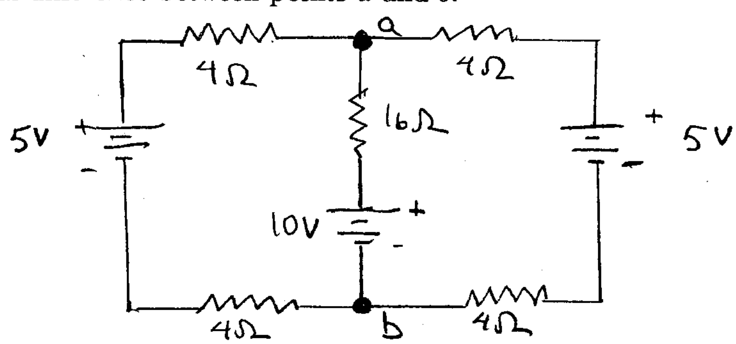
Physics 102– Pledged Problem 7

Time allowed: **2 hours at a single sitting**
Due 5PM Tuesday, March 21, 2006, in the boxes marked Phys 101-102 in the physics lounge. You may use your own textbook, your notes, and a non-programmed calculator. You may also consult the on-line solutions to the corresponding suggested problems. You should consult no other help. Show how you arrived at your answer; the correct answer by itself may not be sufficient.
Further instructions:
(a) Write legibly on **one** side of 8.5" x 11" white or lightly tinted paper.
(b) Staple all sheets together, including this one, in the upper left corner and make one vertical fold.
(c) On the outside, staple side up, print your name in capital letters, your LAST NAME first followed by your FIRST NAME.
(d) Below your name, print the phrase "Pledged Problem 7", followed by the due date.
(e) Also indicate **start time** and **end time**.
(f) Write and sign the pledge, with the understanding that you may consult the materials noted above.

---

10 I. In the circuit below, determine the following:

6 (a) The current through each resisitor, including the direction.
4 (b) The potential difference between points *a* and *b*.

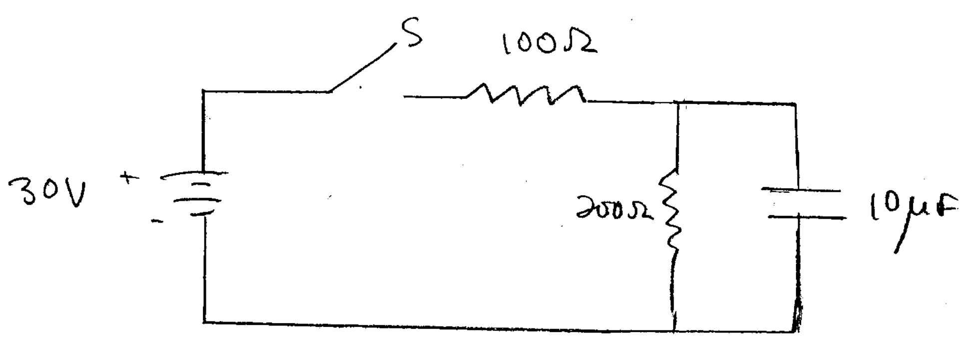


20 II. In the circuit below, the capacitors are initially uncharged. At t=0 the switch is closed.

3 (a) Determine the current in each resistor immediately after the switch is closed.
3 (b) Determine the current in each resisitor a long time after the switch his closed.
4 (c) Determine the voltage across the capacitor a long time after the switch is closed.

After the switch has been closed for a long time, it is opened again.

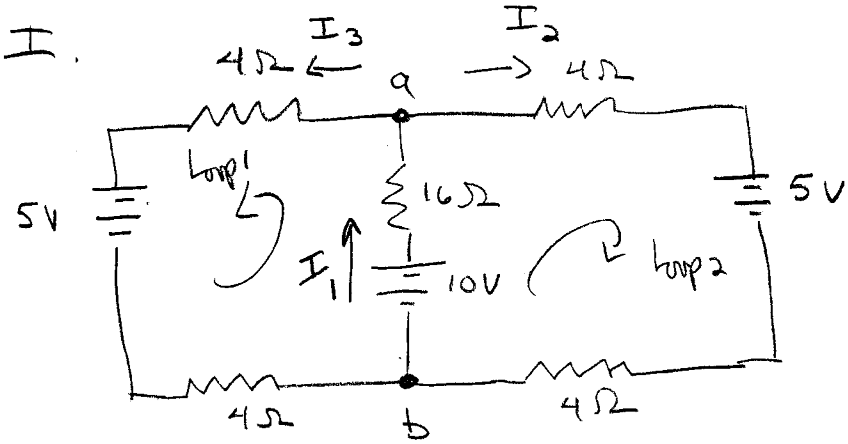
4 (d) Determine the initial current I_0 through the 200Ω resistor immediately after the switch is opened.
3 (e) Determine $I(t)$, the current through the 200 Ω resistor as a function of time after the switch is opened. Sketch $I(t)$.
3 (f) At what time after the switch is opened has the charge on the capacitor fallen to 0.1 of its initial value?



Physics 102

Pledged Problem 7

I.



$I_1 = I_2 + I_3$

(a) We could guess right away that $I_2 = I_3$ by symmetry, but let's show it anyway.
Set up the Kirchoff loop equations:

① $10 - 16I_1 - 4I_3 - 5 - 4I_3 = 0$

$5 - 16I_1 - 8I_3 = 0$

② $10 - 16I_1 - 4I_2 - 5 - 4I_2 = 0$

$5 - 16I_1 - 8I_2 = 0$

Subtracting ② from ① gives

$-8I_3 + 8I_2 = 0$

$I_2 = I_3 = I_1/2$

Now we can easily solve:

$$5 = 16I_1 + 8(I_1/2)$$

$$5 = 20I_1$$

$$I_1 = 1/4\ A$$

$$I_2 = I_3 = \frac{1}{8}\ A$$

Current through 16Ω resistor = 1/4 A
Current through all other resistors = 1/8 A.

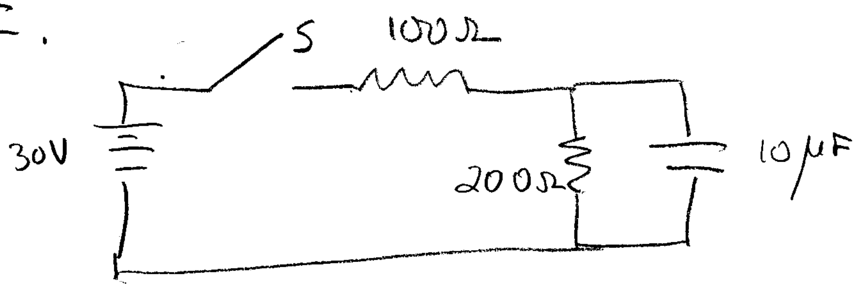
Directions are as shown on the sketch.

(b) $\Delta V\ (b \to a) = 10 - 16I_1 = 10 - 4 = 6V$

$$V_a - V_b = +6V$$

Potential at point a is higher

II.



Switch is closed at $t=0$.

(a) Immediately after S is closed, the capacitor acts like a short, so no current flows through the 200Ω resistor.

$$I_{100} = \frac{30V}{100\Omega} = .3A$$

$I_{100} = 0.3A$ $I_{200} = 0$

(b) A long time after S is closed, the capacitor acts like an open circuit, so all the current flows through both resistors

$$I = \frac{30V}{300\Omega} = .1A$$

$I_{100} = I_{200} = 0.1A$

(c) After a long time, the voltage across the capacitor will be the same as the voltage across the 200Ω resistor, since they are in parallel,

$V_c = I_{200}(200\Omega) = 20V = V_c$

(d) When S is opened again, the 100Ω resistor & 30V battery are removed from the circuit. The capacitor discharges through the 200Ω resistor.

$$I_0 = \frac{V_C}{R} = \frac{20V}{200\Omega} = .1A$$

$$\boxed{I_0 = 0.1A}$$

Same as the current immediately before S is opened.

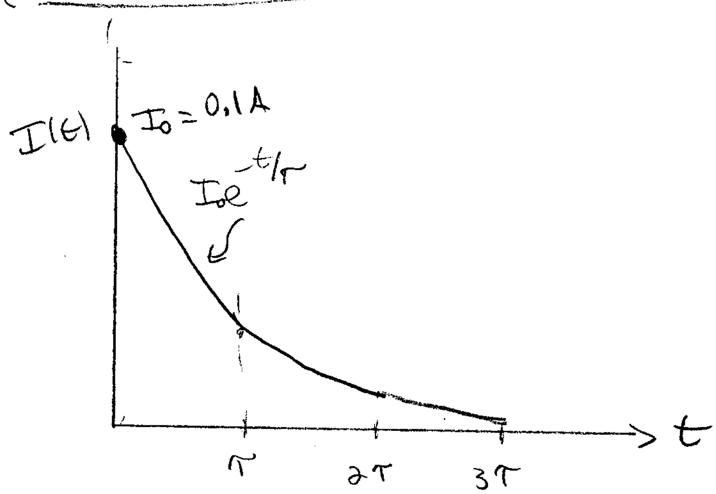
(e) The time constant for discharge is $\tau = RC$. where only the 200Ω resistor contributes.

$$I(t) = I_0 e^{-t/\tau}$$

$$I(t) = 0.1 e^{-t/.002}$$

$\tau = (200\Omega)(10^{-5}F) = 2\times10^{-3}s$

$$\boxed{\tau = .002s = 2ms}$$



(f) $\frac{I}{I_0} = 0.1 = e^{-t/\tau}$

$\ln(.1) = -t/\tau$

$$\boxed{t = 2.3\tau = 4.6ms = .0046s}$$