Reading Quiz – Week 7

Question. Charging a capacitor

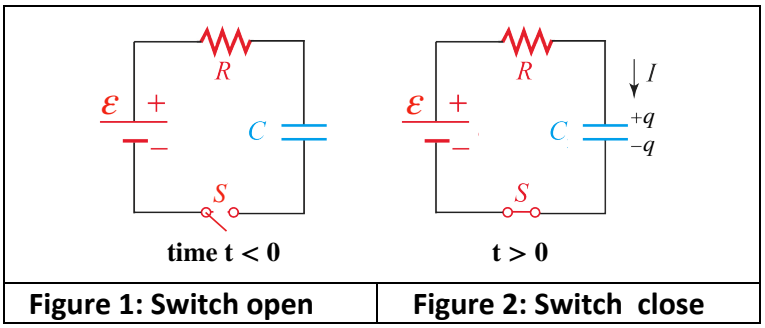


Figure 1: Switch open	Figure 2: Switch close

A capacitor of capacitance C is connected to a circuit as shown in figure1. There is no charge in the capacitor. (In figure 1, switch S is opened, so no charge flows out of the battery.)

At time t = 0 the switch S is closed. Current flows from the positive terminal of the battery bringing +q to the upper plate of the capacitor. For each positive charge added to the upper plate a positive charge leaves the lower plate towards the negative terminal of the battery leaving a negative charge on the lower plate. In this way, the charge in the capacitor increases until it is fully charged.

In this problem you will derive and solve the equation for the charge in the capacitor $q(t)$. We will call the potential of the positive plate V_+ and the potential of the negative plate V_-.

a) At the instant shown in the figure 2, when the charge in the capacitor is q, the difference in potential between the lower and the upper plate is:

1. $V_- - V_+ = -qC$
2. $V_- - V_+ = +qC$
3. $V_- - V_+ = -q/C$
4. $V_- - V_+ = +q/C$

b) Circulate the circuit in figure 2 in the same direction of the current, apply the Kirchhoff's loop rule to the circuit shown in the right figure above: $\Sigma\Delta V = 0$ implies that the differential equation for $q(t)$ is given by:

1. $\varepsilon - IR - \frac{q}{C} = 0$
2. $\varepsilon - IR + \frac{q}{C} = 0$
3. $\varepsilon - \frac{dq}{dt}R - \frac{q}{C} = 0$
4. $\varepsilon - \frac{dq}{dt}R + \frac{q}{C} = 0$

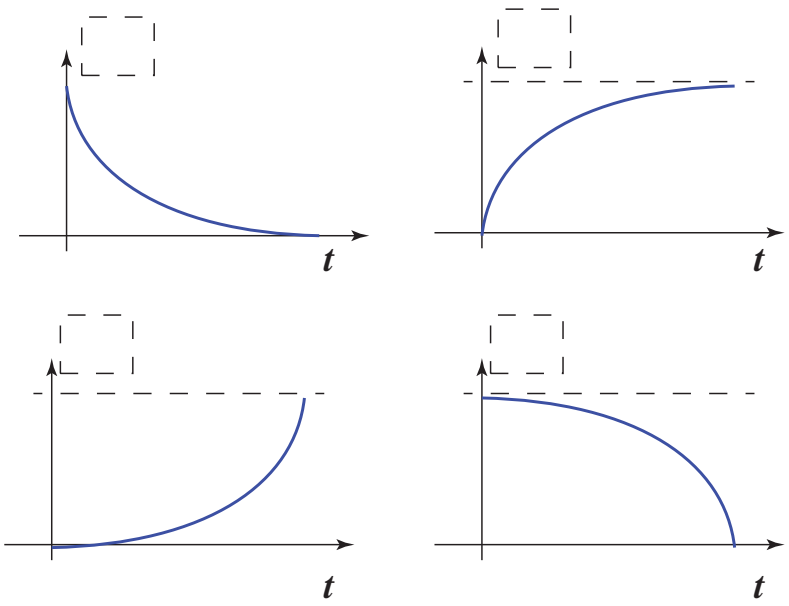
c) Watch video: https://www.youtube.com/watch?v=b7WTaSikcIU
(This is video 2 –in Week 7/ Learning sequence 1)

d) The solution of the differential equation obtained in part b) with the initial condition that at t=0 the charge of the capacitor is zero is:

1. $q(t) = \varepsilon C\left(1 - e^{-t/RC}\right)$
2. $q(t) = \varepsilon C\left(-1 + e^{-t/RC}\right)$
3. $q(t) = \varepsilon C\left(1 + e^{-t/RC}\right)$
4. $q(t) = -\varepsilon C\left(1 + e^{-t/RC}\right)$

e) Watch video: https://www.youtube.com/watch?v=JMc2mY0NPgs
(This is video 3 –in Week 7/ Learning sequence 1)

f) Which of the figures shown below best represents the plot of the charge as a function of time? the plot of the current as a function of time? Pick the figure and fill in the rectangles in the vertical axis with the proper quantities.



g) What are the units of RC?