GPN2-L07

Problem 1

A car battery with a 12 V emf and an internal resistance of 0.040 Ω is being charged with a current of 50 A.What are (a) the potential difference V across the terminals, (b) the rate P_r of energy dissipation inside the battery, and (c) the rate P_{emf} of energy conversion to chemical form? When the battery is used to supply 50 A to the starter motor, what are (d) V and (e) P_r? (05小題)

When the battery is being charged:

(a)________ V

01: **ANS:=14**

(b)________ W

02: **ANS:=1.0E2**

(c)________ W

03: **ANS:=6.0E2**

When the battery is us

(d) ________ V

04: **ANS:=10**

(e)________ W

05: **ANS:=1.0E2**

(a) The potential difference is $V = \varepsilon + ir = 12\text{ V} + (50\text{ A})(0.040\ \Omega) = 14\text{ V}$.

(b) $P = i^2r = (50\text{ A})^2(0.040\ \Omega) = 1.0\times10^2\text{ W}$.

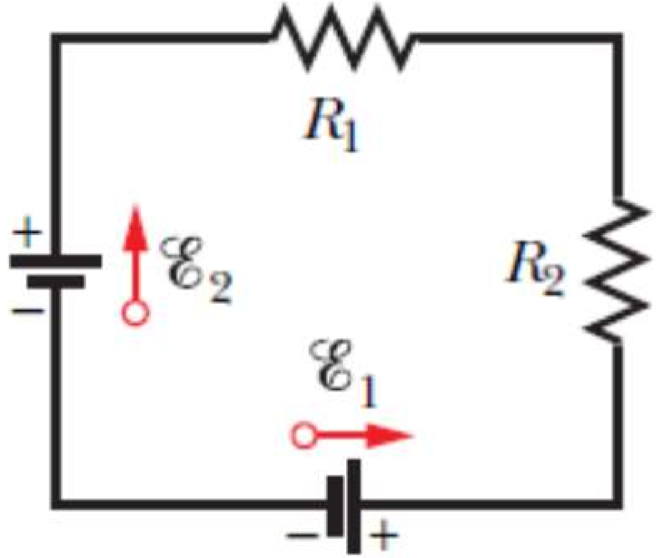
(c) $P' = iV = (50\text{ A})(12\text{ V}) = 6.0\times10^2\text{ W}$.

(d) In this case $V = \varepsilon - ir = 12\text{ V} - (50\text{ A})(0.040\ \Omega) = 10\text{ V}$.

(e) $P_r = i^2r = (50\text{ A})^2(0.040\ \Omega) = 1.0\times10^2\text{ W}$.

Problem 2

In the figure, the ideal batteries have emfs $\epsilon_1 = 12$ V and $\epsilon_2 = 6.0$ V and the resistors have resistances $R_1 = 4.0\ \Omega$ and $R_2 = 8.0\ \Omega$. What are (a) the current, the dissipation rate in (b) resistor 1 and (c) resistor 2, and the energy transfer rate in (d) battery 1 and (e) battery 2? Is energy being supplied or absorbed by ? (05小題)



(a) ________ A

06: **ANS:=0.5**

(b) P_{R_1} =________ W

07: **ANS:=1.0**

(c) P_{R_2} =________ W

08: **ANS:=2.0**

(d) P_{ϵ_1} =________ W

09: **ANS:=6.0**

(e) P_{ϵ_1} =________ W

10: **ANS:=3.0**

(a) $\varepsilon_1 - iR_2 - iR_1 - \varepsilon_2 = 0.\quad i = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_2} = \frac{12\text{ V} - 6.0\text{ V}}{4.0\Omega + 8.0\Omega} = 0.50\text{ A}.$

(b) For R_1, $P_1 = i^2R_1 = (0.50\text{ A})^2(4.0\ \Omega) = 1.0$ W,

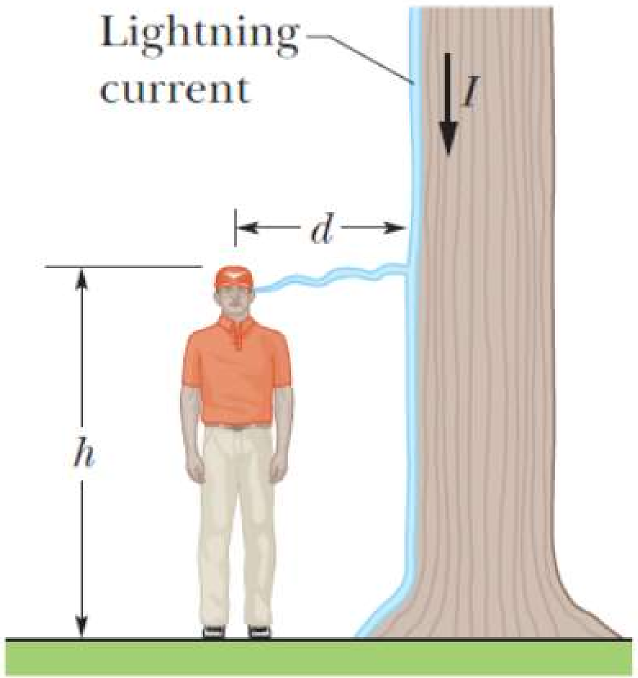
(c) and for R_2, $P_2 = i^2R_2 = (0.50\text{ A})^2\ (8.0\ \Omega) = 2.0$ W.

(d) For ε_1, $P_1 = i\varepsilon_1 = (0.50\text{ A})(12\text{ V}) = 6.0$ W

(e) and for ε_2, $P_2 = i\varepsilon_2 = (0.50\text{ A})(6.0\text{ V}) = 3.0$ W.

Problem 3

Side flash. The figure indicates one reason no one should stand under a tree during a lightning storm. If lightning comes down the side of the tree, a portion can jump over to the person, especially if the current on the tree reaches a dry region on the bark and thereafter must travel through air to reach the ground. In the figure, part of the lightning jumps through distance d in air and then travels through the person (who has negligible resistance relative to that of air). The rest of the current travels through air alongside the tree, for a distance h. If $d/h = 0.400$ and the total current is $I = 5000$ A, what is the current through the person? (01小題)



________ A

11: **ANS:=3571**

across the two paths are the same, $V_1 = V_2$ $i_1R_1 = i_2R_2$, $i = i_1 + i_2 = 5000$ A.

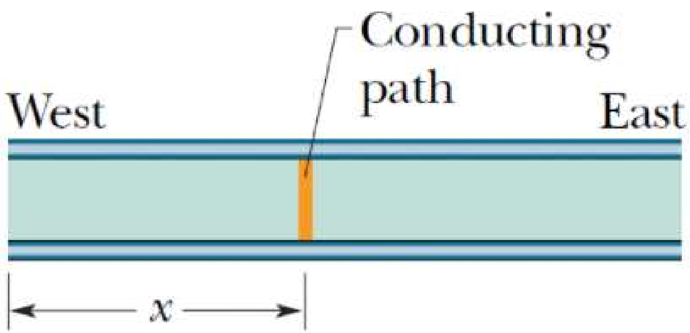
$R = \rho L / A$ $i_1 d = i_2 h \Rightarrow i_2 = i_1(d/h)$.

With $d/h = 0.400$, we get $i_1 = 3571$ A and $i_2 = 1429$ A

the current through the person is $i_1 = 3571$ A

Problem 4

A 10-km-long under-ground cable extends east to west and consists of two parallel wires, each of which has resistance 13 Ω/km. An electrical short develops at distance x from the west end when a conducting path of resistance R connects the wires (the figure). The resistance of the wires and the short is then 100 Ω when measured from the east end and 200 Ω when measured from the west end. What are (a) x and (b) R? (02小題)



(a) x=________ km

12: **ANS:=<u>6.9</u>**

(b) R=________ Ω

13: **ANS:=<u>20</u>**

(a) We denote $L = 10$ km and $\alpha = 13$ Ω/km. Measured from the east end we have

$$R_1 = 100\ \Omega = 2\alpha(L - x) + R,$$

and measured from the west end $R_2 = 200\ \Omega = 2\alpha x + R$. Thus,

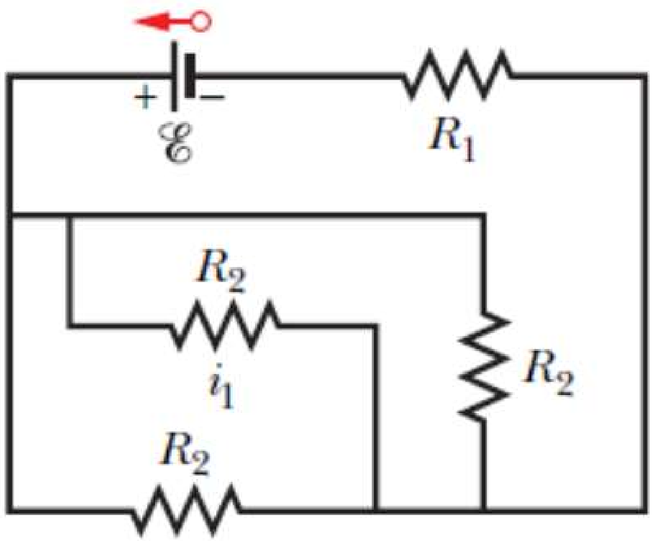
$$x = \frac{R_2 - R_1}{4\alpha} + \frac{L}{2} = \frac{200\,\Omega - 100\,\Omega}{4(13\,\Omega/\text{km})} + \frac{10\,\text{km}}{2} = 6.9\ \text{km}.$$

(b) Also, we obtain

$$R = \frac{R_1 + R_2}{2} - \alpha L = \frac{100\,\Omega + 200\,\Omega}{2} - (13\,\Omega/\text{km})(10\,\text{km}) = 20\,\Omega.$$

Problem 5

In the figure, R_1= 6.00 Ω, R_2= 18.0 Ω, and the ideal battery has emf ϵ=12.0 V. What are the (a) size and (b) How much energy is dissipated by all four resistors in 1.00 min? (02小題)



(a) ________ A

14: **ANS:=0.333**

(b) ________ J

15: **ANS:=720**

(a) The parallel set of three identical R_2 = 18 Ω resistors reduce to R= 6.0 Ω, which is now in series with the R_1 = 6.0 Ω resistor at the top right, so that the total resistive load across the battery is $R' = R_1 + R = 12$ Ω. Thus, the current through R' is (12V)/R' = 1.0 A, which is the current through R. By symmetry, we see one-third of that passes through any one of those 18 Ω resistors; therefore, i_1 = 0.333 A.

(b) We use Eq. 26-27: $P = i^2R' = (1.0\ \text{A})^2(12\ \Omega) = 12$ W. Thus, in 60 s, the energy dissipated is (12 J/s)(60 s) = 720 J.

Problem 6

The current in a single-loop circuit with one resistance R is 5.0 A.When an additional resistance of 2.0 Ω is inserted in series with R, the current drops to 4.0 A. What is R? (01小題)

________ Ω

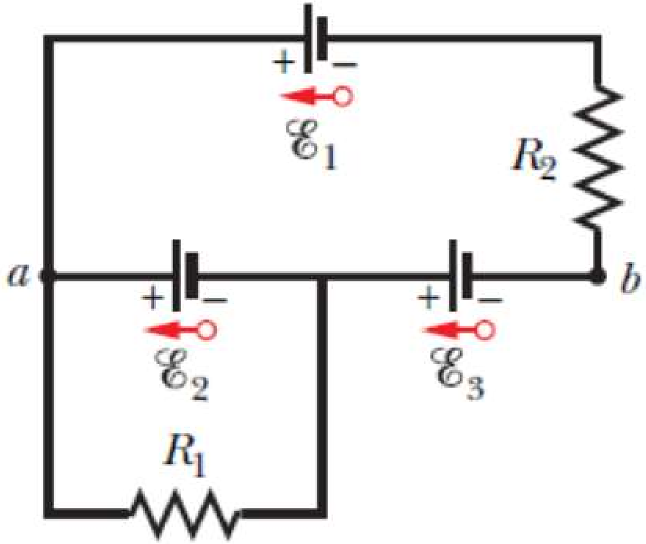
16: **ANS:=8.0**

Let the emf be V. Then $V = iR = i'(R + R')$, where $i = 5.0$ A, $i' = 4.0$ A and $R' = 2.0\ \Omega$. We solve for R:

$$R = \frac{i'R'}{i - i'} = \frac{(4.0\text{ A})(2.0\,\Omega)}{5.0\text{ A} - 4.0\text{ A}} = 8.0\ \Omega.$$

Problem 7

In the figure, R_1= 100 Ω, R_2= 50Ω, and the ideal batteries have emfs ϵ_1= 6.0 V, ϵ_2= 5.0 V, and ϵ_3=4.0 V. Find (a) the current in resistor 1, (b) the current in resistor 2 (absolute value), and (c) the potential difference between points a and b. (03小題)



(a) ________ A

17: **ANS:=0.050**

(b) ________ A

18: **ANS:=0.06**

(c) ________ V

19: **ANS:=9.0**

Let i_1 take it to be positive if it is to the right.

i_2 take it to be positive if it is upward.

$\varepsilon_2 - i_1R_1 = 0$. $\quad i_1 = \frac{\varepsilon_2}{R_1} = \frac{5.0\text{ V}}{100\,\Omega} = 0.050\text{ A}.$

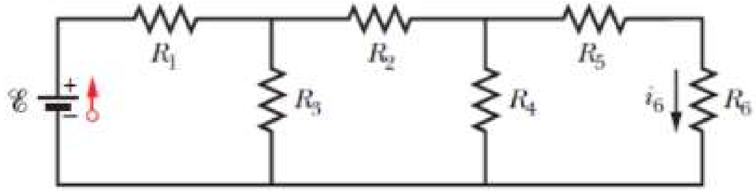
$\varepsilon_1 - \varepsilon_2 - \varepsilon_3 - i_2R_2 = 0$.

$$i_2 = \frac{\varepsilon_1 - \varepsilon_2 - \varepsilon_3}{R_2} = \frac{6.0\text{ V} - 5.0\text{ V} - 4.0\text{ V}}{50\,\Omega} = -0.060\text{ A}, \qquad |i_2| = 0.060\text{ A}.$$

$V_a = V_b + \varepsilon_3 + \varepsilon_2$, $\quad V_a - V_b = \varepsilon_3 + \varepsilon_2 = 4.0\text{ V} + 5.0\text{ V} = 9.0\text{ V}$.

Problem 8

In the figure, the current in resistance 6 is i_6= 1.40 A and the resistances are R_1=R_2=R_3= 2.00 Ω,R_4= 16.0 Ω,R_5= 8.00 Ω, and R_6= 4.00 Ω. What is the emf of the ideal battery? (01小題)



________ V

20: **ANS:=48.3**

V_4, is equal to the sum of the voltages across R_5 and R_6:

$V_4 = i_6(R_5 + R_6) = (1.40\ \text{A})(8.00\ \Omega + 4.00\ \Omega) = 16.8\ \text{V}.$

$i_4 = V_4/R_4 = 16.8\ \text{V}/(16.0\ \Omega) = 1.05\ \text{A}.$

$i_2 = i_4 + i_6 = 1.05\ \text{A} + 1.40\ \text{A} = 2.45\ \text{A}.$

$V_2 = (2.00\ \Omega)(2.45\ \text{A}) = 4.90\ \text{V}.$

The loop rule tells us the voltage across R_3 is

$V_3 = V_2 + V_4 = 21.7\ \text{V}$

$i_3 = V_3/(2.00\ \Omega) = 10.85\ \text{A}$

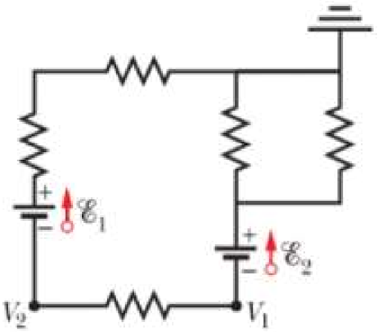
$i_1 = i_2 + i_3 = 2.45\ \text{A} + 10.85\ \text{A} = 13.3\ \text{A},$

$V_1 = (13.3\ \text{A})(2.00\ \Omega) = 26.6\ \text{V}.$

$\varepsilon = V_1 + V_3 = 26.6\ \text{V} + 21.7\ \text{V} = 48.3\ \text{V}.$

Problem 9

In the figure, the ideal batteries have emfs $\mathcal{E}_1 = 5.0$ V and $\mathcal{E}_2 = 12.0$ V, the resistances are each 2.0 Ω, and the potential is defined to be zero at the grounded point of the circuit. What are potentials (a) V_1 and (b) V_2 at the indicated points? (02小題)

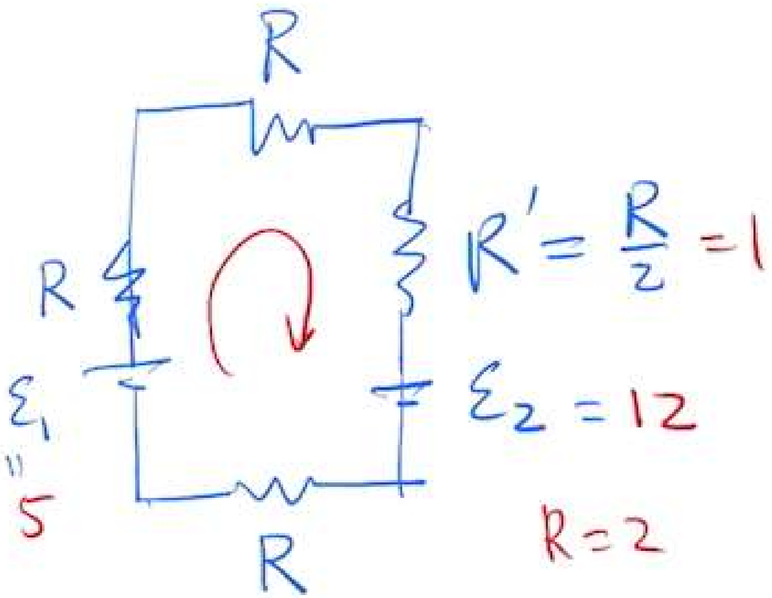


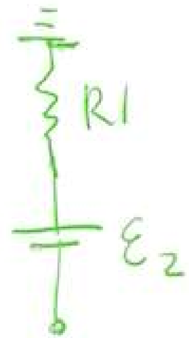
(a) V_1 =________ V

21: **ANS:=-11**

(b) V_2 =________ V

22: **ANS:=-9**





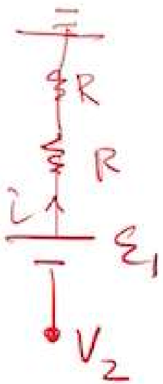
$V_1 + 12 + (-1)(1)$

$V_1 = -11$

$\mathcal{E}_1 - (R' + 3R)i - \mathcal{E}_2 = 0$

$5 - \frac{7}{2} i R - 12 = 0$

$i = -1$

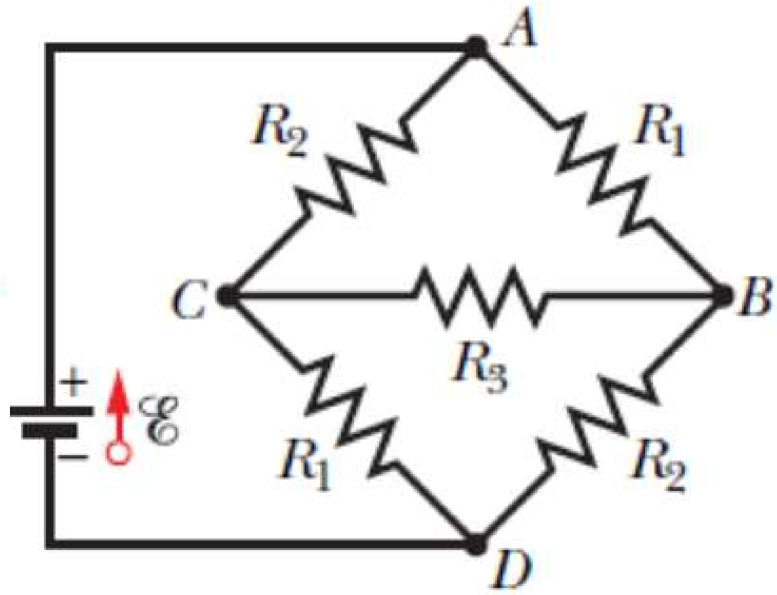


$V_2 + 5 - (-1)(4) = 0$

$V_2 = -9$

Problem 10

In the figure, ϵ=12.0 V, R_1= 2000 Ω, R_2= 3000 Ω, and R_3= 4000 Ω. What are the potential differences (a) $V_A - V_B$, (b) $V_B - V_C$, (c) $V_C - V_D$, and (d) $V_A - V_C$? (04小題)



(a) $V_A - V_B =$ ________ V

23: **ANS:=<u>5.25</u>**

(b) $V_B - V_C =$ ________ V

24: **ANS:=<u>1.50</u>**

(c) $V_C - V_D =$ ________ V

25: **ANS:=<u>5.25</u>**

(d) $V_A - V_C =$ ________ V

26: **ANS:=<u>6.75</u>**

$$i_3 = i_1 - i_2.$$

$$\varepsilon - i_2R_2 - i_1R_1 = 0$$

$$\varepsilon - 2i_1R_1 - (i_1 - i_2)R_3 = 0$$

$$i_1 = 0.002625 \text{ A}, \; i_2 = 0.00225 \text{ A}$$

$$i_3 = i_1 - i_2 = 0.000375 \text{ A}.$$

$$V_A - V_B = i_1R_1 = 5.25 \text{ V}.$$

(b) It follows also that $V_B - V_C = i_3R_3 = 1.50$ V.

(c) We find $V_C - V_D = i_1R_1 = 5.25$ V.

(d) Finally, $V_A - V_C = i_2R_2 = 6.75$ V.

Problem 11

What multiple of the time constant τ gives the time taken by an initially uncharged capacitor in an RC series circuit to be charged to 99.0% of its final charge? (01小題)

________ τ

27: **ANS:=4.61**

$$q = C\varepsilon\left(1 - e^{-t/\tau}\right). \qquad \tau = RC$$

C is the capacitance, ε is applied emf,

$q_{eq} = C\varepsilon.$ The equilibrium charge

$$q = 0.99\,q_{eq} = 0.99\,C\varepsilon,$$

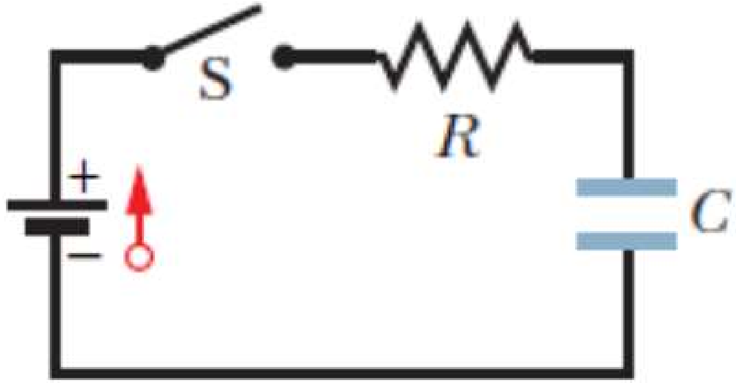
$$0.99 = 1 - e^{-t/\tau}.$$

$$e^{-t/\tau} = 0.01.$$

$$t/\tau = -\ln 0.01 = 4.61 \text{ or } t = 4.61\,\tau.$$

Problem 12

Switch S in the figure is closed at time $t = 0$, to begin charging an initially uncharged capacitor of capacitance $C = 15.0\ \mu\text{F}$ through a resistor of resistance $R = 20.0\ \Omega$ .At what time is the potential across the capacitor equal to that across the resistor? (01小題)



________ ms

28: **ANS:=0.208**

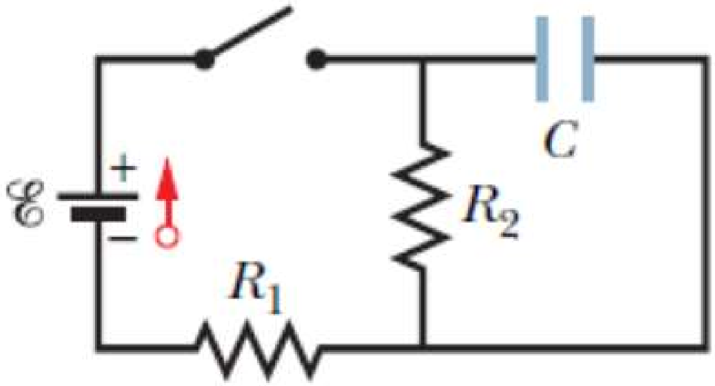
the resistor voltage be equal to the capacitor voltage becomes $iR = V_{cap}$, or

$$Ve^{-t/RC} = V(1 - e^{-t/RC})$$

This leads to $t = RC \ln 2$, or $t =$ 0.208 ms.

Problem 13

In the figure, R_1= 10.0 kΩ, R_2= 15.0 kΩ, C = 0.400 μF,and the ideal battery has emf ϵ=20.0 V. First, the switch is closed a long time so that the steady state is reached. Then the switch is opened at time t = 0.What is the current in resistor 2 at t = 4.00 ms? (01小題)



_________ A

29: **ANS:=4.11E-4**

In the steady state situation,

$$V_0 = R_2 \frac{\varepsilon}{R_1 + R_2} = (15.0\text{k}\Omega)\left(\frac{20.0\text{V}}{10.0\text{k}\Omega + 15.0\text{k}\Omega}\right) = 12.0\text{V}.$$

$V = V_0 e^{-t/RC}$ after the switch is opened (at $t = 0$).

$t = 0.00400$ s, $V = (12)e^{-0.004/(15000)(0.4\times10^{-6})} = 6.16\text{V}$.

the current through R_2 is $6.16/15000 = 4.11 \times 10^{-4}$ A.