14 RC Circuits

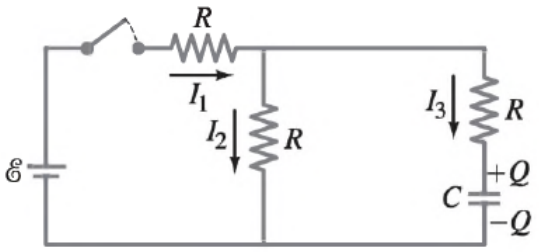
$$I = \frac{dQ}{dt} \qquad \tau = RC \qquad Q_{charging}(t) = CV_0(1 - e^{-t/\tau}) \qquad Q_{discharging}(t) = CV_0 e^{-t/\tau}$$

1. *(Giancoli 26.49)* Consider the circuit shown below, where all resistors have the same resistance R. At $t = 0$, with the capacitor C uncharged, the switch is closed.

(a) At $t = 0$, the three currents can be determined by analyzing a simpler, but equivalent, circuit. Identify this simpler circuit and use it to find the values of I_1 , I_2, and I_3 at $t = 0$.

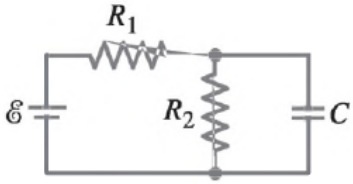
(b) At $t = \infty$, the currents can be determined by analyzing a simpler, equivalent circuit. Identify this simpler circuit and implement it in finding the values of I_1, I_2, and I_3 at $t = \infty$.

(c) At $t = \infty$, what is the potential difference across the capacitor?



2. *(Giancoli 26.50) (a)* Determine the time constant for charging the capacitor in the circuit below *(Hint: Use Kirchhoff s rules.)*

(b) What is the maximum charge on the capacitor?



3. *(Lanzara MT2 Fall 2013)* Consider the circuit shown below that contains capacitors C_1 and C_2 and resistor R. Initially, the switch is open and the capacitor C_1 has charge Q_0. The switch is closed at $t = 0$.

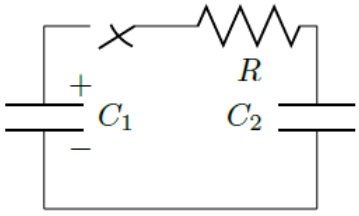
(a) What is the initial current that flows through the resistor right after the switch is closed?

(b) After a very long time, what are the charges Q_1 and Q_2 on C_1 and C_2 respectively?

(c) What is the charge $Q_2(t)$ on C_2 as a function of time?

(d) What is the current flowing into C_2 as a function of time?

(e) How will $Q_2(t)$ be modified if a dielectric κ is inserted in between the plates of capacitor C_2?



4. *(RHK Problem 31.18, 31.19)* An initially uncharged capacitor C is fully charged by a battery V_0 in series with a resistor R. *(a)* Show that the final energy stored in the capacitor is half the energy supplied by the battery.

(b) By direct integration of I^2R over the charging time, show that the internal energy dissipated by the resistor is also half the energy supplied by the battery.

(c) At what time after charging begins is the rate of energy dissipation in the resistor equal to the rate of energy storage in the capacitor?

6. *(Purcell Problem 4.18a)* The circuit in Fig. 4.43 contains two identical capacitors and two identical resistors. Initially, the left capacitor has charge Q_0 (with the left plate positive), and the right capacitor is uncharged. If the switch is closed at $t = 0$, find the charges on the capacitors as functions of time. Your loop equations should be simple ones.

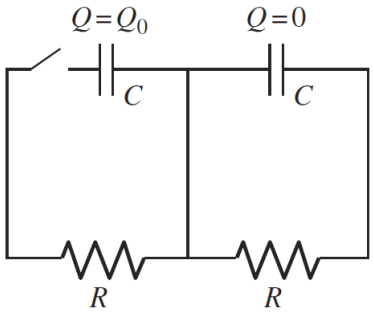


Figure 4.43.

6. *(Purcell Problem 4.18b)* Answer the same question for the circuit in Fig. 4.44, in which we have added one more (identical) resistor. What is the maximum (or minimum) charge that the right capacitor achieves? *(Note: Your loop equations should now be more interesting. Perhaps the easiest way to solve them is to take their sum and difference. This allows you to solve for the sum and difference of the charges, from which you can obtain each charge individually.)*

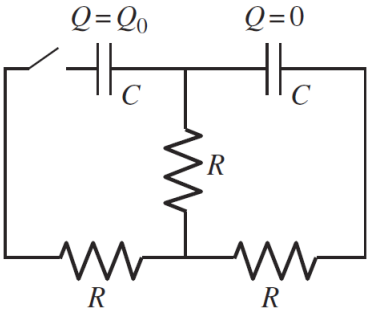


Figure 4.44.