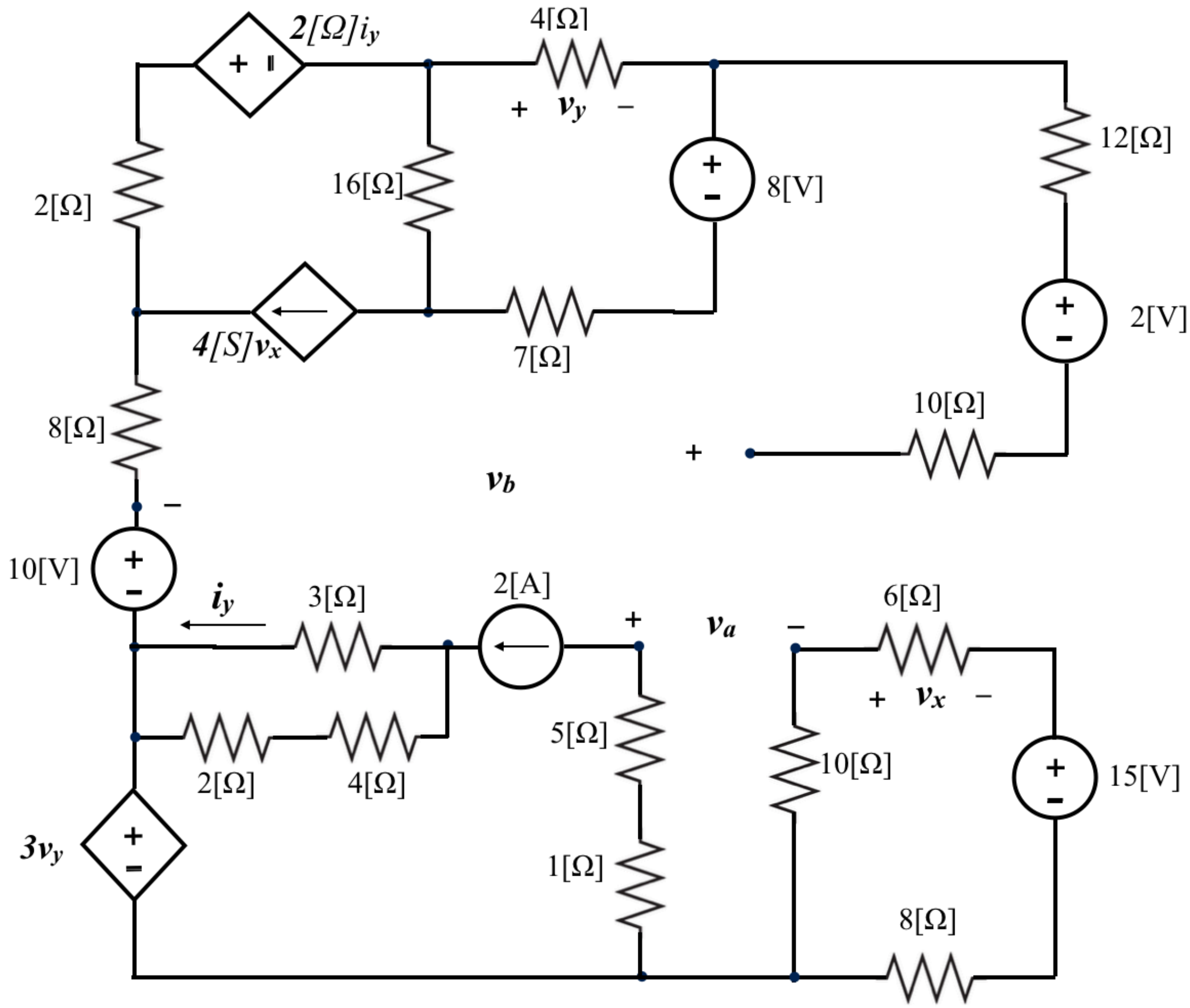
1. {30 Points} Use the circuit shown below to solve this problem. Show your steps clearly. You are encouraged to redraw the circuit as needed.

a) Find the equivalent resistance as seen by terminals **A** and **B**.
b) Find the equivalent resistance as seen by terminals **C** and **D.**



Room for extra work

2. {35 Points} In the circuit shown below
a) Find the power delivered by the 2[A] current source.
b) Find the voltage v_a as marked on the circuit.
c) Find the voltage v_b as marked on the circuit.



Room for extra work

3. {35 Points} Four devices are connected as shown in Figure 1. The power delivered by Device 1 is given by the expression

$$p_{\text{del,D1}}(\text{t}) = 15\left[\frac{\mu W}{s^2}\right]t^2 - 30\left[\frac{\mu W}{s}\right]t\ ; \qquad \text{for} \quad 0 < \text{t} < 5[\text{s}].$$

The voltage $v_x(t)$ on this device is shown in Figure 2. 50% of the power delivered by Device 1 is absorbed by devices in Column A and 50% by devices in Column B. Device 2 absorbs two times (2x) larger power than Device 3. Device 4 and Device 5 absorb the same amount of power.

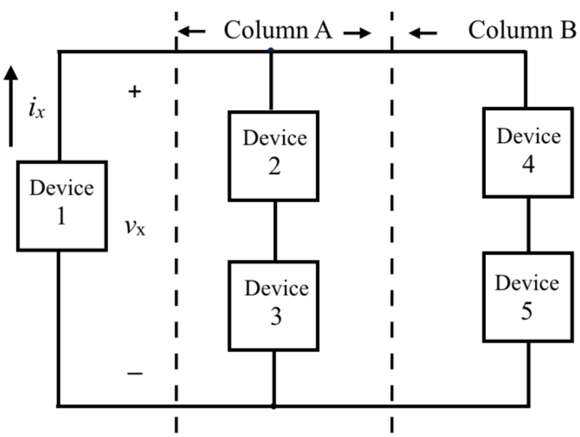


Figure 1

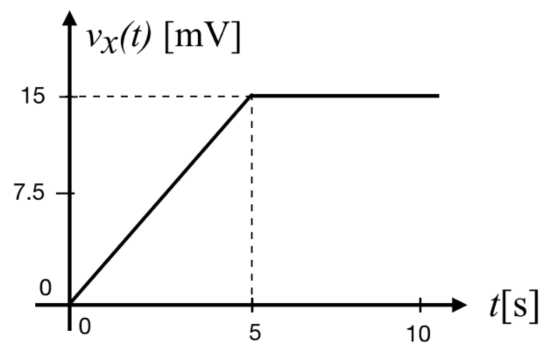
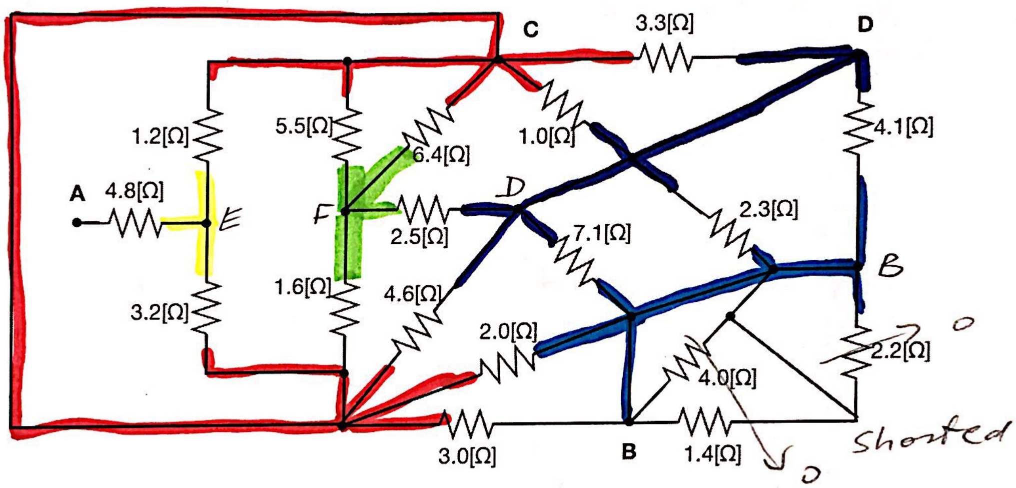


Figure 2

a) For 0 < t < 5[s] plot the current in Device 1 and find time intervals when it delivers the power. Explain your answer.
b) Calculate the number of charges moving through Device 1 in the time interval when it delivers power.
c) Find and make plots of the currents and voltages in Device 2, Device 3, and Device 4 for the time interval when Device 1 delivers the power.

1. {30 Points} Use the circuit shown below to solve this problem. Show your steps clearly. You are encouraged to redraw the circuit as needed.

a) Find the equivalent resistance as seen by terminals **A** and **B**.
b) Find the equivalent resistance as seen by terminals **C** and **D.**



a) Identify resistors to be simplified in the nodes.

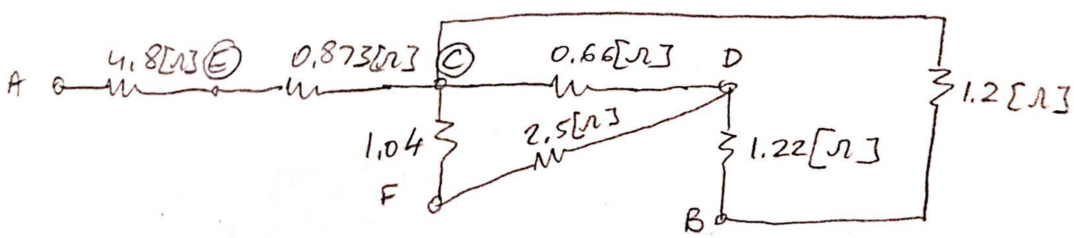
$R_{CE} = 1.2[\Omega] \parallel 3.2[\Omega] = 0.873[\Omega]$

$R_{CD} = 3.3[\Omega] \parallel 1[\Omega] \parallel 4.6[\Omega] = 0.66[\Omega]$

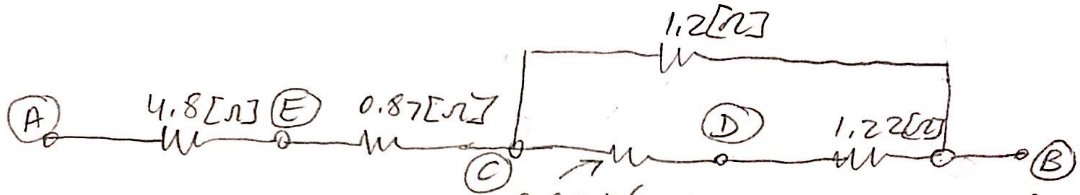
$R_{CF} = 5.5[\Omega] \parallel 6.4[\Omega] \parallel 1.6[\Omega] = 1.04[\Omega]$

$R_{DB} = 4.1[\Omega] \parallel 2.3[\Omega] \parallel 7.1[\Omega] = 1.22[\Omega]$

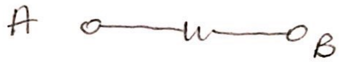
$R_{CB} = 2[\Omega] \parallel 3[\Omega] = 1.2[\Omega]$



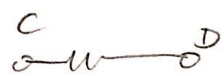
Room for extra work



$0.66 \parallel (1.04+2.5) = 0.556\ [\Omega]$

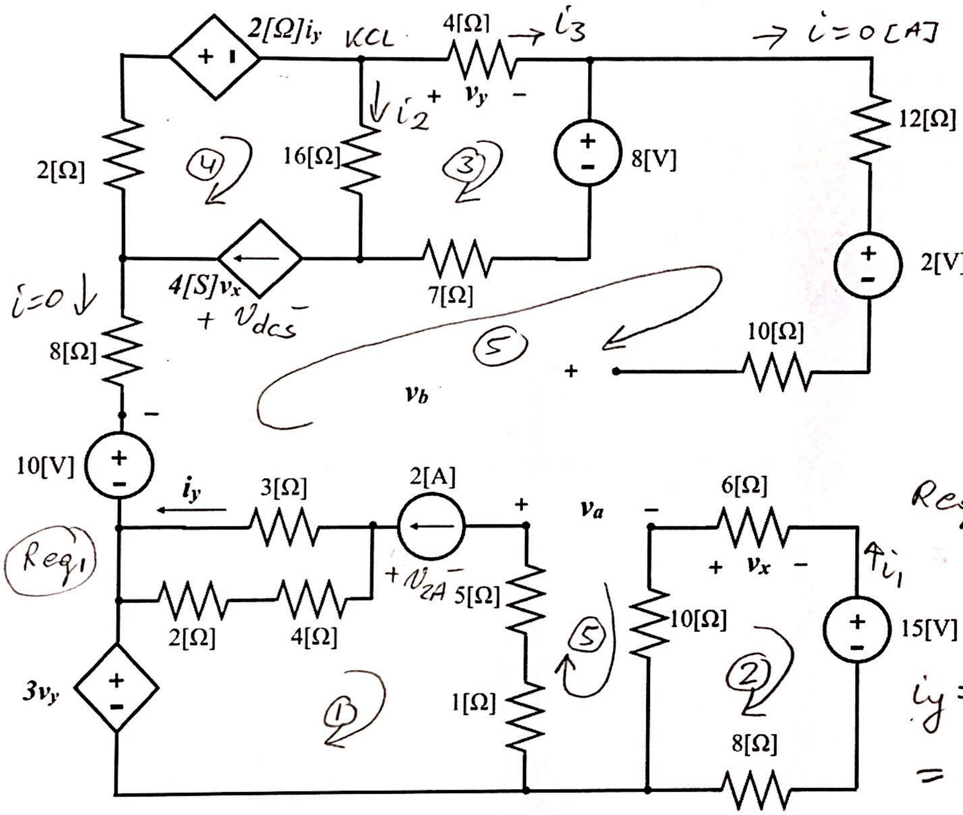


$4.8 + 0.87 + 1.2 \parallel (0.56 + 1.22) =$
$= 6.39\ [\Omega]$

b) 

Removed: $4.8 + 0.87$ + $0.56\ [\Omega] \parallel (1.2 + 1.22) =$
$= 0.451\ [\Omega]$

2. {35 Points} In the circuit shown below
a) Find the power delivered by the 2[A] current source.
b) Find the voltage v_a as marked on the circuit.
c) Find the voltage v_b as marked on the circuit.



$Req_1 = 3 \| (2+4) = 2[\Omega]$

$i_y = 2[A] \cdot \frac{Req_1}{3\Omega} = 1.33[A]$

a) Power from 2[A] Source → label v_{2A} voltage

KVL ① $\quad v_{2[A]} - (5+1)[\Omega] \cdot 2[A] - 3v_y - Req_1 \cdot 2[A] = 0$

$\Rightarrow v_{2[A]} - 3v_y = 12 + 4 = 16[V]$ (1)

we need v_y for $3v_y$ source and v_x for $4v_x$ source.

KVL ② $\quad 15[V] - i_1(8 + 10 + 6) = 0 \Rightarrow i_1 = \frac{15}{24} = 0.625$ [A]

$\boxed{v_x = -3.75[V]}$

Room for extra work

KCL $-4v_x + i_2 + i_3 = 0$ | $i_2 + i_3 = -15[V]$ (1)

KVL ③ $8[V] + i_3 \cdot (7+4) - i_2 \cdot 16 = 0$ | $-i_2 \cdot 16 + i_3 \cdot 11 = -8[V]$

↓

in loop ③ $v_y = -i_3 \cdot 4[\Omega]$ → $i_2 = -5.815[A]$; $i_3 = -9.185[A]$

$v_y = -36.791[V]$

to find voltage v_b we will have to know the voltage on $4v_x$ source. So we use loop ④ with v_{dcs} marked.

$-v_{dcs} + 4v_x \cdot 2[\Omega] + 2i_y + i_2 \cdot 16[\Omega] = 0$

$-v_{dcs} + 4 \cdot (-3.75) \cdot 2 + 2 \cdot 1.33 - 5.815 \cdot 16 = 0$

$v_{dcs} = -120.3[V]$

from eq. ① $v_{2[A]} = 16[V] + 3v_y = -94.22[V]$

$P_{Del, 2[A]} = 2[A] \cdot v_{2[A]} = -188.44[W]$

b) Find v_a

KVL ⑤ $i_1 \cdot 10[\Omega] + 2[A] \cdot (1+5)[\Omega] + v_a = 0$

$v_a = -18.25[V]$

c) $v_b \rightarrow v_b + v_{dcs} - i_3 \cdot 7 - 8[V] + 2[V] = 0$

$v_b = -62.074[V]$

3. {35 Points} Four devices are connected as shown in Figure 1. The power delivered by Device 1 is given by the expression

$$p_{\text{del,D1}}(\text{t}) = 15\left[\frac{\mu W}{s^2}\right]t^2 - 30\left[\frac{\mu W}{s}\right]t\ ; \qquad \text{for} \quad 0 < \text{t} < 5[\text{s}].$$

The voltage $v_x(t)$ on this device is shown in Figure 2. 50% of the power delivered by Device 1 is absorbed by devices in Column A and 50% by devices in Column B. Device 2 absorbs two times (2x) larger power than Device 3. Device 4 and Device 5 absorb the same amount of power.

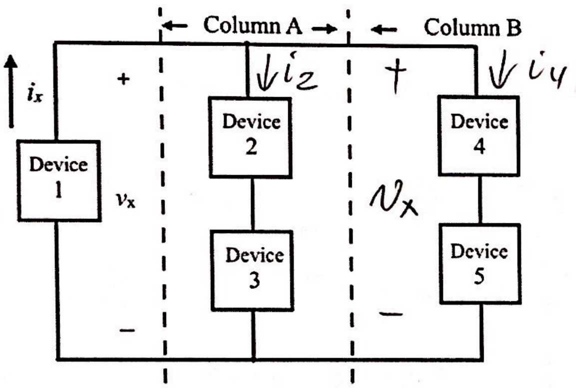


Figure 1

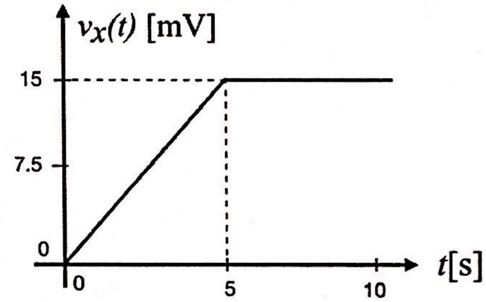


Figure 2

a) For 0 < t < 5[s] plot the current in Device 1 and find time intervals when it delivers the power. Explain your answer.
b) Calculate the number of charges moving through Device 1 in the time interval when it delivers power.
c) Find and make plots of the currents and voltages in Device 2, Device 3, and Device 4 for the time interval when Device 1 delivers the power.

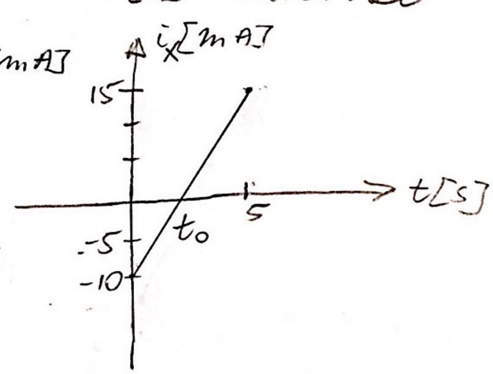
Find current i_x from $P_{del,D1}$ & $v_x(t)$

$v_x = \frac{15}{5}t = 3t$ [mV] in $0 < t < 5$[s] interval

$i_x = \frac{15t^2 - 30t}{3t} = 5t - 10$ [mA]

$i_x(t_0) = 0 \rightarrow t_0 = 2$[s]

Power is delivered by Device 1 during $2[s] < t < 5[s]$



Room for extra work

b) $Q = \int_2^5 i_x(t)\,dt = \int_2^5 (5t - 10)\,dt = \frac{5t^2}{2}\Big|_2^5 - 10t\Big|_2^5 = 22.5\,[mC]$

c) Since the power is split by 50% and
→ D2 & D3 and D4 & D5 are connected
in series → (i_2) the current in column A devices
is the same as (i_y) in column B. The voltage
v_x is also the same for A & B.

for $2 < t < 5\,[s]$

KCL $\quad i_x = i_2 + i_y$

$i_2 = i_y = \frac{i_x}{2} = 2.5t - 5\,[mA]$

$P_{ABS,D2} = 2 \times P_{ABS,D3}$

$v_{D2} = \frac{2}{3} v_x = \frac{2}{3} 3t = 2t\,[mV]$

$v_{D3} = \frac{v_x}{3} = \frac{1}{3} 3t = t\,[mV]$

$P_{ABS,D4} = P_{ABS,D5}$

$v_{D4} = \frac{1}{2} v_x = 1.5t\,[mV]$