Massachusetts Institute of Technology
Department of Physics
8.022 Fall 2004
Assignment 4: Electric Current
Due date: Friday, Oct 15th

1. Purcell 4.18: Maximum power of the battery (10pts).

2. Purcell 4.21: Thévenin equivalent circuits (10pts).

3. Purcell 4.31: Resistor cube (15pts).

4. Purcell 4.32: An infinite network (15pts).

5. Purcell 4.33: Minimum power dissipation (10pts).

6. Conservation of energy and RC circuits (10pts).

   Consider the simplest RC circuit. Suppose that a charge Q_0 is stored on the capacitor initially. Show that the total energy dissipated in the resistor after the switch is closed equals the energy that was stored before the switch was closed.

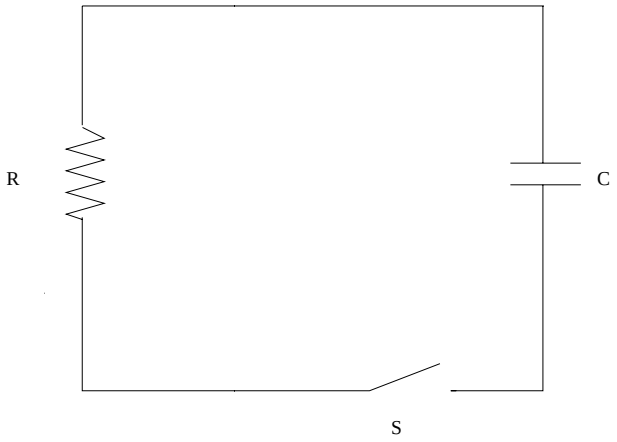

Figure 1: Simplest RC circuit.

7. Circuit network (15pts).

   Consider the following circuit:

   Suppose that the capacitor is initially discharged. The switch is closed at $t = 0$. find the current $I_B(t)$ through the battery (i.e., in the middle branch) as a function of time, and the charge on the capacitor $Q(t)$.

8. Electric potential, charge density, and Taylor expansion (15pts).
   a)The electric potential of some configuration is given by the expression

$$V(\vec{r}) = A\frac{e^{-\lambda r}}{r} \tag{1}$$

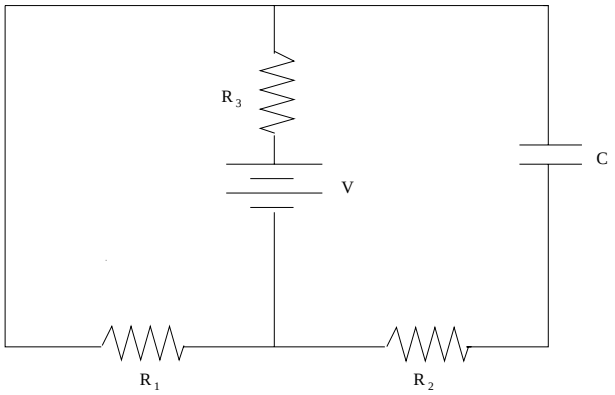

Figure 2: RC circuit.

where A and λ are constants.
i)Find the electric field $\vec{E}$, the volume charge density and the total charge Q.
ii)How is Q distributed over the space?

b)Now the electric potential is given by the expression

$$V(\vec{r}) = A\frac{e^{-\lambda r}}{r} - A\frac{e^{-2\lambda r}}{2r} - A\frac{1}{2r} \tag{2}$$

again, A and λ are constants.
i)Find the electric field $\vec{E}$, the volume charge density and the total charge Q.
ii)How is Q distributed over the space this time?
iii)Taylor Expand the potential till the first non-vanishing order of λ.