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ENEE 473
Experiment #1: Ohm's Law

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I. Purpose of Experiment: To determine experimentally if Ohm's law is valid, namely that \( V = RI \) and the relation between \( V \) and \( I \) is a straight line whose slope is \( R \) the resistance in Ohms.

II. Instrumentation: A carbon resistor of nominal value 100 Ohm was used. Since it is rated at only 1 W, the maximum voltage applied cannot exceed 10 V for a long time. A variable DC voltage source was used with two meters: one to measure current in mA, the other to measure voltage in Volts. A switch was used to begin and stop the experiment. The connections are shown in the figure below:

![Electrical Circuit Diagram]

III. Data Collected: The data is shown in a Matlab® script below. In this report the author is using Matlab® combined with MSWord®.

```matlab
clear;
Vs=[0 1 2 3 4 5 6 7 8 9 10 11];
V=[0 1.01 2.03 2.99 3.95 5 6.01 7.05 8.02 8.93 12.1 10.93];
I=[0 10.1 20.2 30 39.9 50.2 60.5 71 79.5 89.3 100.2 111];
```

Remarks: The voltage is in volts and the current in mA, hence to find the resistance in Ohm, one needs to consider the 1000 factor in current to convert it to Ampere. Note also that in the plot below the point just before the last (the 11th) seems very far from the expected line. We consider this an error either in recording the data or in reading it. In this type of experiment it is best to disregard this point. First the data is plotted (next page) with all the data points. Later on, we perform the computations after eliminating this 11th "bad" data point.
IV. Results: The graph above shows that one point at approximately 100 mA is off the curve and should be eliminated. This is done in the statements below where the 11th data point is removed and the scale of current changed to A:

```matlab
Vv=V; Vv(:,11)=[];
Ii=I/1000; Ii(:,11)=[];
```

Next the "modified" data is plotted with the "best" linear fit, the values in P are the slope and Y-intercept of the (least square error) linear fit:

```matlab
[P]=polyfit(Ii,Vv,1)
y=P(1)*Ii+P(2);
plot(Ii,Vv,'ko',Ii,y,'k-');xlabel('Current in A');
ylabel('Voltage in Volt');title('Plot of modified data and best linear fit'); grid
```
The resistance is found to be 99.2 Ohm, the nominal value is 100, the percent error (compared to the nominal value) is:

\[
\text{PercentError} = \frac{\text{abs}(100 - P(1))}{100} \times 100
\]

\[
\text{PercentError} = 0.7574
\]

The error is only 0.76%, i.e. the resistor should have a "double gold" tolerance ring! It is very accurate. [No ring is ±20%, silver ring is ±10%, gold ring is ±5% and double gold ring is ±1%].

V. Conclusions: This experiment demonstrated that Ohm's law is a very accurate one, namely that current and voltage are in fact related in a linear fashion by the resistance according to the equation: \( V = RI \). The resistor selected for this experiment deserves a "double gold" tolerance ring. It is interesting to see the effect
of not neglecting the 11\textsuperscript{th} data point as was done previously. The statements below restore the 11\textsuperscript{th} point in computing the "best" fit:

\begin{verbatim}
I2=I/1000;
[P]=polyfit(I2,V,1)
y=P(1)*I2+P(2);
plot(I2,V,'ko',I2,y,'k-');xlabel('Current in A');
ylabel('Voltage in Volt');title('Plot of raw data and best linear fit');
grid

P =
    105.9502   -0.1757
\end{verbatim}

It is seen now that the relative error (compared to nominal value of 100 Ohm) is almost 6\%, much higher than before due to the erroneous 11\textsuperscript{th} point.

\textbf{PercentError} = \frac{\text{abs}(P(1)-100)}{100} \times 100

\textbf{PercentError} =
    5.9502