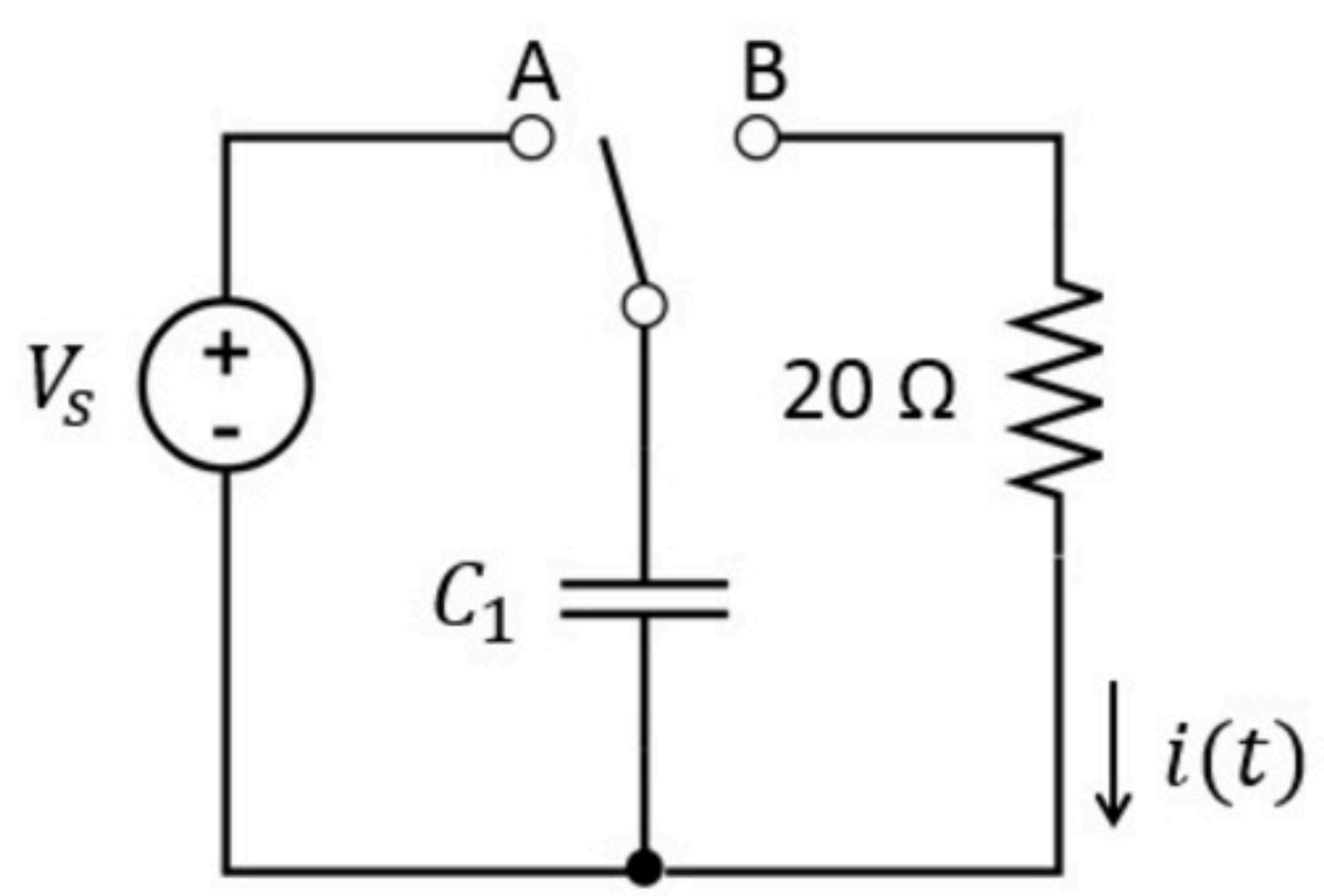
First order circuits 009

Problem has been graded.

For $t < 0$, the switch has been in position *A* for a long time. At time $t = 0$, it moves from *A* to *B*.

Find the time t_1 it takes to reduce the capacitor voltage to 37% of its initial voltage ($\frac{1}{e} \approx .37$).

What is the total energy *E* received by the resistor from the moment the switch is flipped until the capacitor is completely discharged?



Given Variables:

Vs : 12 V

C1 : 2 uF

Calculate the following:

t1 (ms) :

0.04

E (mJ) :

0.144

Hint: To calculate E, consider where the energy is coming from. Verify by integrating the P(t).

For $t < 0$, the switch has been in position A for a long time. At time $t = 0$, it moves from A to B.

Vs : 2 V

C1 : 2 uF

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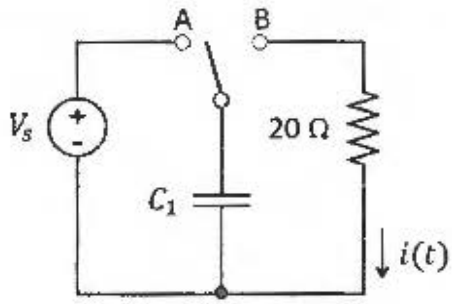
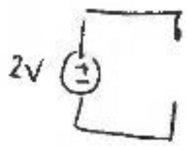


$\boxed{1}$

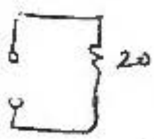
(a) $t = 0^-$:



$v_c(0^-) = 2V$

(b) $t = 0^+$: $v_c(0^+) = 2V$

(c) $t = \infty$



$v_c(\infty) = 0V$

(d) $R_{TH} = 20\,\Omega$

$\tau = R_{TH} \cdot C = 40\,\mu s$

$\Rightarrow v_c(t) = 2e^{-t/\tau}$ $\qquad v_c(t_1) = \frac{1}{e} \cdot v_c(0^+) = \frac{2}{e}$

$\Rightarrow 2e^{-t_1/\tau} = 2e^{-1} \Rightarrow \frac{t_1}{\tau} = 1 \Rightarrow t_1 = \tau = 40\,\mu s$ $\qquad \boxed{t_1 = 0.04\,ms}$

$\boxed{2}$ $E_{rec.} = E_{supplied}$ ⇒ Coming from Capacitor

$E = \frac{1}{2}CV^2 = \frac{1}{2} 2 \cdot 10^{-6}\, 2^2 = 4\,\mu J$ $\qquad \boxed{E = 0.004\,mJ}$

$\boxed{\text{OR}}$ $\quad i(t) = Ae^{-t/\tau} + B = 0.1\, e^{-t/\tau}$

$i(0^+) = \frac{2V}{20\Omega} = 0.1\,A$ $\qquad E = \int P = \int_0^\infty i^2 R = 20 \cdot (0.1)^2 \int_0^\infty e^{-2t/\tau} dt$

$i(\infty) = 0$ $\qquad = -0.2\, \frac{\tau}{2}\, e^{-2t/\tau}\Big|_0^\infty$

$= 0.1\,\tau \quad \Rightarrow E = 4\,\mu J$