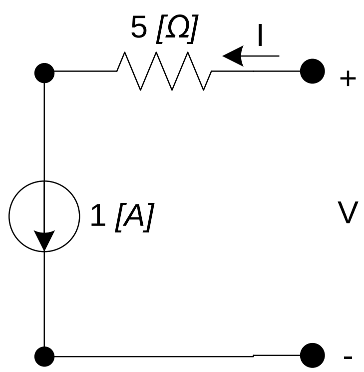
Problem 1 : DC I-V Characteristics (10 pts)

Draw the **DC** I-V characteristics for figures 1-2. (5 pts each)
(DC in this case means nothing else than that a particular voltage or current has been applied for a long time such that all transients have died out until we measure the resulting current or voltage respectively)

Make sure you label your graph such that the characteristics are completely defined (the shape of curve alone is not good enough)



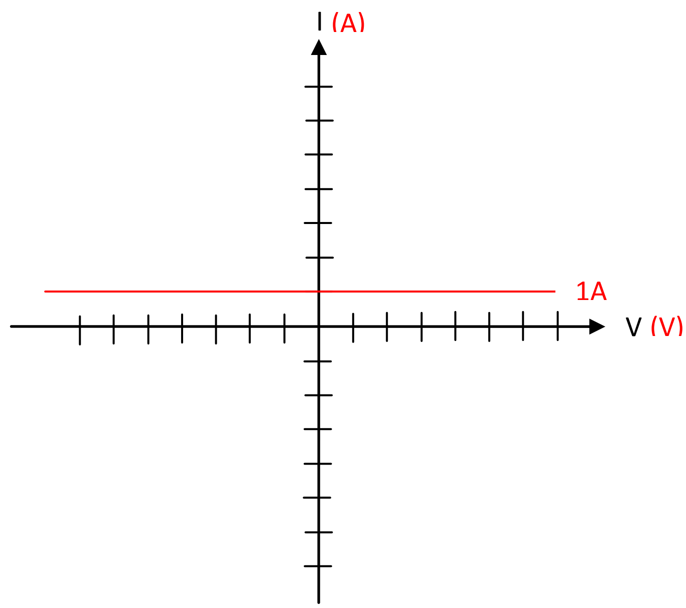
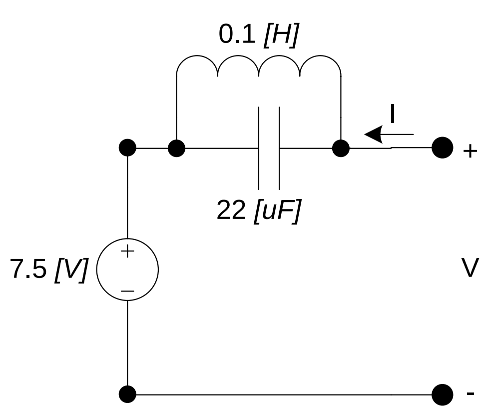


Figure 1.



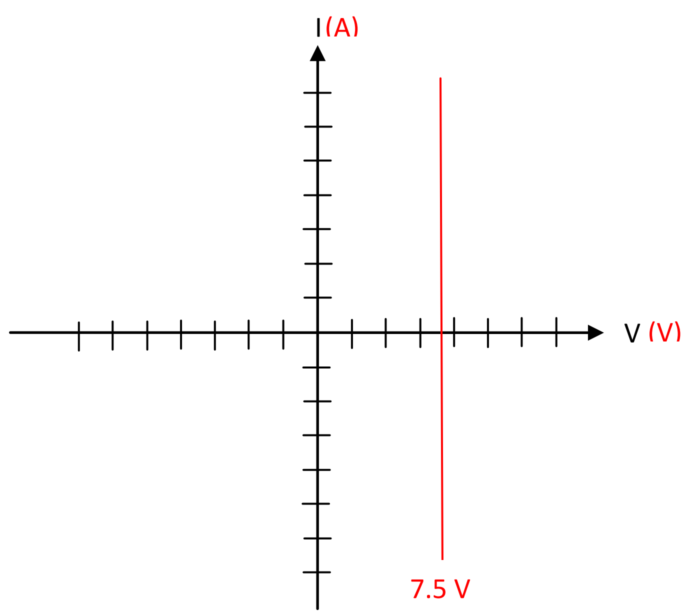


Figure 2.

Problem 2: Thevenin and Norton Circuits (20 pts)

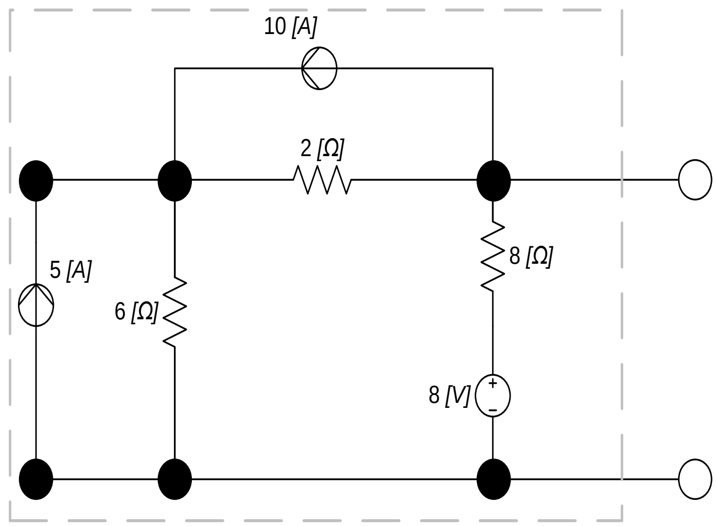
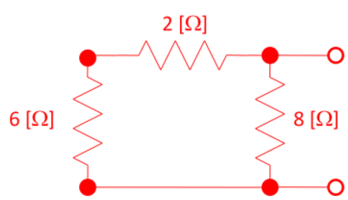


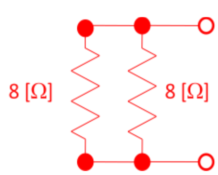
Figure 3.

a) Determine R_{th} of the circuit shown in Figure 3 (show your work) (6pts)

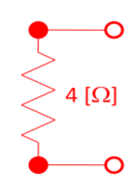
Step 1: Zero out all independent sources



Step 2: Reduce resistor network using series/parallel resistor combinations



Series: $R_{eq} = R_1 + R_2$: $R_{eq} = 6\Omega + 2\Omega = 8\Omega$

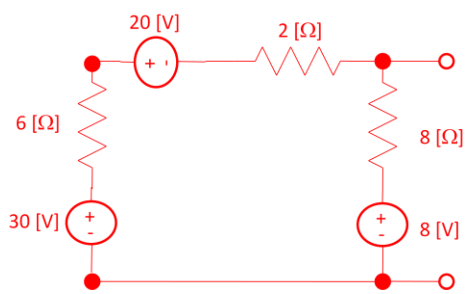


Parallel: $R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2}$: $R_{eq} = \frac{8\Omega \cdot 8\Omega}{8\Omega + 8\Omega} = 4\Omega$

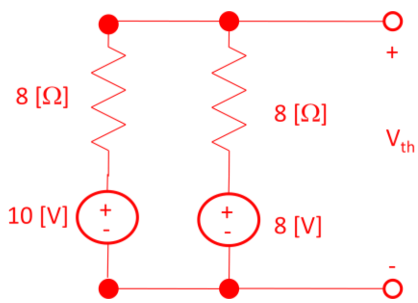
$R_{th} = 4[\Omega]$

b) Determine V_{th} of the circuit shown in Figure 3 (show your work) (14pts)

Step 1: Convert current sources to voltage sources using Source Transformation



Step 2: Combine the sources and resistors on the left and top side of the circuit



Step 3: Now utilize the voltage divider relation to solve for V_{th}

$$V_{th} = \frac{8\Omega}{8\Omega + 8\Omega}(10V - 8V) + 8V = \frac{1}{2}2V + 8V = 9V$$

NOTE: This problem can also be solved using Nodal Analysis to determine V_{th}. In this case, one can either solve the KCL and KVL equations directly, or use Superposition to solve for V_{th} due to each source and then add the results together to get the final answer.

$\boxed{V_{th} = 9[V]}$

Problem 3: Nodal Analysis (30 pts)

Solve for i_x and v_1 of the figure below (show your work)
(24 pts (80 %) for setting up the problem correctly,6 pts (20 %) for correct numerical solutions)

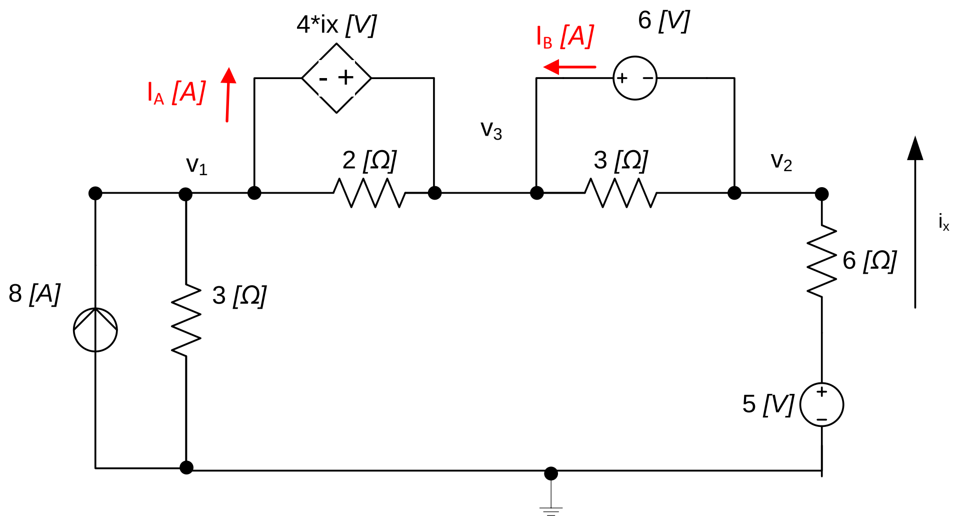


Figure 4.

Step 1: Apply KCL to each node

(1) V_1: $8\,[A] + \frac{4\cdot i_x\,[V]}{2\,[\Omega]} = i_A + \frac{V_1}{3\,[\Omega]}$

(2) V_2: $i_x + \frac{6[V]}{3[\Omega]} = i_B$

(3) V_3: $i_A + i_B = \frac{4\cdot i_x[V]}{2[\Omega]} + \frac{6[V]}{3[\Omega]}$

OR

(4) GND: $\frac{V_1}{3[\Omega]} = i_x + 8[A]$

NOTE: Either Combine (1), (2) and (3) to get (4) or apply KCL to GND node directly

Step 2: Apply KVL

(5) $V_1[V] + 4\cdot i_x[V] - 6[V] + 6[\Omega]\cdot i_x[A] = 5[V] \Rightarrow 10\cdot i_x[V] - 11[V] = -V_1[V]$

Step 3: Combine (4) and (5) to solve for V_1 and i_x

$-10\cdot i_x + 11 = 3\cdot i_x + 24$

$13\cdot i_x = -13$

$i_x = -1[A]$

$V_1 = 3\cdot i_x + 24 = -3 + 24 = 21[V]$

$\boxed{i_x = -1[A]}$

$\boxed{V_1 = 21[V]}$

Problem 4: Transient Behavior of RC circuits (40 pts)

a) Sketch $\mathbf{V_X}$ and $\mathbf{I_X}$ versus time for the circuit shown in Figure 5. (16 pts each)
For t<0, the switch SW2 is closed (on), switch SW1 is open (off) and they have been like that for a long time. At t=0 SW1 turns on (closes) and SW2 turns off (opens). Draw your answer from $t=0^-$ until all transient signals are gone.

Remember: A sketch does not have to be extremely accurate; however your curves should have the right shape and you should make sure you indicate and label the initial and final values as well as the (approximate) value at $t = \tau$ in your graph. (Another thing to remember $1/e = 0.368$)

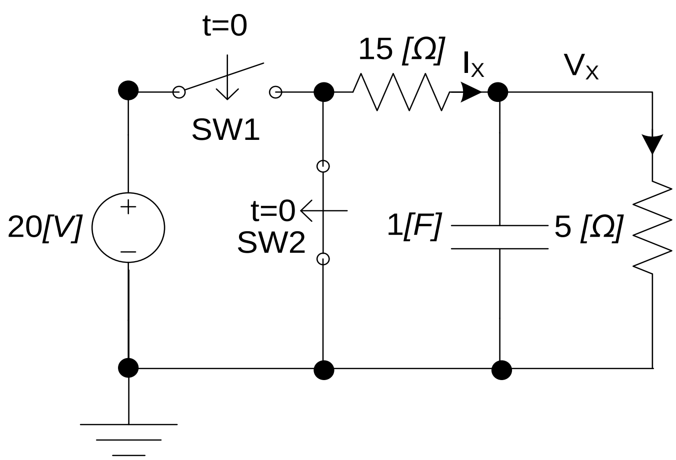
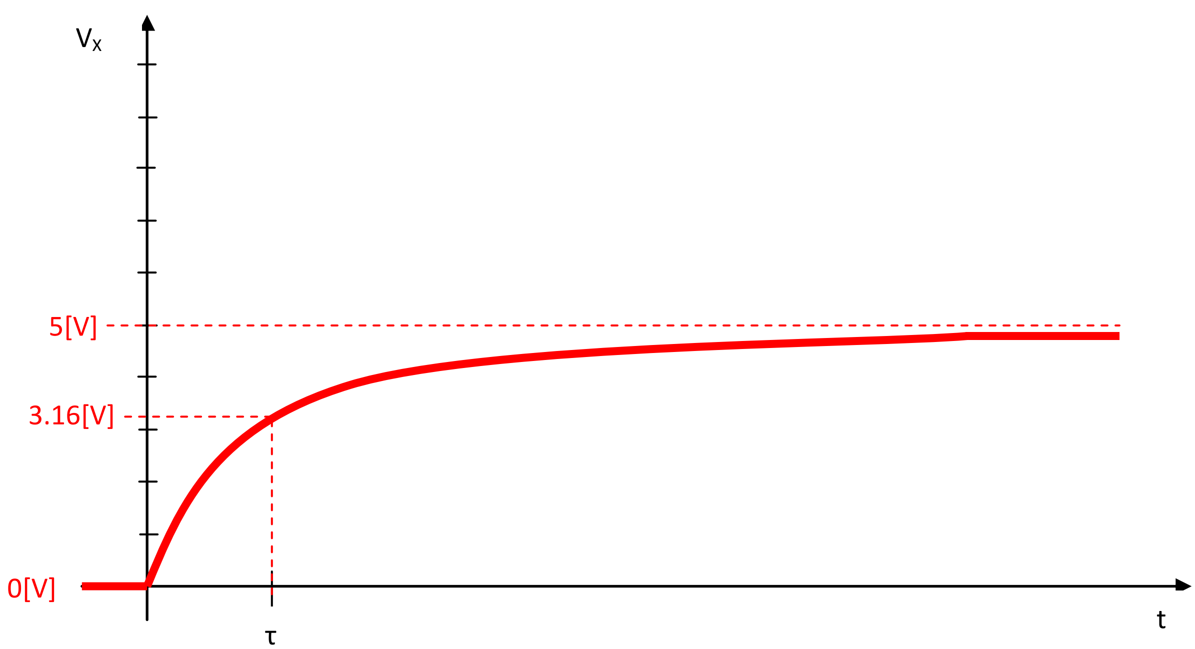
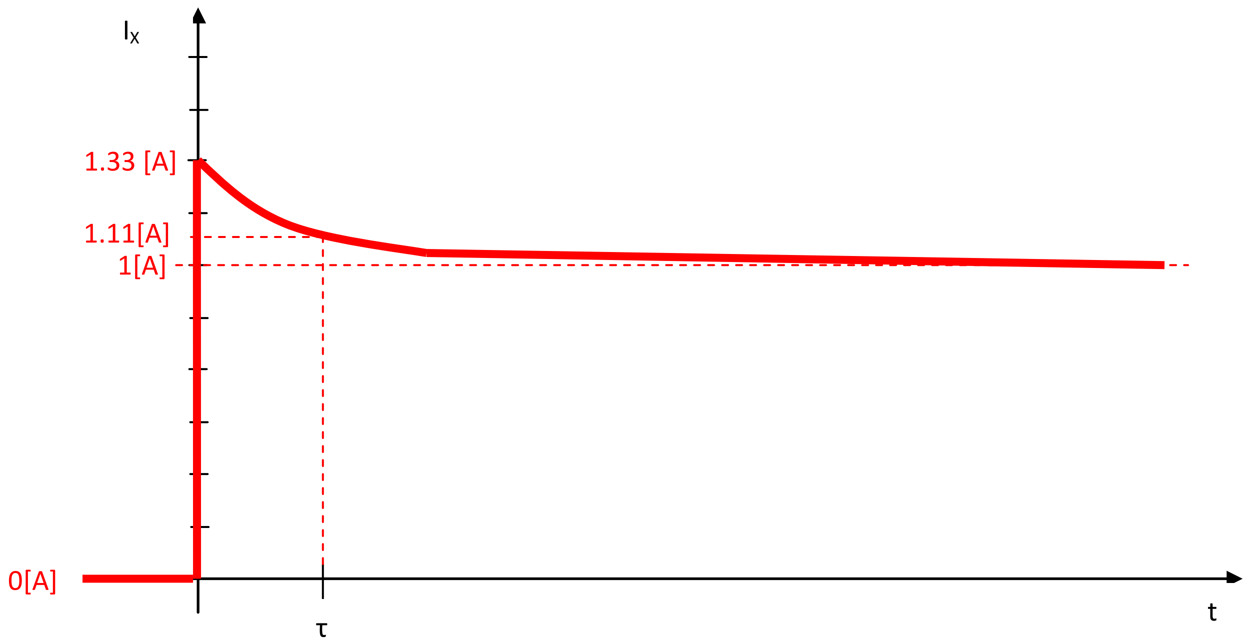


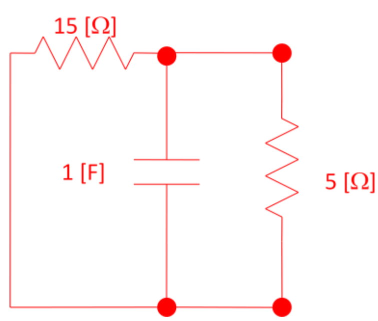
Figure 5.





b) What is the time constant of that circuit for t>0 (show your work) (8 pts)

Step 1: Determine the equivalent resistance seen by the capacitor



$$R_{eq} = \frac{15[\Omega] \cdot 5[\Omega]}{15[\Omega] + 5[\Omega]} = \frac{75}{20}[\Omega]$$

Step 2: Calculate the time constant

$$\tau = R_{eq} \cdot C = \frac{75}{20}[\Omega] \cdot 1[F] = \frac{75}{20}[sec]$$

$$\boxed{\tau = 75/20[sec]}$$