Abdelhafid Boussouf University Center, Mila
Institute of Mathematics & and Computer Science
Mathematics Department
second series of exercises "Electrokinetics"

1 Electric Conductor

1.1 Exercise 1

A plastic wire of 80 cm in length must have a resistance of 0.1 Ω. What should be its diameter? We are given $\eta = 1.1 \times 10^{-7} \Omega \cdot \text{m}$.

1.2 Exercise 2

A 12V battery is charged by a current of 20A for 1 hour.

a) What is the power required to charge the battery at this speed?

b) What is the energy supplied to the battery?

2 Ohm's Law and circuits

2.1 Exercise 3

What is the equivalent resistance of three resistances of 5 Ω connected in series? If a potential difference of 60 V is applied across the terminals of the assembly, what is the current flowing through each resistance?

2.2 Exercise 4

What is the equivalent resistance of three resistances of 5 Ω connected in parallel? If a potential difference of 60 V is applied across the terminals of the assembly, what is the current flowing through each resistance?

2.3 Exercise 5

A potential difference of 20V is applied to the circuit below. Find the current flowing through each resistance and the total current flowing through the circuit.7

2.4 Exercise 6

Consider the electric circuit in the figure below 2:

a) Determine the currents I_1, I_2, and I_3 circulating in the circuit and specify their actual directions of circulation.

b) Deduce the potential difference between points b and f.

c) What is the power P_f supplied by the 20V electromotive force generator?

d) What is the power P_j dissipated by the Joule effect in the circuit?

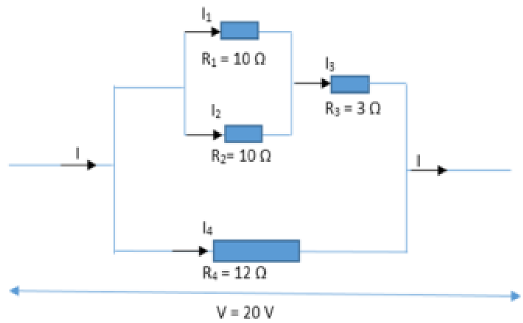

Figure 1: Electric Circuit for Exercise 5

e) What does the difference $P_f - P_j$ correspond to?

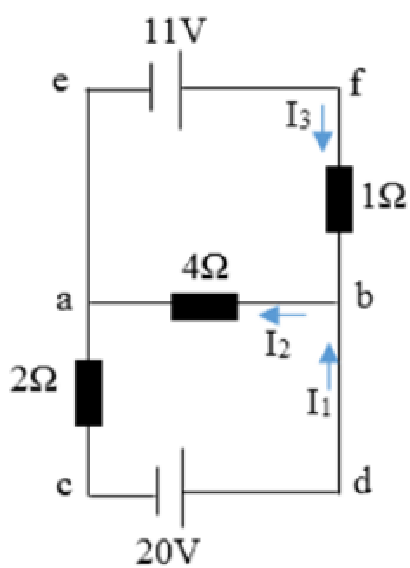

Figure 2: Exercise 6

3 Solution of Exercise series 2

3.1 Exercise 1

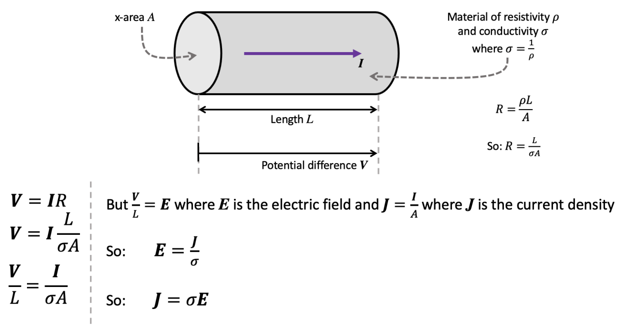

Figure 3: Electric Current in conductor

We have:

$$R = \eta\frac{L}{s}, \quad s = \pi r^2 \qquad (4.35)$$

$$R = \eta\frac{L}{\pi r^2} \implies r = \sqrt{\eta\frac{L}{\pi R}} \qquad (4.36)$$

A.N.:

$$r = \sqrt{\frac{1.1 \times 10^{-7} \times 80 \times 10^{-2}}{3.14 \times 0.1}} = 5.3 \times 10^{-4}\,\mathrm{m} \implies D = 2r = 1.06\,\mathrm{mm} \qquad (4.37)$$

3.2 Exercise 2

a) We have:

$$P = VI = 12 \times 20 = 240\,\mathrm{W} \qquad (4.38)$$

b)

$$W = Pt = 240 \times 3600 = 8.64 \times 10^5\,\mathrm{J} \qquad (4.39)$$

3.3 Exercise 3

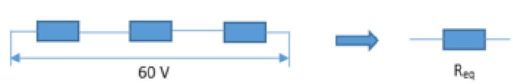

Figure 4: Circuit for Exercise 3

We have:

$$R_{eq} = 5 + 5 + 5 = 15\,\Omega \qquad (4.40)$$

The current flowing through the assembly is:

$$I = \frac{V}{R_{eq}} = \frac{60}{15} = 4\,\text{A} \qquad (4.41)$$

Since the resistors are connected in series, this current flows through each of them.

3.4 Exercise 4

$$\frac{1}{R_{eq}} = \frac{1}{5} + \frac{1}{5} + \frac{1}{5} = \frac{3}{5} \implies R_{eq} = \frac{5}{3} = 1.67\Omega \qquad (4.42)$$

$$I_1 = \frac{V}{R_1}, \quad I_2 = \frac{V}{R_2}, \quad I_3 = \frac{V}{R_3} \qquad (4.43)$$

$$I_1 = I_2 = I_3 = \frac{60}{5} = 12\,\text{A} \qquad (4.44)$$

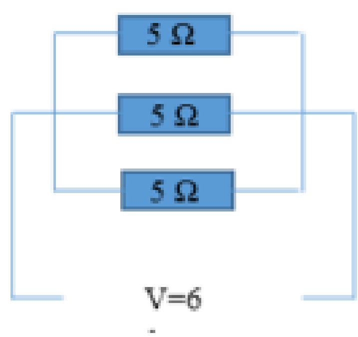

Figure 5: Circuit for Exercise 4

3.5 Exercise 5

We have:

$$I_4 = \frac{V}{R_4} = \frac{20}{12} = 1.67\,\text{A} \qquad (4.45)$$

The circuit is equivalent to:
With:

$$R_{eq} = ((R_1//R_2) + R_3)//R_4 = 4.8\,\Omega \qquad (4.46)$$

Hence:

$$R_{eq} = I = \frac{V}{R_{eq}} = \frac{20}{4.8} = 4.17\,\text{A} \qquad (4.47)$$

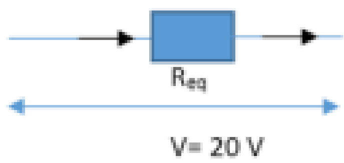

Figure 6: Equivalent Circuit for Exercise 5

We have:

$$I = I_3 + I_4 \implies I_3 = I - I_4 = 4.17 - 1.67 = 2.50\,\text{A} \qquad (4.48)$$

Since:

$$R_1 = R_2 = 10\,\Omega \implies I_1 = I_2 \qquad (4.49)$$

We have:

$$I_3 = I_1 + I_2 = 2I_1 \qquad (4.50)$$

Hence:

$$I_1 = \frac{I_3}{2} = \frac{2.5}{2} = 1.25\,\text{A} \qquad (4.51)$$

3.6 Exercise 6:

a) The currents I_1, I_2, and I_3 circulating in the circuit:
Equation (node b):

$$I_2 = I_1 + I_3 \qquad (4.52)$$

Equation (mesh abdc):

$$2I_1 + 4I_2 = 20 \qquad (4.53)$$

Equation (mesh feab):

$$4I_2 + I_3 = 11 \qquad (4.54)$$

From equations (4.53) and (4.54), we have:

$$I_1 = 10 - 2I_2, \quad I_3 = 11 - 4I_2 \qquad (4.55)$$

Substituting (4.55) into (4.52), we obtain:

$$I_2 = 10 - 2I_2 + 11 - 4I_2 \implies 7I_2 = 21 \implies \begin{cases} I_2 = 3\,\text{A} \\ I_1 = 4\,\text{A} \\ I_3 = -1\,\text{A} \end{cases} \qquad (4.56)$$

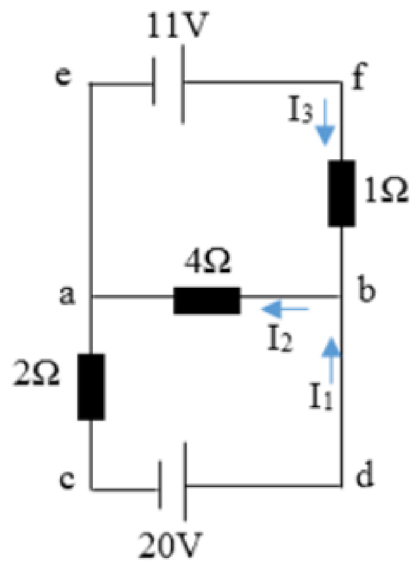

Figure 7: Exercise 6

Consequently, I_3 must be in the opposite direction.
a) The potential difference between points b and f:

$$V_b - V_f = 1 \times I_3 = 1\,\mathrm{V} \qquad (4.57)$$

b) The power P_f supplied by the generator:

$$P_f = 20 \times I_1 = 20 \times 4 = 80\,\mathrm{W} \qquad (4.58)$$

c) The power P_j dissipated by the Joule effect:

$$P_j = 1 \times I_3^2 + 4 \times I_2^2 + 2 \times I_1^2 = 69\,\mathrm{W} \qquad (4.59)$$

d) The difference $P_f - P_j$:

$$P_f - P_j = 80 - 69 = 11\,\mathrm{W} \qquad (4.60)$$

$$= 11 \times I_3 = 11\,\mathrm{W}$$

$P_f - P_j$ corresponds to the power consumed by the 11V receiver.