# 9. Flow

Using a DC source, investigate how the resistance between two metallic wires dipped into flowing water (or water solution) depends upon the speed and direction of the flow.

# 9.1. Introduction

- George Simon Ohm (1787-1854)
  - In 1925, he applied for a job as a post in the Jesuit Gymnasium Cologne.
  - As he was asked to make na unpublished work, he decided to study eletricity.

| | |
|---|---|
| U=R.i | R=ρ.L/A |

  - However, his work was refused, because of the analogy between the eletricity conduction and the heat conduction.

# 9.1. Introduction

- Important definition
  - Eletrical resistance is basically the dificulty imposed by a certain conductor to the passage of electricity. It can be measured with a multimeter and its unit is the ohm (Ω).

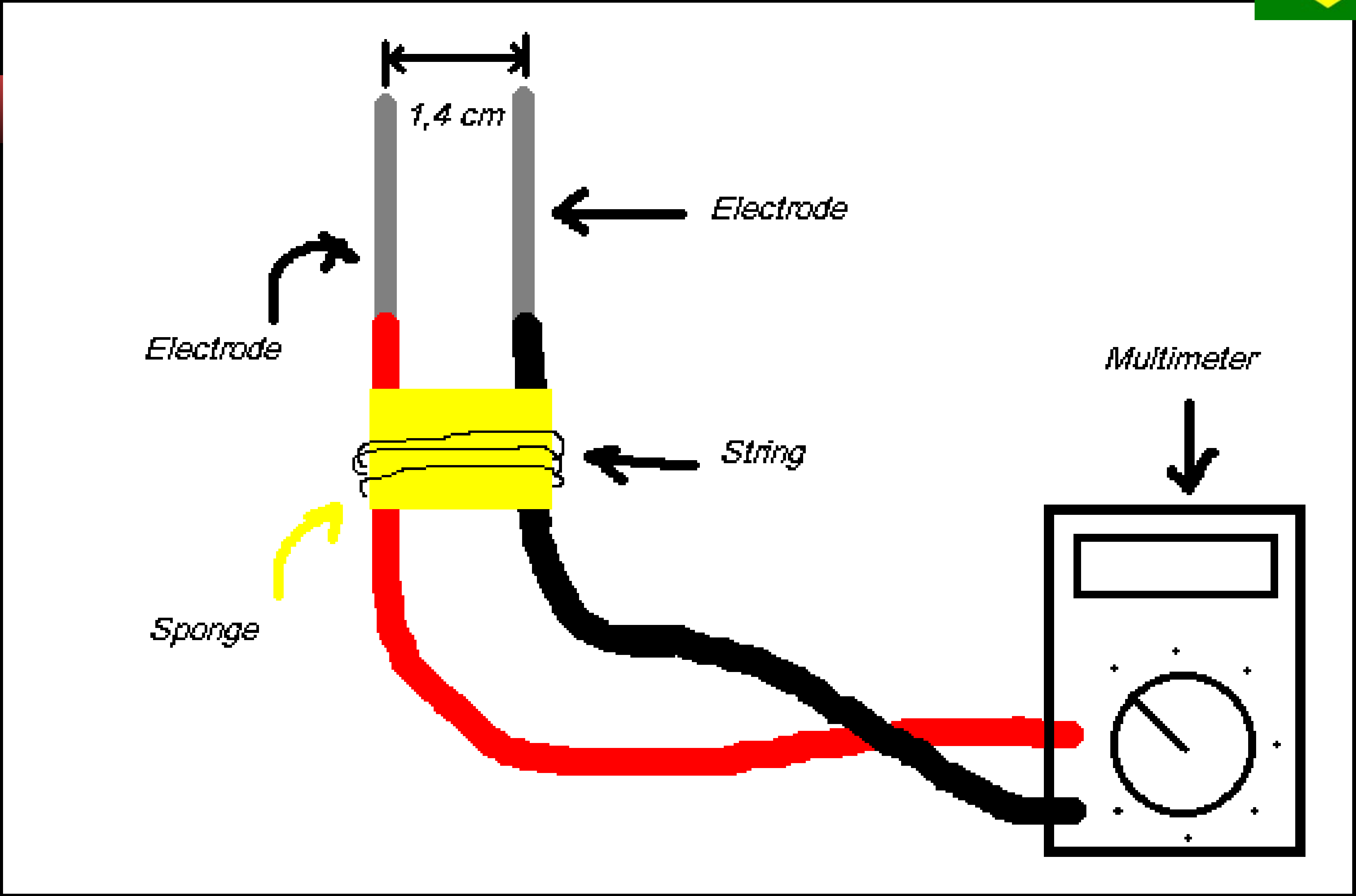
# 9.2. Methodology

- First Experience:
  - Influence of different ions
- Second Experience:
  - Influence of the speed of the flow
  - Influence of the direction of the flow

# 9.3. Material used

- Digital Multimeter
- Plastic basin (40cm x 26cm x 10cm)
- 2 liter water jar
- Salts: NaCl, $Na_2SO_4$
- Small synthetic sponge
- String
- Flowing water
- Scales


# Picture 1



# 9.4. First Experience

## Procedure

- In two different recipients, a wide variety of amounts of salt was dissolved in the water in order to verify the influence of both the number of ions per molecule and the salt dissociation.
- Salts used: $NaCl$ ($\alpha=90\%$), $Na_2SO_4$ ($\alpha=30\%$)

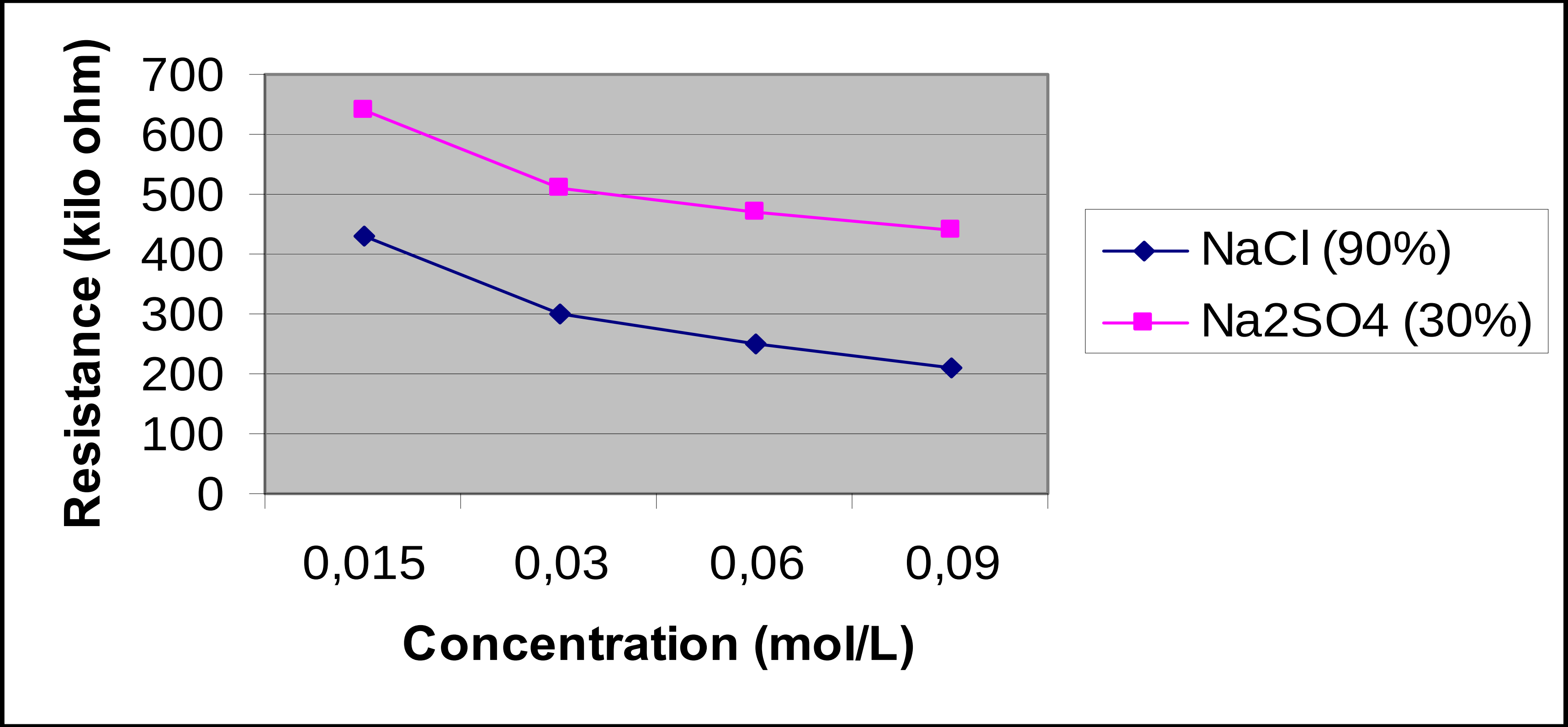
# 9.4. First Experience

- Results

| Concentration (mol/L) | Resistance (kilo ohm) | |
|---|---|---|
| | NaCl (90%) | $Na_2SO_4$ (30%) |
| 0.015 | 430 | 640 |
| 0.03 | 300 | 510 |
| 0.06 | 250 | 470 |
| 0.09 | 210 | 440 |

# 9.4. First Experience

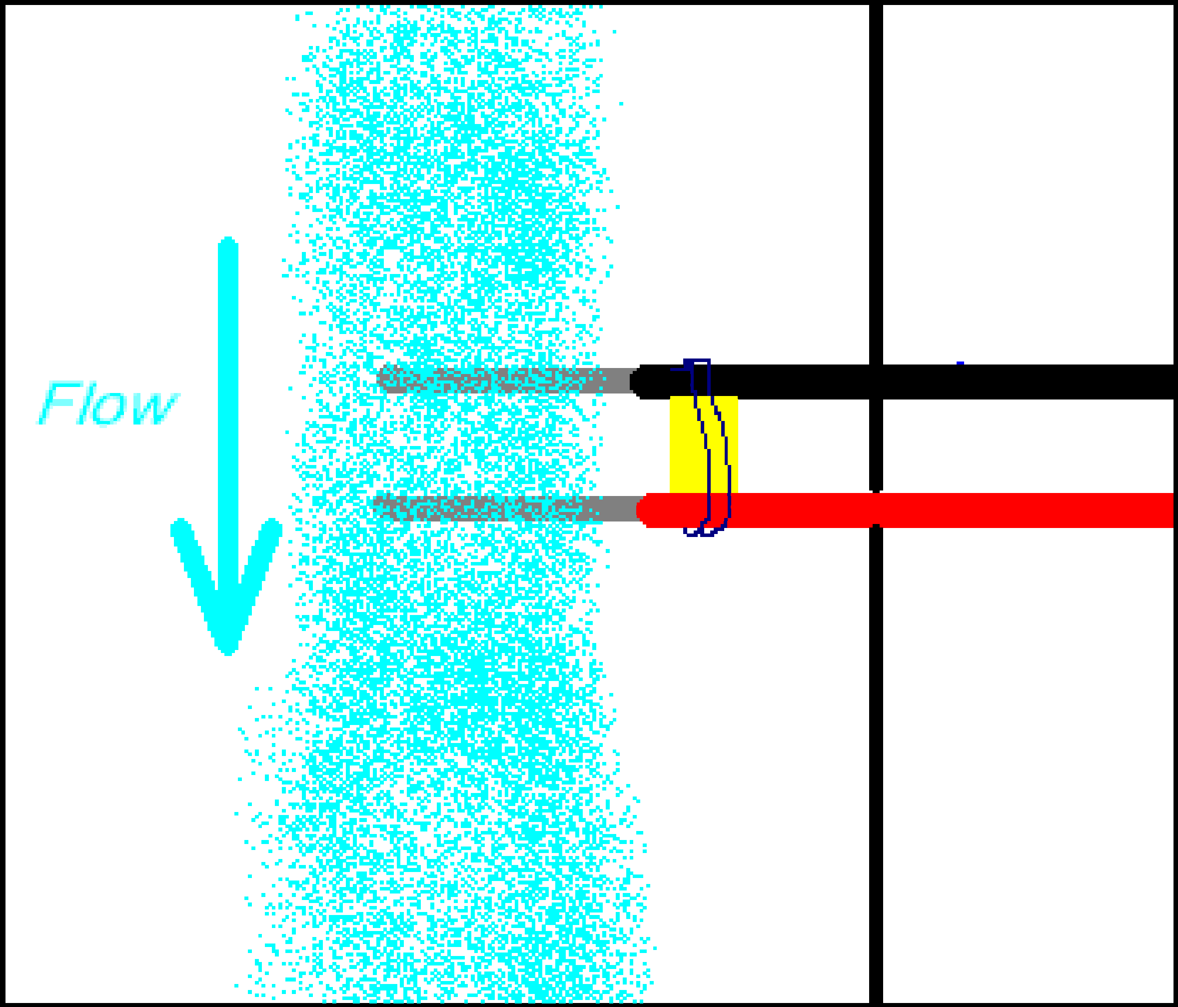
- Results



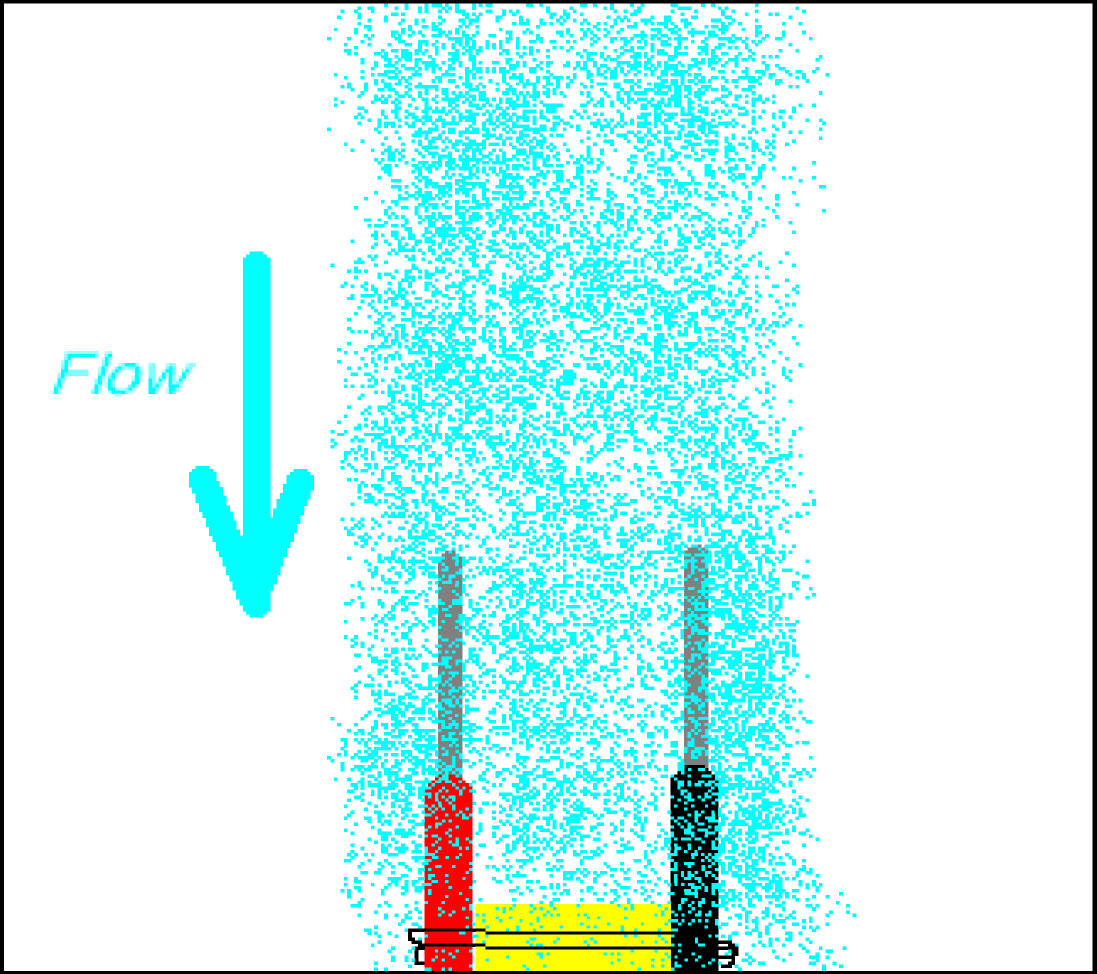
# 9.5. Second Experience

- Procedure
  - In order to verify how the resistance between the wires depends on the speed of the flow, electrodes were dipped into four different situations.
  - Besides, this experience was repeated in different flow directions, as it is shown in Pictures 2 and 3.

# Picture 2



# Picture 3



# 9.5. Second Experience

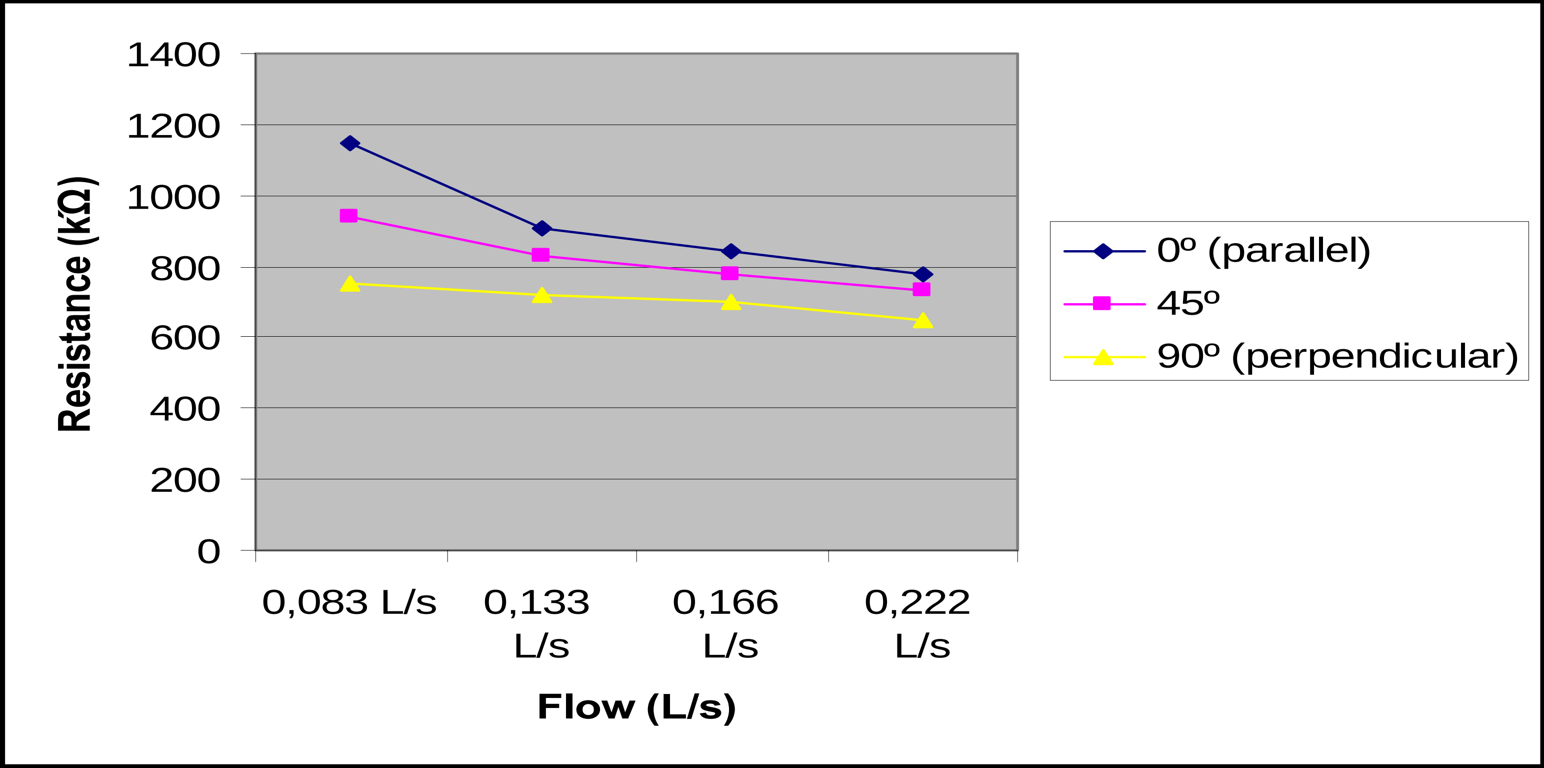
- Results

| | 0º (paralell) | 45º | 90 º (perpendicular) |
|---|---|---|---|
| 0.083 L/s | 1150 kΩ | 940 kΩ | 750 kΩ |
| 0.133 L/s | 910 kΩ | 830 kΩ | 720 kΩ |
| 0.166 L/s | 845 kΩ | 780 kΩ | 700 kΩ |
| 0.222 L/s | 780 kΩ | 730 kΩ | 650 kΩ |

0,083 L/s = 1L/12s  0,133 L/s = 1L/7.5s  0,166 L/s = 1L/6s  0,222 L/s = 1L/4.5s

# 9.5. Second Experience

- Results




0.083 L/s – 1L/12s    0.133 L/s – 1L/7.5s    0.166 L/s – 1L/6s    0,222 L/s – 1L/4.5s

# 9.6. Error Analyses

- Multimeter precision
- Multimeter battery
- Salt dissociation ($NaCl$, $Na_2SO_4$)
- Material and sizes of the recipient
- Metallic wires length

# 9.7. Conclusions

- Salt concentration
  - It is possible to conclude that the salt concentration on the water solution dramatically reduces the resistance between the electrodes
  - However, the latter tends to stabilize due to water's saturation point.

# 9.7. Conclusions

- Different salts
  - The resistances measured in the first experience comproved that the bigger is the number of ions dissociated in the solution, the lower is the resistance
  - Therefore, a good eletricity conductor solution should be made with a salt with a big number of ions per molecule and a great dissociation in the liquid.

# 9.7. Conclusions

- We can also infer that the increase on the water outflow reduces the resistivity between the electrodes.
- This happens because the free ions in the water move faster when the outflow is increased. As a result, more ions conduct electricity between the electrodes per interval of time, reducing the resistance.

# 9.7. Conclusions

- According to the results, the resistance is lower when the water flows perpendicularly through the electrodes.
- This must occur because the water flows naturally from the top electrode to the bottom one.
- Meanwhile, when the electrodes are parallel to the water flow, the ions are pushed down, increasing the resistance.