A special report is one that is written up outside the first year laboratory. The following is considered a very good special report. We have included many of the features that we would like to see in a laboratory report. We have kept the conclusions to the level that we could reasonably expect from a good student with little background experience. This report would get about 95% provided we were certain that the student actually attended the laboratory and undertook the work.

THE MEASUREMENT OF RESISTANCE USING A VOLTMETER AND AN AMMETER

By Terry Freeman partnered with Alan Jones.

Introduction

Resistors are used in electric circuits to determine the current that flows through various branches of these circuits. They also determine the electric potential (commonly called voltage) at points in the circuit. Because of this, it is important to know the values of the resistance of each resistor that might be found in a circuit. The following well known equation describes Ohm's law

$$V = IR\ .$$

This equation relates the resistance, *R*, the current through the resistor, *I*, and the voltage across the resistor, *V*.

The aim of this experiment was to determine how well the resistance of a resistor can be determined by simple measurements of *I* and *V*. The results of these measurements were compared with values found by other means.

EQUIPMENT AND METHODS

The following equipment was provided for this experiment:

- two ammeters (ranges 50mA to 5A & 50μA to 5000μA),
- a DC voltmeter (ranges 3V to 300V),
- a size D torch cell,
- a multimeter (voltage DC & AC, Ohms and current DC & AC)
- a selection of resistors
- and a chart for interpreting the colour codes on the resistors.

Two circuits were shown in the manual, both were tried for this experiment. The first circuit (network A) is shown below.

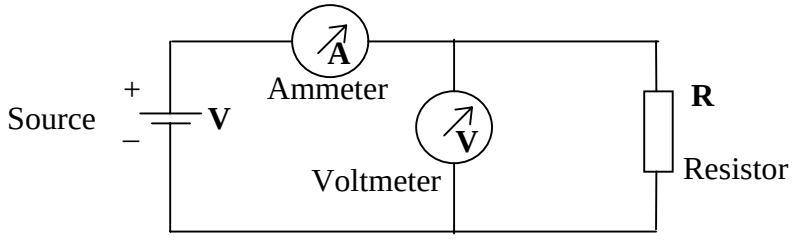

Figure 1, Network A.

The second circuit (network B) is also shown below.

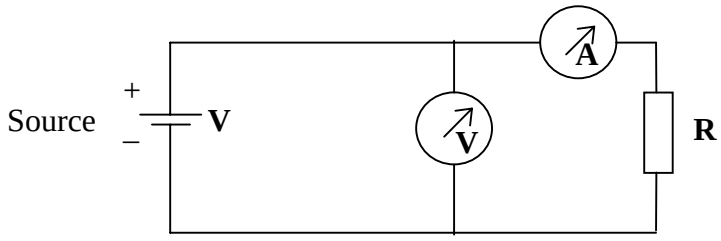

Figure 2, Network B.

The manual states that network A is best used when R is small compared to R_V, which is the resistance of the voltmeter. Similarly if R is large compared to R_V, then circuit B is best used. Both circuits were tried for each of the resistors.
The manual suggested that if there was some doubt about a value of R, then this could be checked using the digital voltmeter. The digital voltmeter was a digital multimeter that also acted as a digital ohmmeter and ammeter. It was quite simple to check the values of all the resistors using this multimeter.

RESULTS AND UNCERTAINTIES

The resistors that were provided were coded by letters. We first found the resistance values for each resistors from the colour code and checked these values using the digital multimeter.

Letter	Colour code (Ω all 5%)	Multimeter value (Ω)
A	$1\,5 \times 10^0$	14.8
B	$3\,2 \times 10^0$	36.2
C	$6\,8 \times 10^1$	682
D	$8\,2 \times 10^2$	8.13×10^3
E	$3\,9 \times 10^3$	38.4×10^3
F	$4\,7 \times 10^4$	0.464×10^6
G	$1\,5 \times 10^5$	1.492×10^6
H	$1\,0 \times 10^6$	10.4×10^6

We then used network A to find the voltage across, and the current through each of the resistors that were on the board.

	V (volt)	I	V/I (Ω)	Colour code value
A	1.28	78±2 mA	16.4±0.4	15 Ω
B	1.40	36±2 mA	38.9±2	33 Ω
C	1.48	2.0±0.2 mA	740±70	680 Ω
C	1.36	2 350 μA	578±12	680 Ω
D	1.46	620 μA	2350	8200 Ω
E	1.26	455 μA	2770	39 kΩ
F	1.26	42.2 μA	2990	470 kΩ
G	1.26	42.2 μA	2990	1.5 MΩ
H	1.26	42.2 μA	2990	10 MΩ

Comments

The values of *R* measured by the multimeter agree with the colour code to within the expected 5%.

There is a considerable difference in the measured currents when changing the range of the ammeter. This can be seen for the two different sets of values for resistor C.

The readings from the voltmeter were much lower than expected. These were checked using the multimeter and the agreement was within 0.01 V. The battery did not appear to be flat.

All the different higher value resistors gave much the same result of about 3 kΩ.

Because of the problems with these results, the experiment was repeated using network B.

	V (volt)	I	V/I (Ω)	Colour code value	difference
A	1.44	86 mA	16.7	15 Ω	+11%
B	1.46	37 mA	39.5	33 Ω	+20%
B	1.46	44 mA	33.2	33 Ω	+0.6%
C	1.49	1.8 mA	830	680 Ω	+22%
C	1.49	1920 μA	776	680 Ω	+14%
D	1.49	160 μA	9300	8200 Ω	+13%
D	1.49	166 μA	9000	8200 Ω	+10%
E	1.50	36 μA	42000	39 kΩ	+8%
E	1.50	37.3 μA	40200	39 kΩ	+3%
F	1.49	3.2 μA	470000	470 kΩ	0%
G	1.49	1.1 μA	1400000	1.5 MΩ	-7%
H	1.50	0	very large	10 MΩ	

Comments.

These results appear to be in better agreement than those found using network A. The average discrepancy between the values measured using the suggested circuits and the colour code value is 11%.

Results are given twice when the range of the ammeter was changed.

DISCUSSION

The results show that recognisable values of the resistors between 15 Ω to 680 Ω can be found by dividing the voltage across the resistor by the current flowing through the resistor. According to the colour code, the uncertainty of the resistance values should be up to 5%. In the above results, many of the observed differences are larger.

Network B gave good values of *V*/*I* for the larger resistances (except the very large one where the small current could not be detected). The manual suggests this indicates that *R* is large compared to R_V.

The values of resistance and voltage that were measured by the multimeter all seem to agree with the colour code. It seems that the values of the current measured by the ammeters causes the most problems. These values are not the same when the range of the ammeter is changed.

When the first circuit (network A) was used, no realistic values of the higher resistances could be calculated. Perhaps the resistance of the voltmeter R_V was smaller than measured resistance R. Again, this is what the manual suggests.

CONCLUSION

Many of the values of V/R that were found in this experiment do not agree to within 5% of the colour code values. However, when the voltmeter is placed across both the resistor being measured and the ammeter, the agreement is at least recognisable. We could not test the ammeters against the multimeter so we suspect that these are the chief cause of the inaccuracy. The first circuit used, with the voltmeter placed directly across the measured resistor, could not give recognisable values of the lower resistances. All the high resistors gave the same result, perhaps this value of about 3 kΩ is the resistance of the voltmeter.

While the results for the lower resistances are disappointing, placing the voltmeter across both the ammeter and the resistor gives recognisable results for most of the resistors across the range. We would expect better results if we had better ammeters and if we used the digital voltmeter.