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General Physics: Electromagnetism, Problem Set 7

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Exercise 1 :

Consider the circuit below. The internal resistance of the battery is  $r = 1\ \Omega$ , the resistance of the resistor is  $R = 10\ \Omega$ . What is the *EMF* of the battery, if the heat power delivered on the resistor is  $P = 40\ \text{W}$ ? How much of heat energy  $W_B$  will be delivered in the battery during 1 hour?

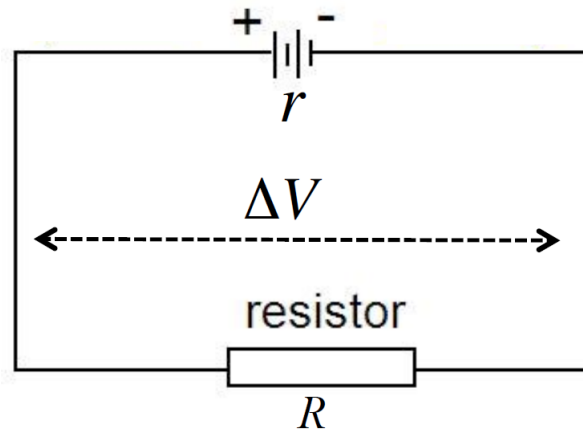


Figure 1: Simple circuit with a battery and a resistor.

Exercise 2 :

Two  $100\ \Omega$  light bulbs are connected (a) in series and (b) in parallel to a  $24\ \text{V}$  battery. What is the current through each bulb in both cases? For which circuit will the bulbs be brighter?

Hint: The more power consumed, the brighter the bulb.

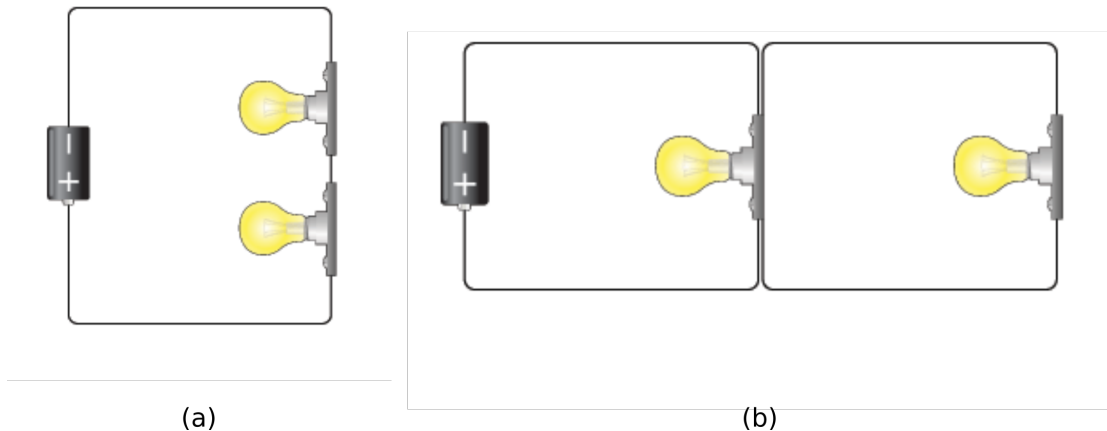


Figure 2: Series (a) and parallel (b) circuit of two light bulbs powered by a battery.

### Exercise 3 :

Determine the equivalent resistance of the “ladder” of equal resistors  $R$  shown in the figure below. In other words, what resistance would an *ohmmeter* read if connected between points A and B?

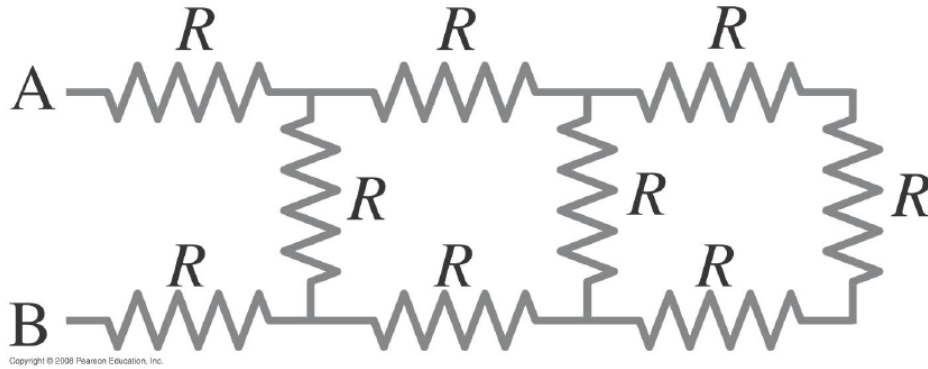


Figure 3: "Ladder" of resistors.

### Exercise 4 :

Calculate the current in each resistor inside the circuit shown below.

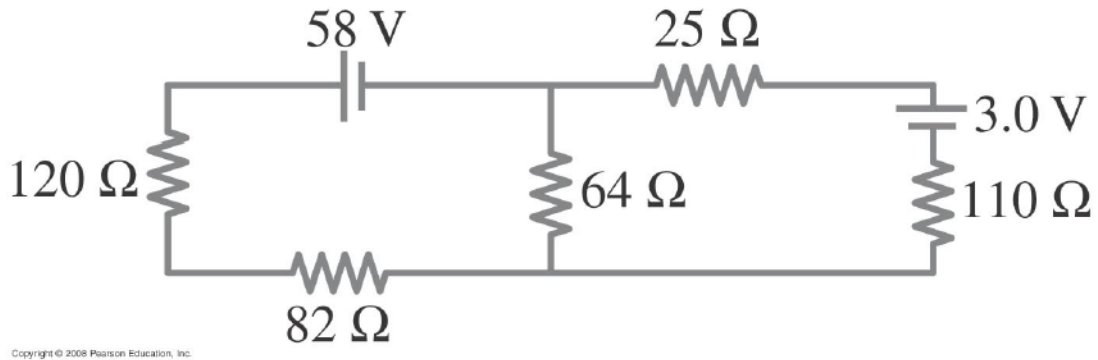


Figure 4: Circuit with two batteries and resistors.

### Exercise 5 :

A good battery of a car is used to start a second car with a low battery. The good battery has an  $EMF$  of  $12.5\text{ V}$  and an internal resistance of  $0.020\ \Omega$ . Let's suppose that the low battery has an  $EMF$  of  $10.1\text{ V}$  and an internal resistance of  $0.10\ \Omega$ . The cables have a resistance  $R_j = 0.0026\ \Omega$  each and can be connected as shown in the figure below. Let's suppose that all the rest of the car can be represented as a  $R_c = 0.15\ \Omega$ .

1. Find the current  $I_3$  flowing into the starter motor if only the low battery is connected;
2. Find the current flowing into the starter motor if now also the good battery is connected.

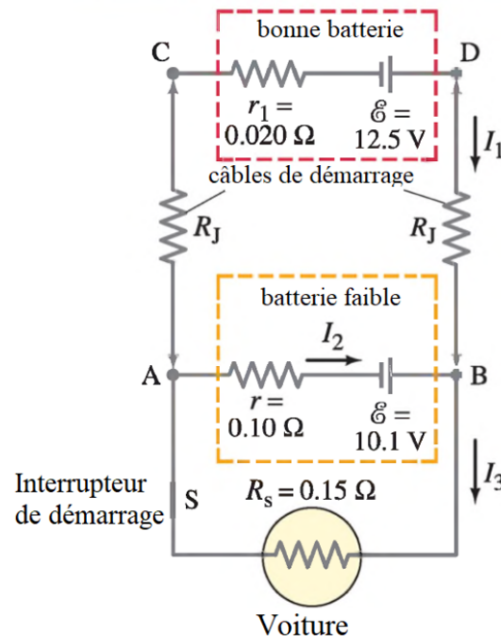


Figure 5: Schematic of the equivalent circuit.

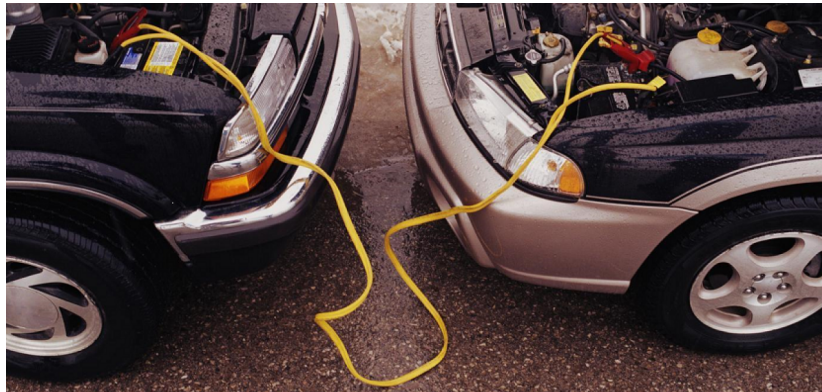


Figure 6: Two batteries, a good one and a low one, connected as shown in the circuit on top.

### Exercise 6 :

Electronic devices (like computers for example) usually use RC circuits to protect against current failure (as shown in the Figure 1). If the power source stops working (which can be represented by opening the switch  $S$ ), the capacitor will supply voltage in the circuit until it discharges. If the protective circuit has to maintain the supply voltage at at least 75% of the full voltage for 0.20 s. What is the resistance  $R$  needed to maintain this voltage? The capacity of the capacitor is  $8.5 \mu\text{F}$ . Suppose that the electronic device attached to the circuit consumes negligible current.

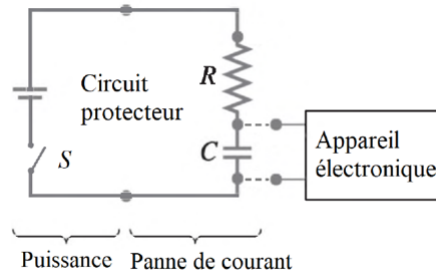


Figure 7: Scheme of an example of a protection circuit in electronic devices.

### Exercise 7 :

Consider a circuit below that contains several resistors  $R = 5 \Omega$ , two batteries with  $\text{emf} = E$  each, switch  $S$  and capacitor  $C = 10^{-6}\text{F}$ . At time  $t = 0$  the capacitor has no charge and the switch closes.

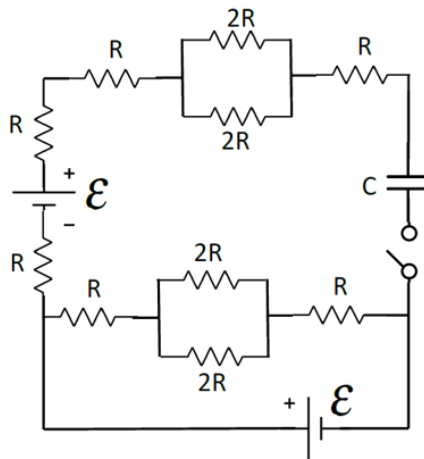


Figure 8: Circuit with two batteries, a switch and multiple resistors.

- Draw a simplified equivalent circuit of this initial complex circuit.
- Determine the time-constant for charging the capacitor (use the solution of the differential equation for a RC circuit powered by a battery from the lecture).