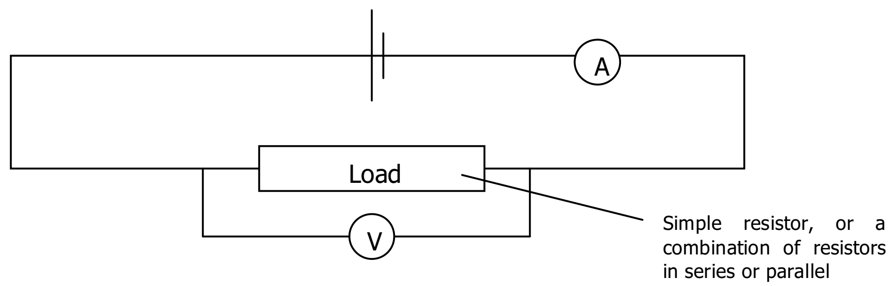
Internal Resistance and EMF (ELC)

Physics Portfolio By Clement Ng 12.6

Aim: To find out the internal resistance and EMF of a given power supply.
Method:

- Arrange apparatus as shown in the below circuit diagram
- Start off by recording the corresponding voltage (terminal pd) and current by figuring out the values available in the voltmeter and ammeter.
- Repeat previous procedures while the external load is varied, so that you obtain a set of voltage and current readings.
- Calculate averages and plot a graph of current against voltage. Use the graph to figure out the internal resistance and the EMF of the power supply.

Diagram:



[illegible]

Reading #1:

Voltage (v) (± 0.01V)	Current (A) (± 0.01A)	Resistance (Ω) (Provided on resistor)
0.981	0.09	10.0
0.424	0.38	1.0
1.097	0.07	15.0
0.471	0.31	1.5
1.231	0.01	100.0
1.255	0.01	150.0

Reading #2:

Voltage (v) (± 0.01V)	Current (A) (± 0.01A)	Resistance (Ω) (Provided on resistor)
0.998	0.09	10.0
0.502	0.40	1.0
1.094	0.07	15.0
0.584	0.35	1.5
1.207	0.01	100.0
1.223	0.01	150.0

Reading #3:

Voltage (v) (± 0.01V)	Current (A) (± 0.01A)	Resistance (Ω) (Provided on resistor)
1.061	0.10	10.0
0.460	0.45	1.0
1.089	0.07	15.0
0.580	0.38	1.5
1.193	0.01	100.0
1.215	0.01	150.0

Observations: As different external loads, or resistors were plugged into the circuit, several voltage and current readings were recorded. It was also noticed that the readings on both meters kept on jumping, therefore uncertainties of ± 0.01 was deduced for both the current and voltage values.

[illegible]

Arranged in increasing voltage and resistance values:

Average Voltage (v) (± 0.01V)	Average Current (A) (± 0.01A)	Resistance (Ω) (Provided on resistor)
0.4620	0.410	1.0
0.5450	0.347	1.5
1.0133	0.093	10.0
1.0933	0.070	15.0
1.2103	0.010	100.0
1.2310	0.010	150.0

Please note that all data processing graphs are presented at the last page of this report.

[illegible]

Conclusions

Several things could be found out from the data processing graph. Using the equation E = V + Ir, (where E is the EMF (V), V is the useful volts across the load (V), I is the current (A) and r is the internal resistance (Ω)) we could find out what the gradient of the V/I graph plotted would represent.

Since V here is plotted on the y-axis, and I is plotted on the x-axis, we can arrange the equation into the following form:

$$V = -Ir + E$$
$$y = mx + c$$

When compared with the straight-line equation above, we can see clearly that the gradient m would represent the internal resistance, and the y intercept c would represent the EMF. However, since there is a –Ir involved in the equation, this would mean that the V/I graph would have a down sloping gradient, which was what my graph has shown.

To conclude from the graph, the gradient is –1.739 (± 0.05). The uncertainty value here is obtained by using the max/min lines produced by the error bars. Since I is positive, the only value that would contribute to the –Ir value is r. This would mean that the internal resistance of the power supply would be 1.739 Ω with a (± 0.05 Ω) uncertainty.

I have also found out from the y intercept that the EMF of the power supply is 1.21V (± 0.01V). The uncertainty value here is again deduced by using the max/min lines created by the error bars.

When comparing this EMF value with the actual literature value of 1.243V, we can see that we are actually quite accurate. One has to keep in mind that this literature value only represents an open circuit with no resistor or external load involved. Therefore it is not surprising that the uncertainty value obtained from the experiment does not cover up for the differences between both EMF values.

Evaluations

Error 1: non constant temperature change

It was observed in the experiment that the temperature, although aimed to be kept the same, still fluctuated a bit, as the air conditioner was switched on/off, sunlight shining in from the windows, increasing the temperature of the room. Since this was the case, temperature would no longer be constant. Since temperature is directly related to the performance of the resistor, this would mean that the voltage and current readings might involve an error. This maybe indicated in the V/I graph by reading number four, (0.347, 0.545), as you can see, even though error bars are drawn, the resulting max/min/normal lines did not actually have frequent contact with the points. The value is the odd one out, which may involve an error.

Error 2: cell battery running down

Throughout the experiment, we tried to use the same cell in order to keep the EMF constant. However, keeping the cell battery running for the whole experiment did actually create the opposite effect. Since the battery was kept on, this would mean that it would actually run down, the EMF value would hence not be constant and may directly influence other measured variables in the experiment.

Error 3: Graphs drawn and interpreted inaccurately

One of the major applications of the experimental results is to use them to calculate the gradient/internal resistance values from the V/I graphs. If the graphs were plotted inaccurately or even wrong on the first place then these values would also bound to be wrong.

From the graph we can see that it is completely up to interpreter to draw the max/min and normal lines of best fit. This would mean that gradient values may vary and maybe inaccurate, leading to poor findings. Furthermore, the thickness of lines would also have a major effect on the interpretation of point values for analysis.

As you can see, a slight error in graph plotting would cause the overall performance of the experiment to degrade. This is why this error is one of the key elements in controlling the accuracy of the experiment.

Improvement 1:

To ensure the temperature is constant simply turn off all air conditioners and don't turn them back on during the experiment, shut all windows and curtains to prevent sunlight heating up the room, perform the experiment in a smaller room so that the temperature can be more easily monitored. In addition, a thermometer can also be used to record the temperature in the experimental area. If you find that the temperature has increased by a little, try turning the air conditioner to return to the original temperature. If you find that the temperature has decreased, then try opening the curtains and let sunlight warm the room a little. By attempting all these improvements, temperature would hopefully be constant, and would have minor effects on the final experimental conclusions.

Improvement 2:
It would be impossible in the experiment to completely gain control of the EMF value and prevent the cell battery from running down. The only best improvement is to switch off the circuit when readings are recorded or between small breaks. That way, the battery would not run down as quickly and hopefully by the end of the experiment, the EMF value would not have altered significantly.

Improvement 3:
To improve on graph plotting skills, we could use a computer to help us. Many computer software's nowadays can help us plot the results and calculate the gradients directly. After the experimental results are obtained, simply copy them into the program and plot graphs of V/I. These graphs would be much more accurate then hand plotted ones, and internal resistance values would be calculated to the highest degree of accuracy.
Unfortunately, allowing the computer to do the job for you does not show any skills in data processing. Thus another improvement can be done by using calculus. Calculus is a good tool in mathematics to calculate the gradient of a known equation. The final results maybe even more accurate then the computer values. However, this would be inappropriate in this experiment, since knowing the equation would already give as the internal resistance and EMF values. This improvement maybe effective on other investigations.

By Clement Ng 12.6
Thursday, July 4 2002 05:12AM