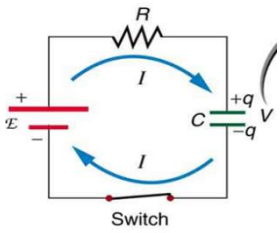
Charging a Capacitor



- Circuit with a _____, _____, and _____
- Initially capacitor is _____
- When battery connected current _____ to charge _____
- As charges build up, there is _____ resistance because of the _____ of the _____ on the parallel _____
- When capacitor is _____ charged, _____ current will flow

$$q = CV\left(1 - e^{-\frac{t}{RC}}\right)$$

  - $RC = \tau$ (time constant – The time required to charge the capacitor to 63.2%)
  - $CV = Q$ (maximum charge)

$$V = \mathcal{E}\left(1 - e^{-\frac{t}{RC}}\right)$$

  - V is voltage across the capacitor, $\mathcal{E}$ is emf, t is time, R is resistance of circuit, C is capacitance

Discharging a Capacitor

- The battery is _____
- The _____ acts like a _____ supplying _____ to the circuit

$$q = Qe^{-\frac{t}{RC}}$$

$$V = V_0 e^{-\frac{t}{RC}}$$

- Often capacitors are used to charge _____, then discharge _____ like in camera flash.
- Done by have _____ values for _____ in charging and discharging.

- Camera flashes work by charging a _____ with a _____.
  - Usually has a large time constant because _____ cannot produce charge very _____
  - The capacitor is then _____ through the _____ circuit with a _____ time constant

An uncharged capacitor and a resistor are connected in series to a battery. If $V = 12\ V$, $C = 5\ \mu F$, and $R = 8 \times 10^5\ \Omega$. Find the time constant, max charge, max current, and charge as a function of time.

Homework

1. Regarding the units involved in the relationship $\tau = RC$, verify that the units of resistance times capacitance are time, that is, $\Omega \cdot F = s$.

2. When making an ECG measurement, it is important to measure voltage variations over small time intervals. The time is limited by the RC constant of the circuit–it is not possible to measure time variations shorter than RC. How would you manipulate R and C in the circuit to allow the necessary measurements?

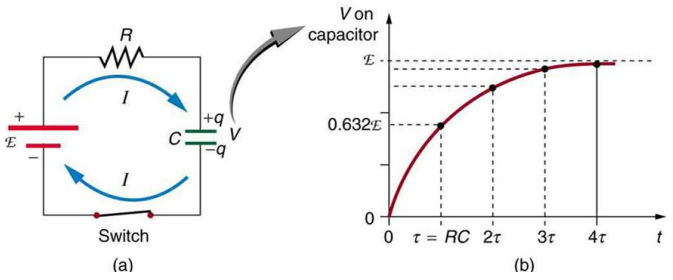


Figure 1

3. When charging a capacitor, as discussed in conjunction with Figure 1, how long does it take for the voltage on the capacitor to reach emf? Is this a problem?

4. When discharging a capacitor, as discussed in conjunction with Figure 2, how long does it take for the voltage on the capacitor to reach zero? Is this a problem?

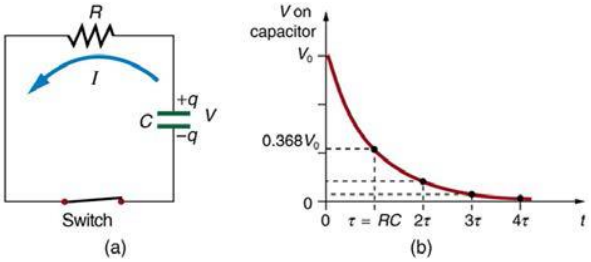


Figure 2

5. An electronic apparatus may have large capacitors at high voltage in the power supply section, presenting a shock hazard even when the apparatus is switched off. A "bleeder resistor" is therefore placed across such a capacitor, as shown schematically in Figure 3, to bleed the charge from it after the apparatus is off. Why must the bleeder resistance be much greater than the effective resistance of the rest of the circuit? How does this affect the time constant for discharging the capacitor?

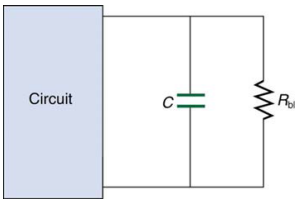


Figure 3

6. The timing device in an automobile's intermittent wiper system is based on an RC time constant and utilizes a 0.500-μF capacitor and a variable resistor. Over what range must R be made to vary to achieve time constants from 2.00 to 15.0 s? (OpenStax 21.63) **4.00 to 30.0 MΩ**

7. A heart pacemaker fires 72 times a minute, each time a 25.0-nF capacitor is charged (by a battery in series with a resistor) to 0.632 of its full voltage. What is the value of the resistance? (OpenStax 21.64) $\mathbf{3.33 \times 10^7\ \Omega}$

8. The duration of a photographic flash is related to an RC time constant, which is 0.100 μs for a certain camera. (a) If the resistance of the flash lamp is 0.0400 Ω during discharge, what is the size of the capacitor supplying its energy? (b) What is the time constant for charging the capacitor, if the charging resistance is 800 kΩ? (OpenStax 21.65) **2.50 μF, 2.00 s**

9. A 500-Ω resistor, an uncharged 1.50-μF capacitor, and a 6.16-V emf are connected in series. (a) What is the initial current? (b) What is the RC time constant? (c) What is the current after one time constant? (d) What is the voltage on the capacitor after one time constant? (OpenStax 21.68) $\mathbf{12.3\ mA,\ 7.50 \times 10^{-4}\ s,\ 4.53\ mA,\ 3.89\ V}$

10. An ECG monitor must have an RC time constant less than 1.00×10^2 μs to be able to measure variations in voltage over small time intervals. (a) If the resistance of the circuit (due mostly to that of the patient's chest) is 1.00 kΩ, what is the maximum capacitance of the circuit? (b) Would it be difficult in practice to limit the capacitance to less than the value found in (a)? (OpenStax 21.70) $\mathbf{1.00 \times 10^{-7}\ F,\ No}$