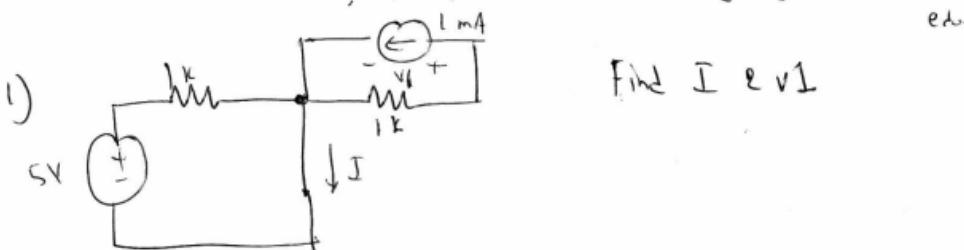


09/24/02

EECS 40 Midterm 1 ~~Difficult~~ problems solution(s)

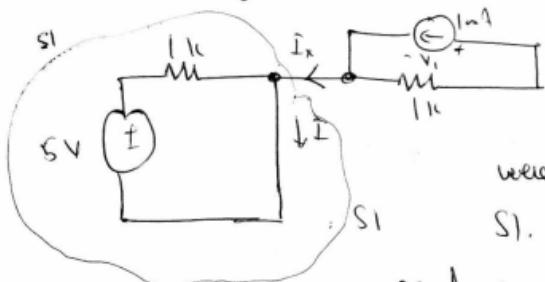
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Mail comments, corrections, etc to mbharat@eecs.berkeley.edu



Sol: The goal behind this problem is to make you understand KCL.

Redrawing the circuit above:

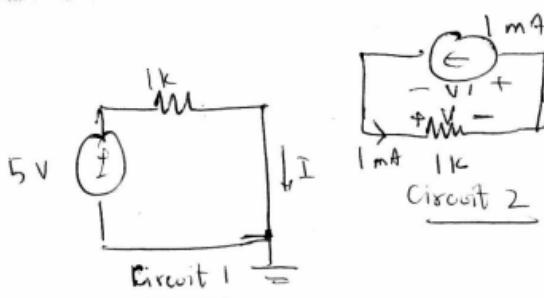


Suppose a current  $I_x$  were to flow into the surface S1. KCL indicates that an equal amount  $I_x$  should flow out.

In our case, there is no path for  $I_x$  ~~to~~ to flow out.

$\Rightarrow$  No current flows between the two circuits.

$\Rightarrow$  We can redraw the circuit as two independent circuits.



Circuit 1: Applying Ohm's law

$$I = \frac{(5 - 0)}{1\text{k}}$$

$$\Rightarrow I = 5 \text{ mA}$$

Circuit 2:

Applying Ohm's law;

$$V = (1\text{mA}) (1\text{k})$$

$$= \underline{1\text{V}}$$

Applying KVL yields

$$-V - V_1 = 0$$

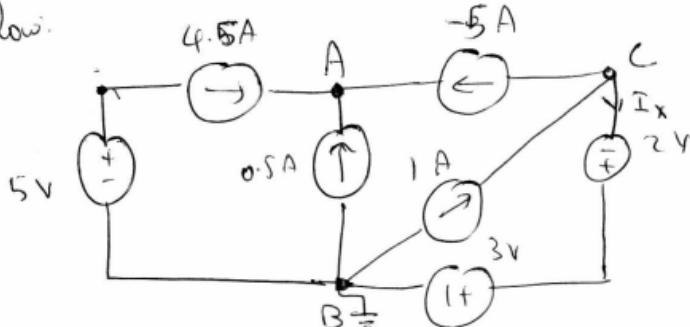
$$\Rightarrow V_1 = -V$$

$$\Rightarrow \boxed{V_1 = -1\text{V}}$$

Note: This type of a circuit is called as a hinge circuit. (Thanks to Prof. Ross for pointing this out).

(2)

(2) What is wrong (if any) with the IDEAL circuit below.



Sol: The goal behind this problem is to make you understand KCL, KVL and power balancing.

KCL, KVL and power balancing (i.e. power absorbed = power delivered) are statements of the law of conservation of energy.

So, you simply have to check if KCL, KVL or power balance is violated. If so, then the circuit can't exist. (in reality).

$$\text{KCL @ A: } \sum I_{\text{in}} = \sum I_{\text{out}}$$

$$\Rightarrow 4.5 + 0.5 = 5 \text{ A}$$

$\Rightarrow$  ok!

KCL @ C:

$$\sum I_{in} = \sum I_{out}$$

$$\Rightarrow 5 + 1 = I_x$$

$$\Rightarrow \underline{\underline{I_x = 6}} \quad \text{--- (1)}$$

KCL @ B:

$$\sum I_{in} = \sum I_{out}$$

$$\Rightarrow I_x = 0.5 + 1 + 4.5$$

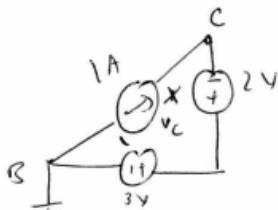
$$\Rightarrow I_x = 6 \quad \text{--- (2)}$$

(2) & (1) agree  $\Rightarrow$  GREAT! KCL satisfied

KVL:

Looks like we have two unknown node voltages  $V_A$  &  $V_C$  [I fixed my ground at B].

Wait! we can find  $V_C$ . Consider the loop below.



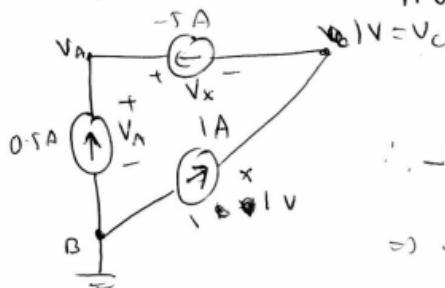
Applying KVL:

$$-V_C - 2 + 3 = 0$$

$$\Rightarrow \boxed{V_C = 1 \text{ V}}$$

Wmmmm... What about  $V_A$ ?

Well, let us start apply KVL.



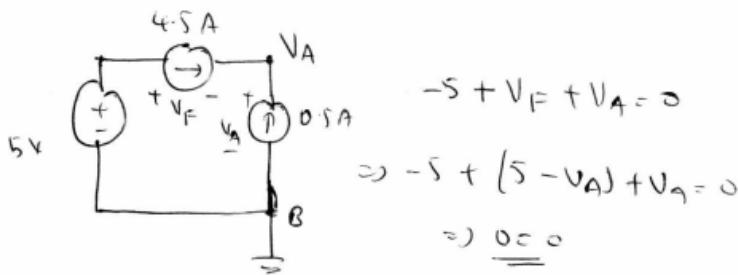
$$\therefore -V_A + V_x + 1 = 0$$

$$\Rightarrow -V_A + (V_A - 1) + 1 = 0$$

$$\Rightarrow 0 = 0 \quad \text{--- (1)}$$

Wmmmm... ok, we know that.

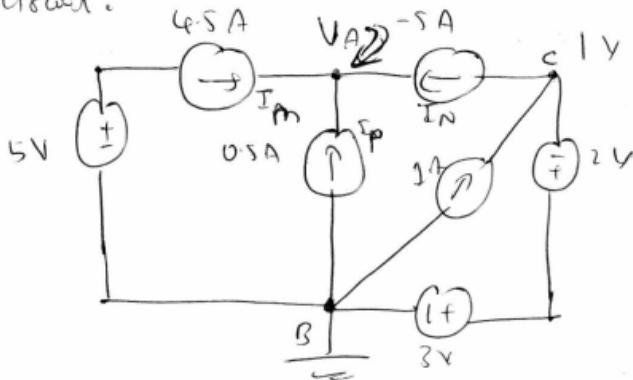
Let us try another loop.



You can keep trying, you will end up with a valid mathematical result.

What does this mean?  $\Rightarrow \underline{V_A \text{ does not matter.}}$  Think about it. Would it matter if  $V_A = 11, -3.4, e$  in (1)? No!

Physically, where is  $V_A$ ? Look closely at the circuit:

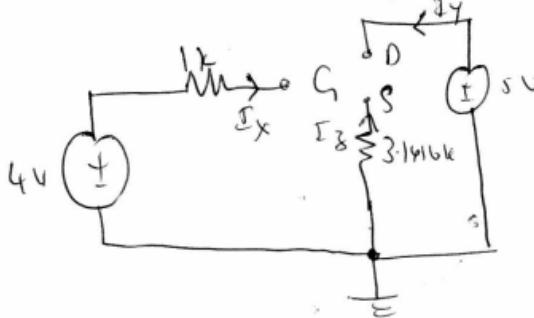


The value of  $V_A$  just affects the voltage across the current source(s)  $I_M$ ,  $I_N$  &  $I_P$ .

But, current sources don't care what the voltage is across them!, they just make ~~sure~~ sure the current is constant in a branch. This is why we could not find  $V_A$ , it could be anything.

Does this make sense? Remember we are dealing with a linear system. From basic linear algebra, you <sup>may</sup> know that a linear system can have (a) no solution (b) unique solution or (c) infinitely many solutions. In our case, we have infinitely many solutions  $\Rightarrow$  CIRCUIT IS VALID

(3) In the circuit below, find  $V_{GS}$ ,  $V_{DS}$  &  $V_{DS}$ .



Sol. The goal of this problem is to make you understand open circuits.

In the circuit above,  $I_x = I_y = I_z = 0$ , because the circuit above is <sup>worst case</sup> an OPEN CIRCUIT.

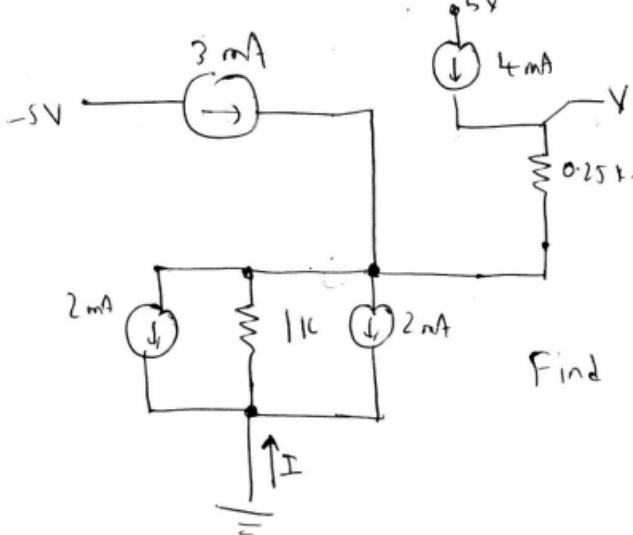
$$\therefore V_G = 4 \text{ V} \quad V_D = 5 \text{ V} \quad V_S = 0 \text{ V}$$

$$V_{GS} = V_G - V_S = 4 \text{ V}$$

$$V_{DS} = V_D - V_S = 5 \text{ V}$$

$$V_{DG} = V_D - V_S = 1 \text{ V}$$

(4)



Find V and I

The goal of this problem is to make you understand circuit diagrams and voltage the concept of the reference voltage.

(a)  $I =$  does not make sense.

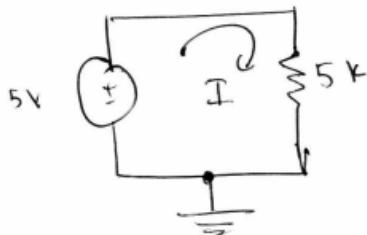
~~As I said earlier, the goal behind this question is to tell you~~

The question shows I coming out of the reference voltage symbol ~~!!!?~~ ~~@!!~~. This is IMPOSSIBLE.

Hence, it doesn't make sense to find a value for I.

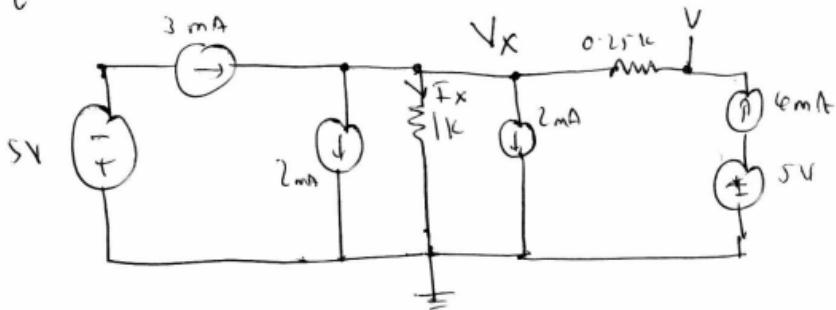
5

Please note: In the circuit below.



There is no  $I$  flowing into ground. The  $\frac{+}{-}$  is a symbol!!!!

So, the next question you may ask is, where does the current flow???? The circuit diagram in this question is in "electrical engineering short-hand form". (this is my term). Basically, the circuit is:



This is one way to redraw the circuit. There are many other ways to <sup>redraw</sup> it. Heck, maybe you don't even have to redraw it!

Applying KCL @  $V_x$ :

$$\sum I_n = \sum I_{out}$$

$$4mA + 3mA = 2mA + 2mA + I_x$$

$$\Rightarrow I_x = \underline{3mA}$$

$$\therefore V_x = (3mA) \cdot (1k) = \underline{\underline{3V}} \quad [\text{Ohm's law}]$$

Now, applying ohm's law again to  $\frac{0.25}{0.25} k$ ,

$$(V - V_x) = (0.25k)(4mA)$$

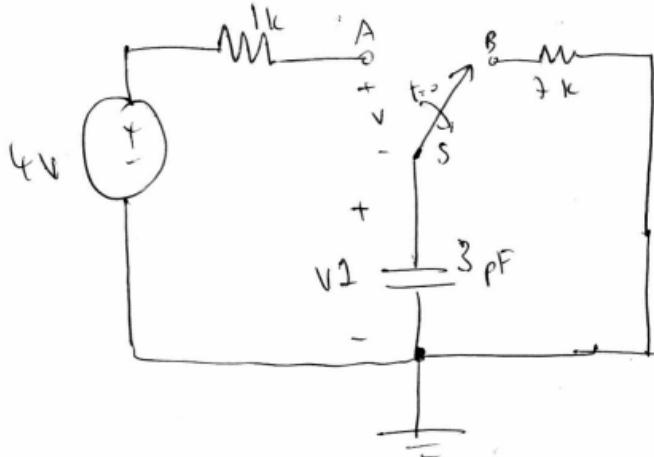
$$\Rightarrow V - V_x = 1$$

$$\Rightarrow \boxed{V = 4V}$$

⑥

2

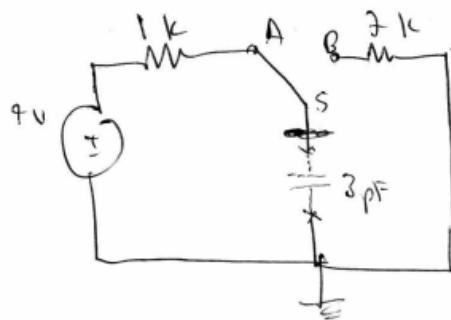
(5) \* In the circuit below, Switch S has been in position A for a long time. At  $t=0$ , switch instantaneously moves to position B. Find V at  $t=0^+$  and plot  $V_1$  as a function of time (for all  $t$ ).



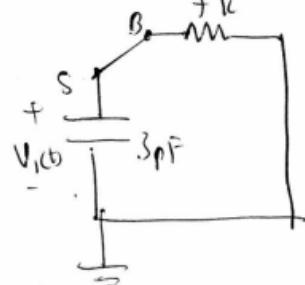
Sol) The goal behind this problem is to make you understand how capacitors work.

Let us consider the two cases: when the switch is at A and when the switch moves to B separately.

① Switch @ A



② Switch @ B



Now, the switch has been at position A for a long time  $\Rightarrow$  capacitor is fully charged to 4 V. Therefore, the initial voltage on the capacitor is 4 V.

$$\therefore V_1(0^-) = 4 \text{ V}$$

The notation  $0^-$  means "just before an instant before switch moves to B, which happens at  $t=0$ ".

When the switch moves to B, what happens to the initial voltage across the capacitor?

It does not change instantaneously. If it

were to change instantaneously, then the current through the capacitor,

[switch @ B    continued]

(7)

$$i = C \frac{dv}{dt}$$

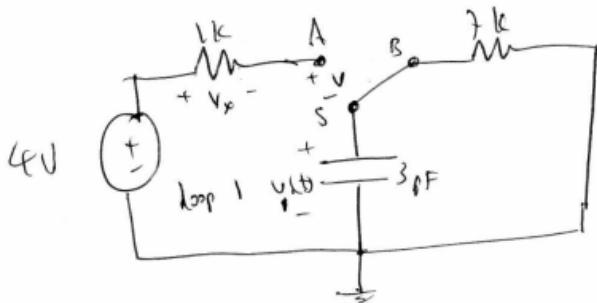
would ~~be~~ go to  $\infty$ .

$$\therefore v_1(0^-) = v_1(0^+) = 4 \text{ V}$$

THIS IS A VERY FUNDAMENTAL

PROPERTY OF CAPACITORS  $\Rightarrow$  CONTINUITY  
OF VOLTAGE ACROSS DISCONTINUITIES IN THE  
SYSTEM.

Now, consider the complete circuit @  $t > 0$ :



At  $t=0^+$ , apply KVL (Loop 1)

$$-4 + V_x + V + v_i = 0 \quad (\text{at } t=0^+)$$

Now, loop 1 is open,

$\Rightarrow V_x = 0V$  (no current flows through the resistor)

$$\therefore -4 + V + 4 = 0$$

$$\Rightarrow \boxed{V = 0V \text{ at } t=0^+}$$

What about  $v_c(t)$ ? Well, the initial voltage on the capacitor is 4V. The cap. then discharges through a 7k for  $t > 0 \Rightarrow$  SIMPLE AC DISCHARGE!

