



Digital version

ENGS124 Electricity and Magnetism Lab Section B

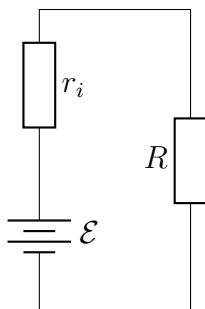
Finding the internal resistance of a li-ion battery

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1 Theory

All batteries in the real world have internal resistances. They can be modeled by a series resistor. If we connect an external resistor (R) to this battery, we have the following schematic:



After applying Kirchhoff's voltage law, the following equation is reached:

$$\mathcal{E} = I(r_i + R) \implies V_R = \mathcal{E} - r_i I$$

An experiment was carried out to test this equation and find the internal resistance of an 18650 lithium ion battery.

2 Experiment

The following circuit was assembled, with an 18650 li-ion battery and a range of resistors. The voltage across the resistors were measured, as well as the voltage across the battery, before connecting the resistors. With a 5Ω resistor, the power on it is $P = \frac{V^2}{R} \approx \frac{4^2}{5} \approx 3.2W$, way above the $0.25W$ rating of small resistors. This is why high power ($5W$) resistors were used.

Instrument or material	Description
Multimeter	Voltage and resistance measurement functionality
Battery and holder	A charged lithium ion battery
Resistors	High power resistors
Cables	For the multimeter and battery

Table 1: List of instruments and materials

Variable	Value	Resolution
Resistor resistance	Controlled	0.1Ω
Voltages across resistor	Measured	$0.01V$

Table 2: List of variables

V_{battery} (V)	R (Ω)	V_R (V)	I (A)
4.06	9.60	3.98	0.41
4.06	7.90	3.98	0.50
4.06	2.10	3.77	1.80
4.05	4.20	3.88	0.92
4.05	6.60	3.95	0.60
4.05	5.10	3.93	0.77
4.05	1.10	3.53	3.21
4.05	21.60	4.01	0.19
4.05	32.70	4.03	0.12

Table 3: Experiment data

Source of error	Type of error	Countermeasures
Resistance measurement	Random	Multimeters are not very good at measuring resistances.
Cable resistance	Systematic	Since we are using low value resistors, the cable resistances can distort the results
Resistor heating	Systematic	The measurement was taken very fast to limit resistor heating

Table 4: Estimated errors

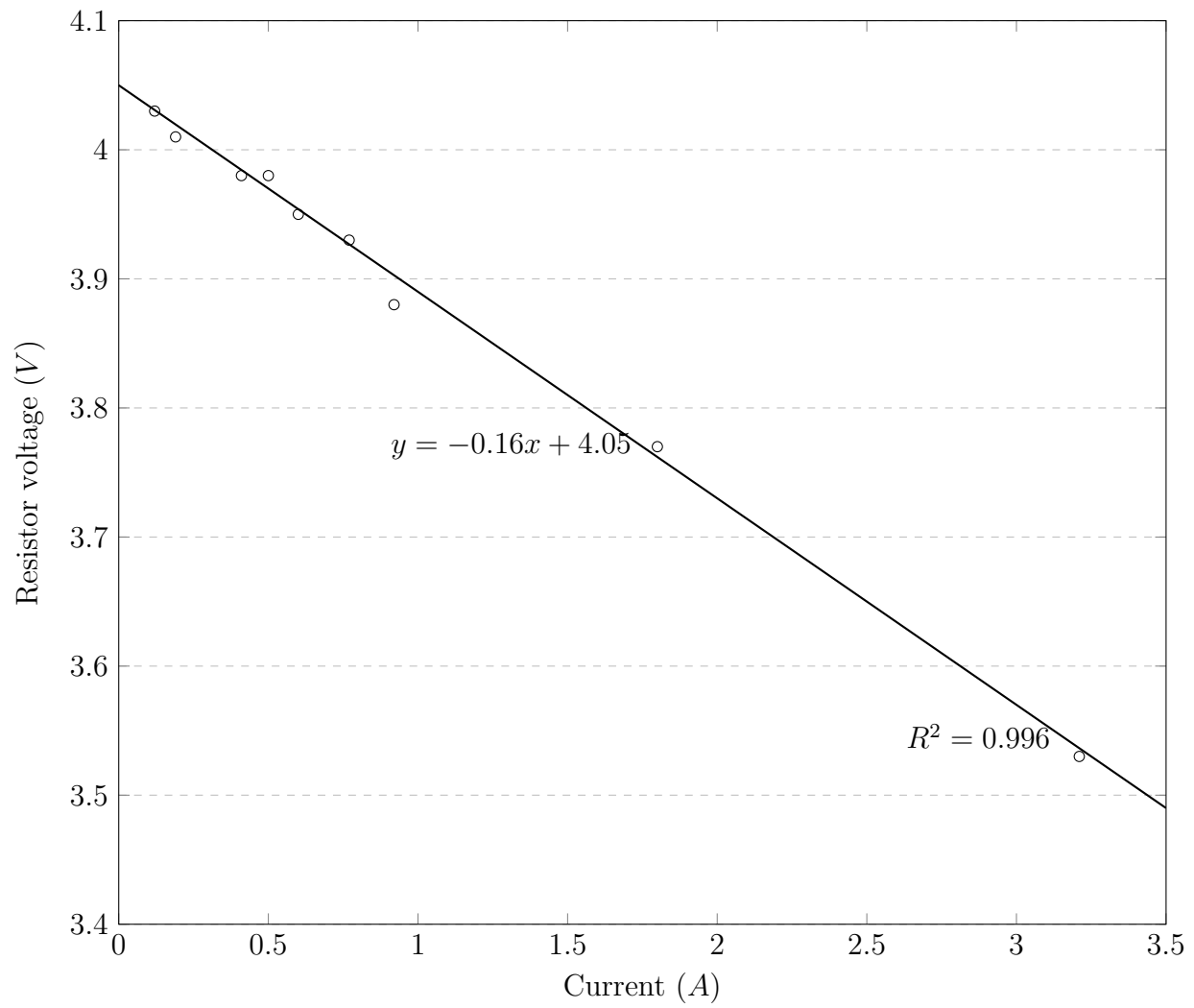


Figure 1: Plot of dependence of voltage accross the resistor from current

The above found equation was confirmed and the internal resistor is calculated to be $r_i \approx 0.16\Omega$.