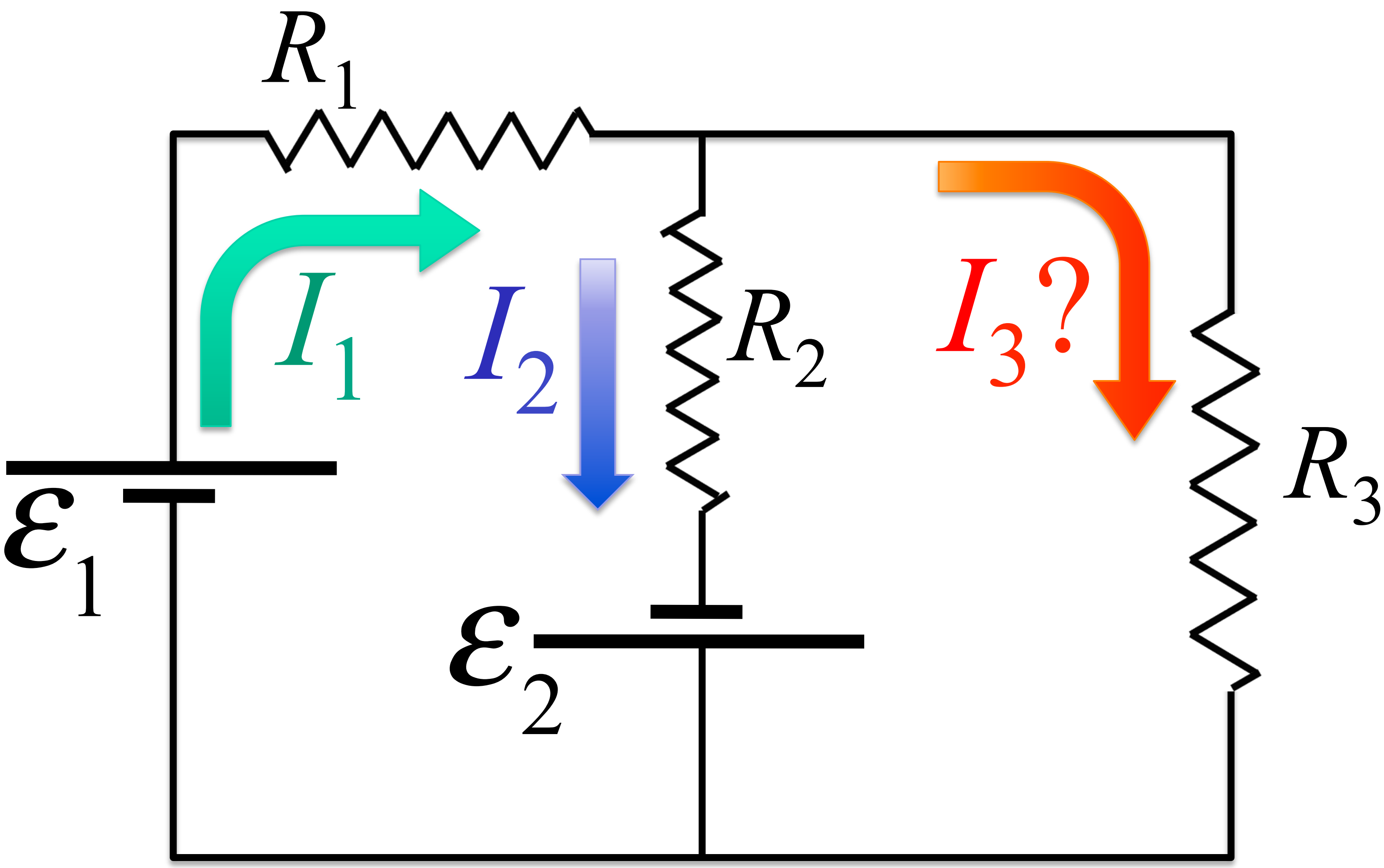
Chapter 25: Circuit theory
Thursday October 6th

- Series/parallel circuits – finish examples from Tuesday
  - Complex circuit
  - Parallel batteries with internal resistance
- RC circuits
  - Charging a capacitor
  - Discharging a capacitor
  - Demonstration

Reading: up to page 431 in the text book (Ch. 25)

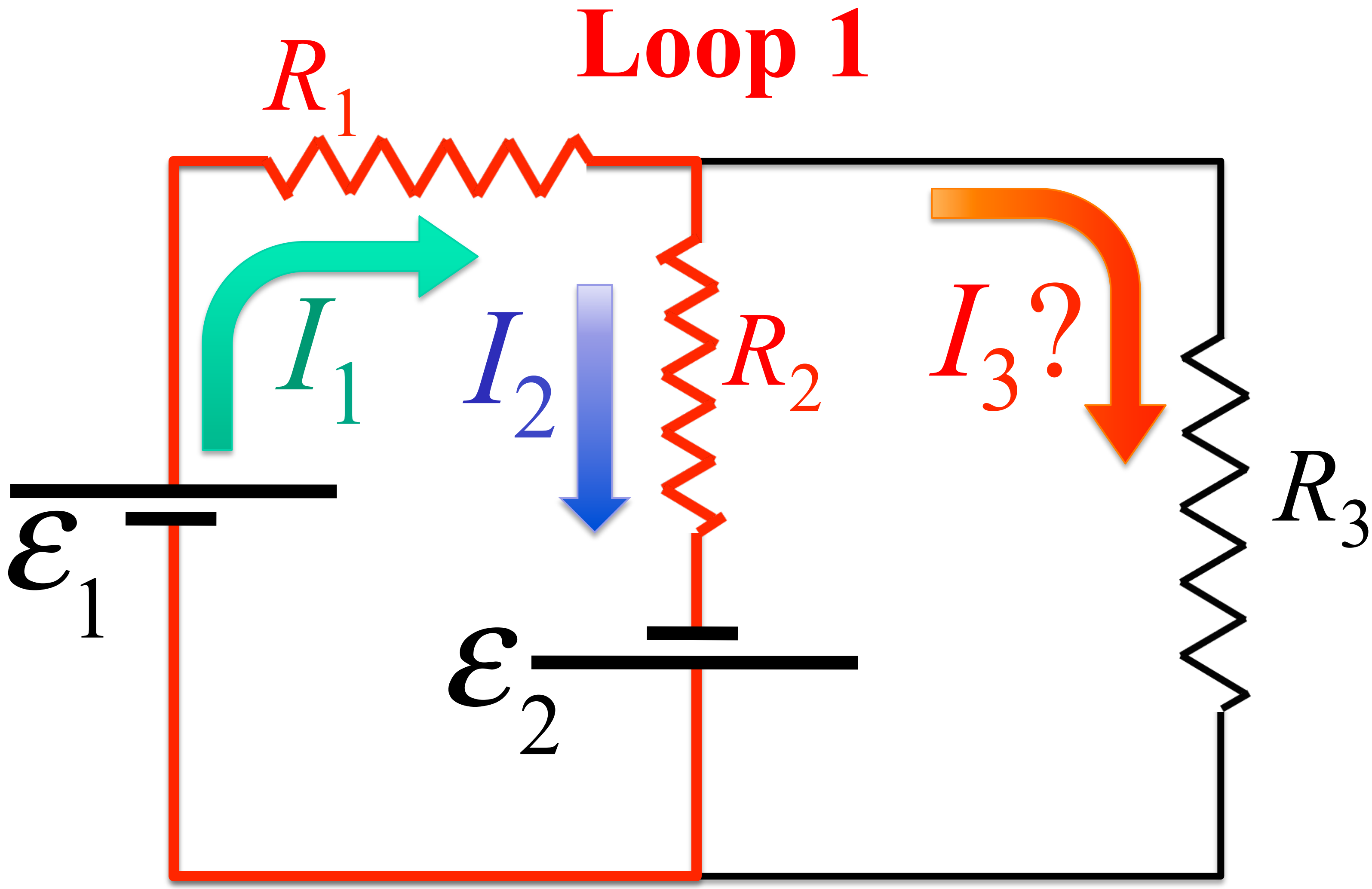
Example: multiple batteries



Find current I_3

$\varepsilon_1 = 10\ \text{V};\ \varepsilon_2 = 20\ \text{V};\ R_1 = 15\ \Omega;\ R_2 = 6\ \Omega;\ R_3 = 7\ \Omega.$

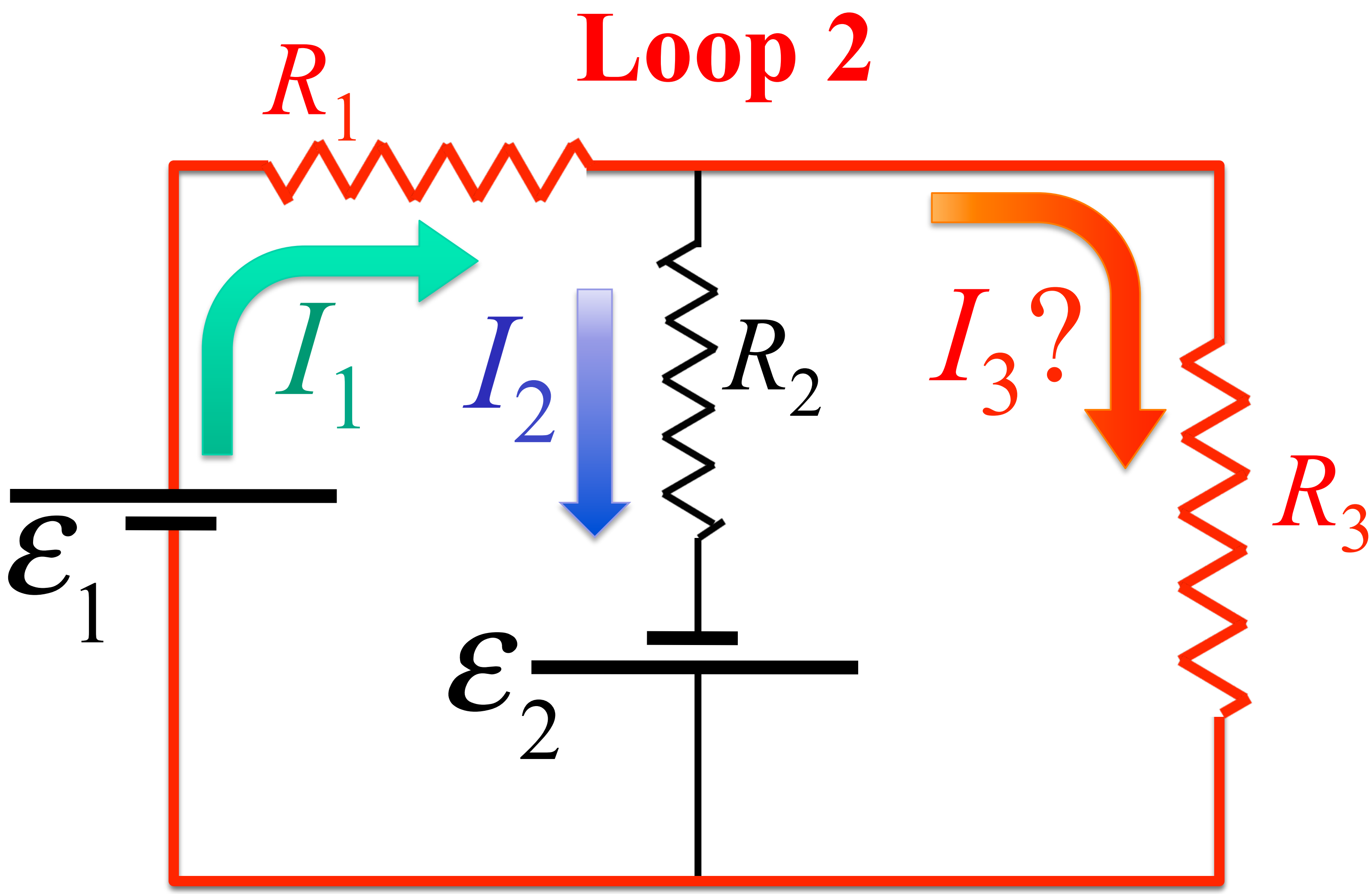
Example: multiple batteries



Find current I_3

$$\varepsilon_1 = 10 \text{ V};\ \varepsilon_2 = 20 \text{ V};\ R_1 = 15\ \Omega;\ R_2 = 6\ \Omega;\ R_3 = 7\ \Omega.$$

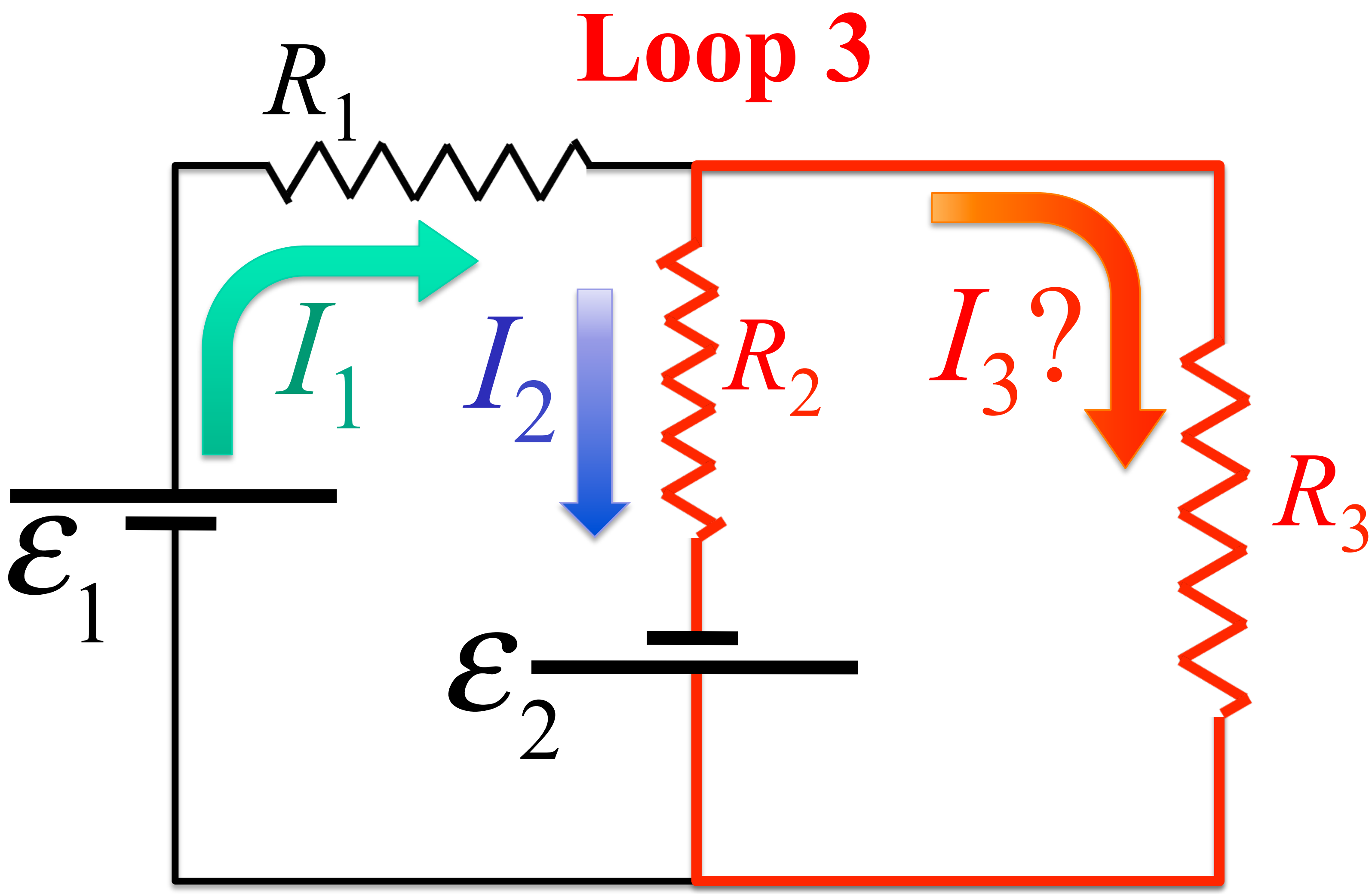
Example: multiple batteries



Find current I_3

$\varepsilon_1 = 10\ \text{V};\ \varepsilon_2 = 20\ \text{V};\ R_1 = 15\ \Omega;\ R_2 = 6\ \Omega;\ R_3 = 7\ \Omega.$

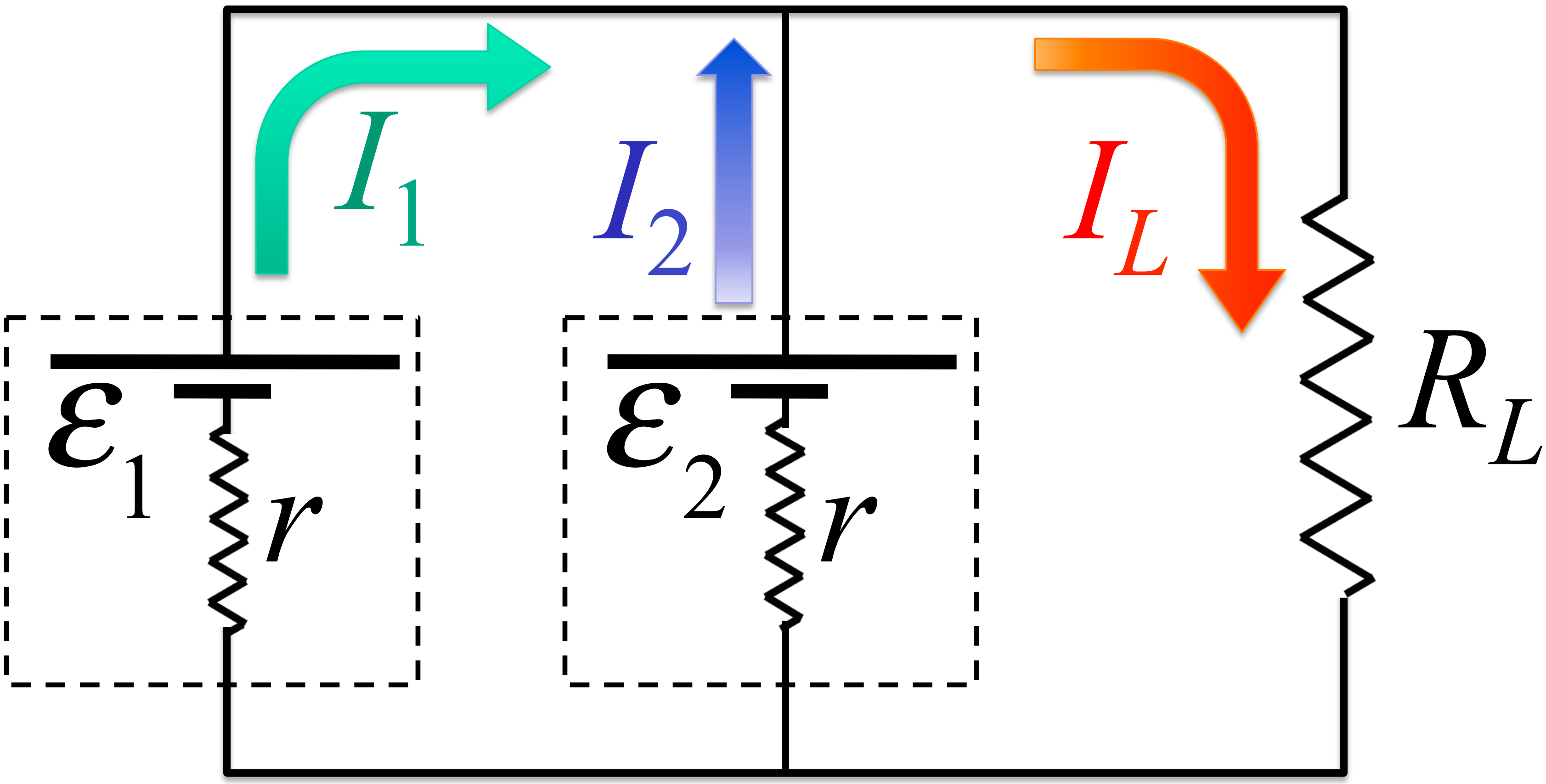
Example: multiple batteries



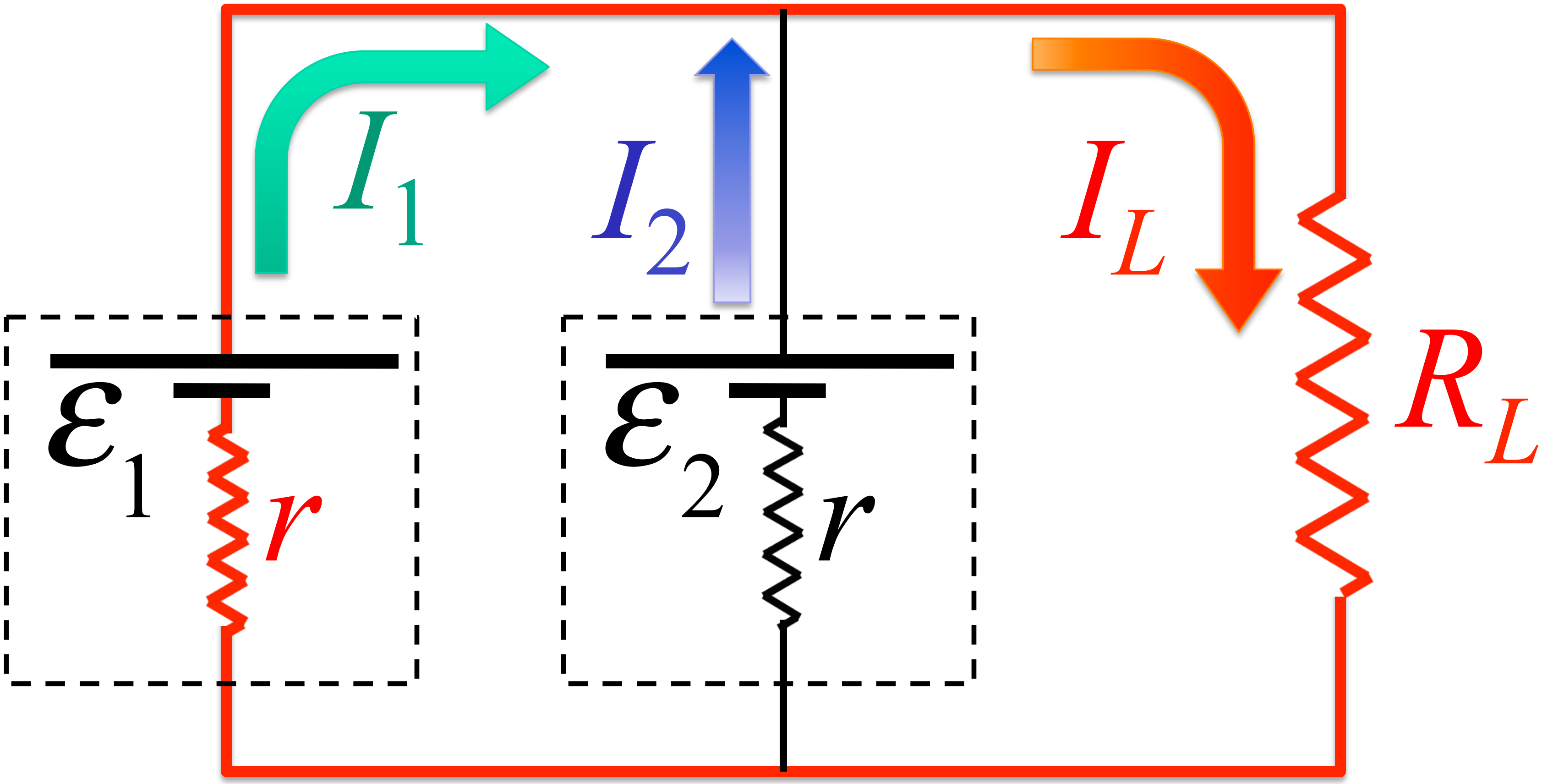
Find current I_3

$\varepsilon_1 = 10$ V; $\varepsilon_2 = 20$ V; $R_1 = 15\ \Omega$; $R_2 = 6\ \Omega$; $R_3 = 7\ \Omega$.

Example: parallel batteries

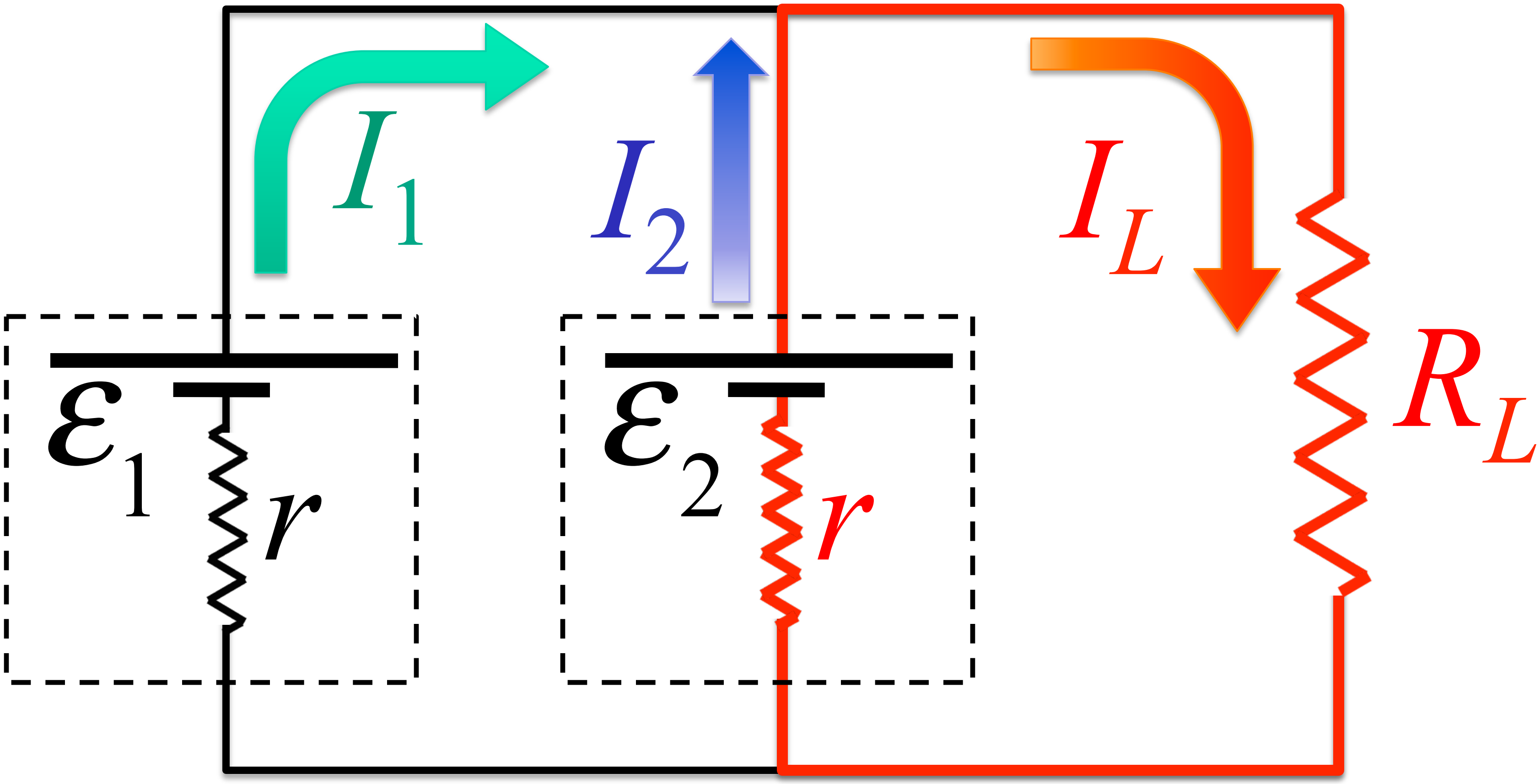


Example: parallel batteries



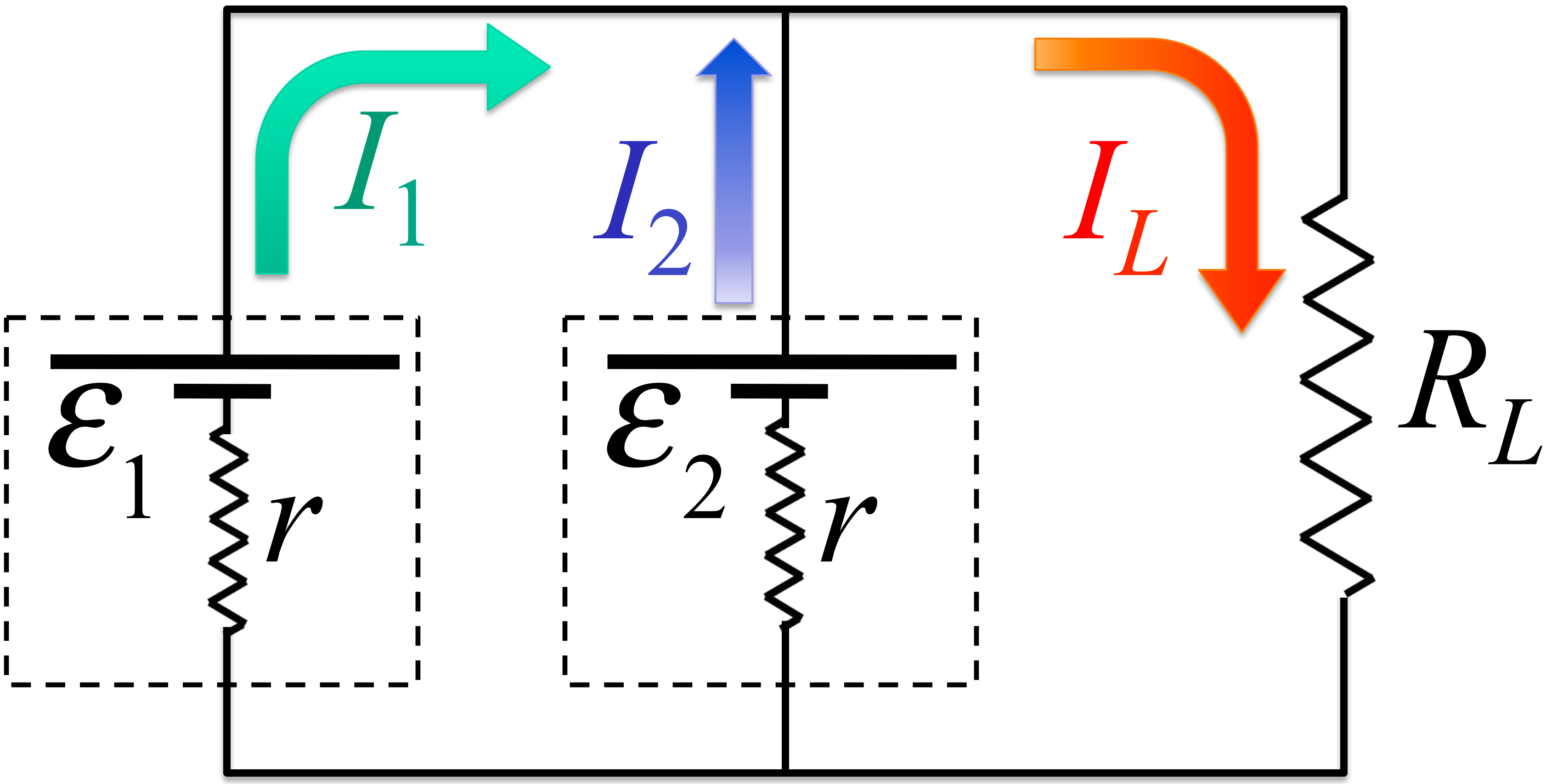
Loop 1

Example: parallel batteries



Loop 2

Example: parallel batteries

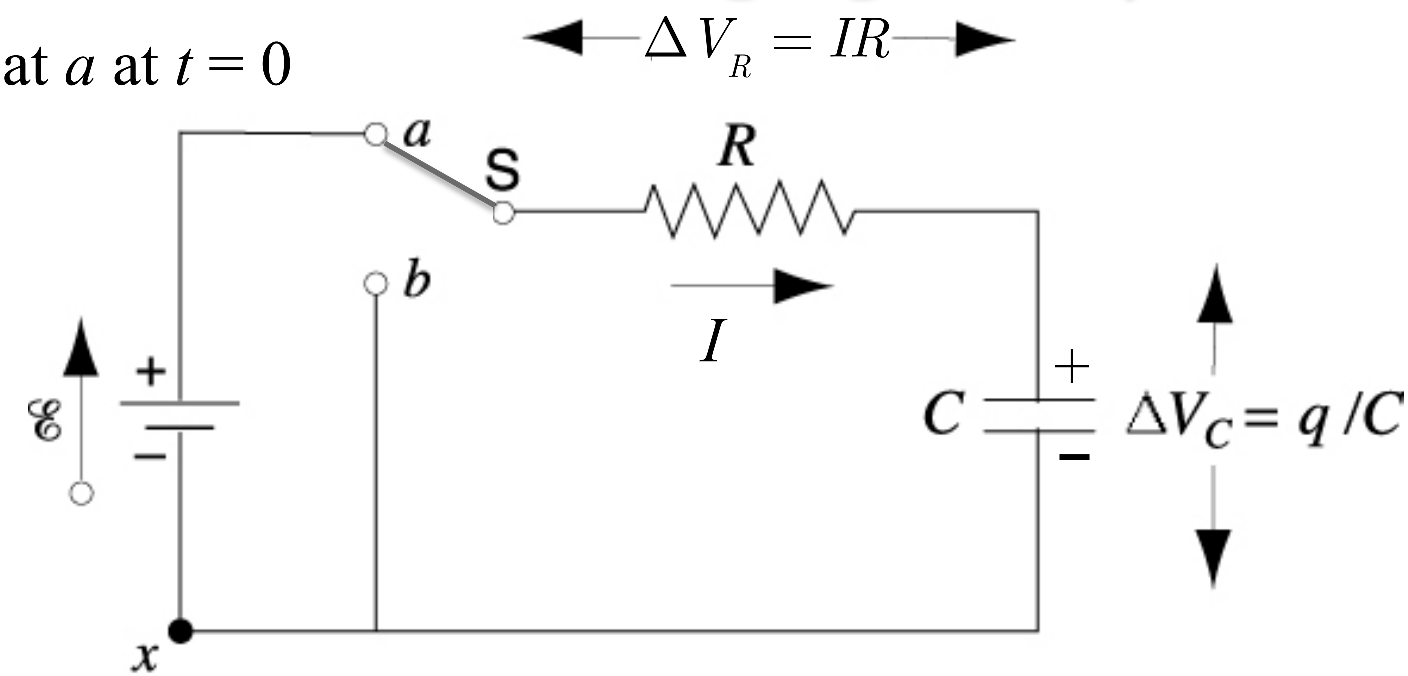


$$I_L = \frac{\varepsilon_1 + \varepsilon_2}{2R_L + r}, \text{ if } \varepsilon_1 = \varepsilon_2 = \varepsilon, \text{ then } I_L = \frac{2\varepsilon}{2R_L + r} = \frac{\varepsilon}{R_L + r/2}$$

Lesson: if you need lots of current, use batteries in parallel.

RC circuits (charging a capacitor)

Switch at a at $t = 0$



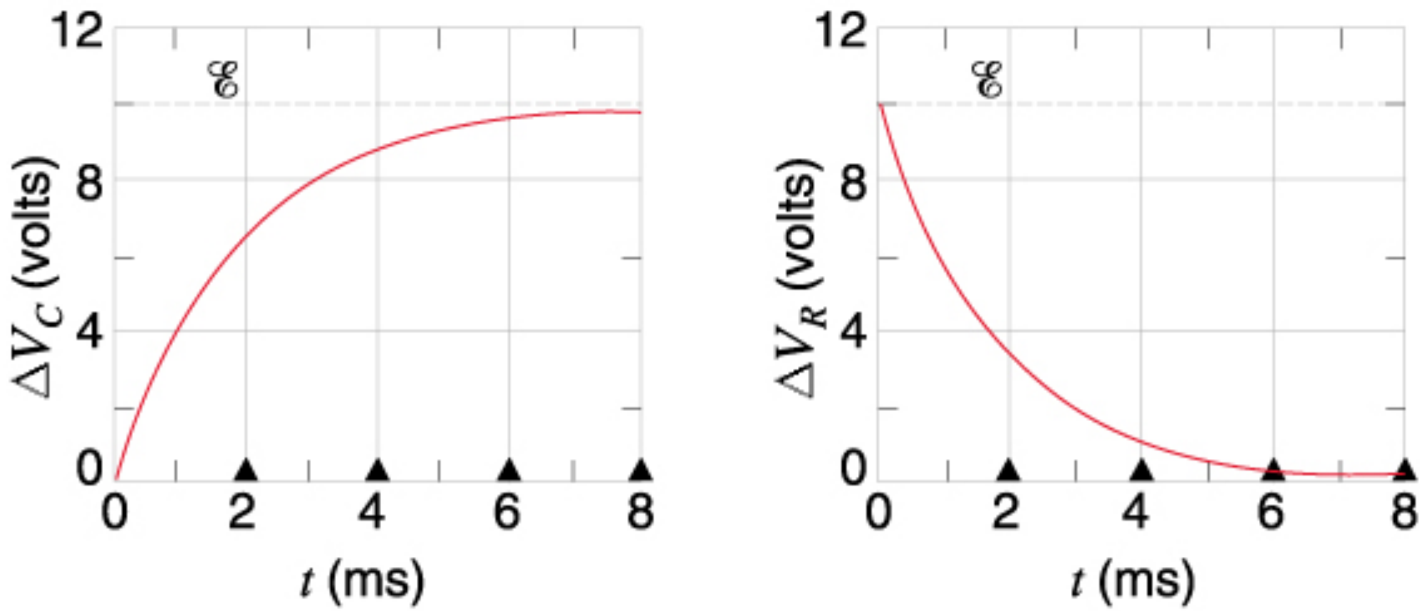
Kirchoff' s 2nd law:

$$\varepsilon - IR - \frac{q}{C} = 0$$

$$\varepsilon = R\frac{dq}{dt} + \frac{q}{C}$$

$$q = C\varepsilon\left(1 - e^{-t/RC}\right) \qquad I = \frac{\varepsilon}{R}e^{-t/RC}$$

RC circuits (charging a capacitor)



Kirchoff' s 2nd law: $$\varepsilon - IR - \frac{q}{C} = 0$$

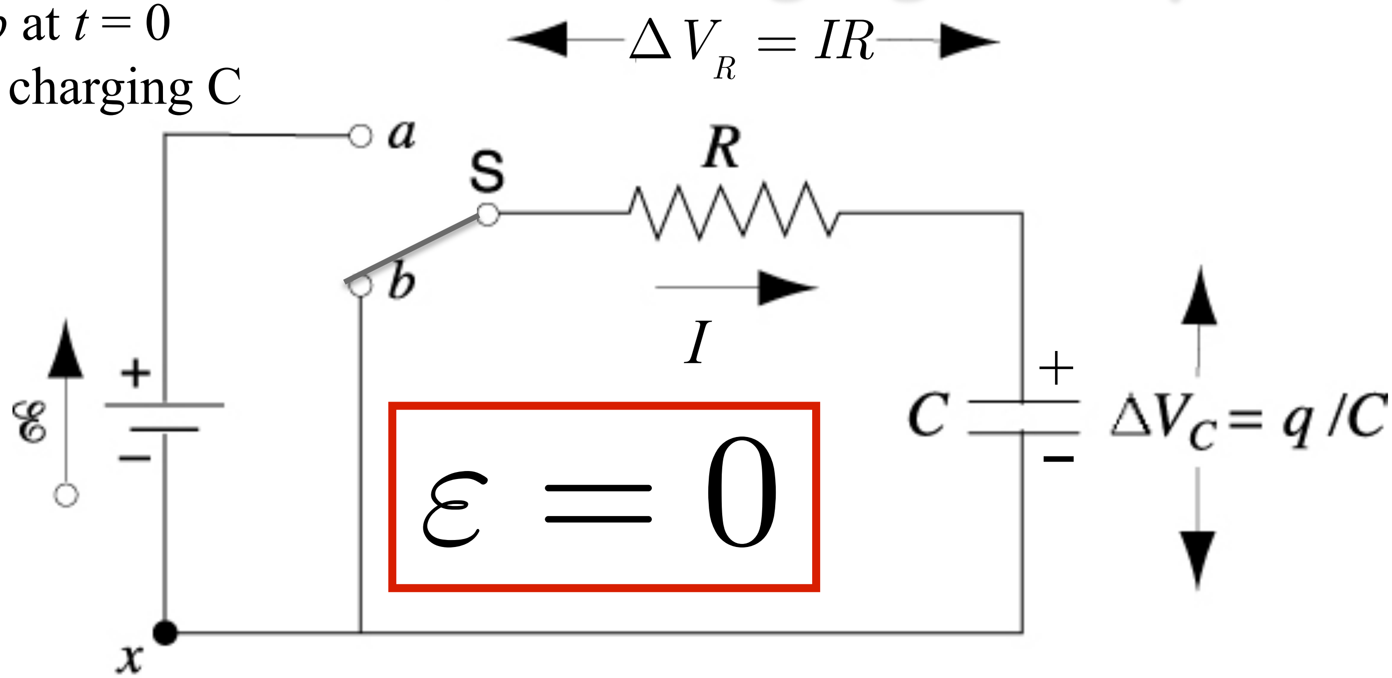
$$\varepsilon = R\frac{dq}{dt} + \frac{q}{C}$$

$$q = C\varepsilon\left(1 - e^{-t/RC}\right)$$

$$I = \frac{\varepsilon}{R}e^{-t/RC}$$

RC circuits (discharging a capacitor)

Switch at b at $t = 0$
After fully charging C



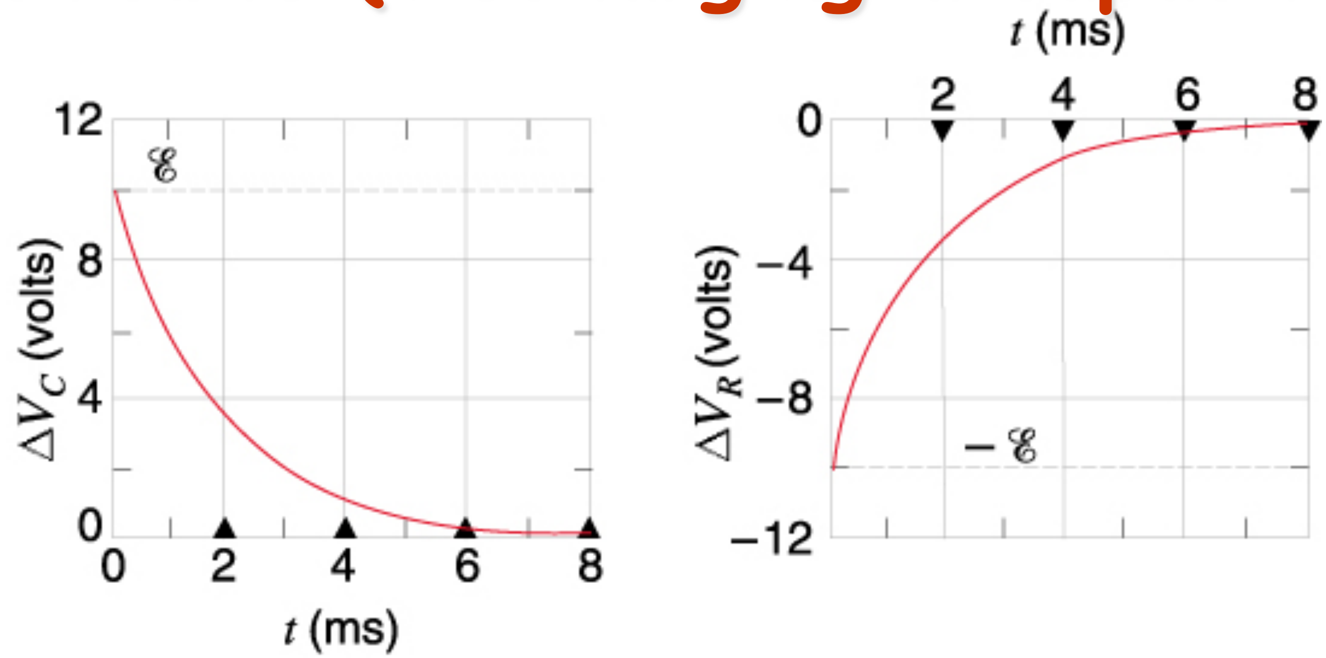
Kirchoff's 2nd law:

$$-IR - \frac{q}{C} = 0$$

$$q_0 = \varepsilon C \qquad R\frac{dq}{dt} + \frac{q}{C} = 0$$

$$q = q_0 e^{-t/RC} \qquad I = -\frac{q_0}{RC}e^{-t/RC} = -\frac{\varepsilon}{R}e^{-t/RC}$$

RC circuits (discharging a capacitor)



Kirchoff' s 2nd law: $$-IR - \frac{q}{C} = 0$$

$$q_0 = \varepsilon C \qquad\qquad R\frac{dq}{dt} + \frac{q}{C} = 0$$

$$q = q_0 e^{-t/RC} \qquad I = -\frac{q_0}{RC}e^{-t/RC} = -\frac{\varepsilon}{R}e^{-t/RC}$$