DISCOVERING THE EXISTENCE OF FLAW IN THE PROCEDURE OF DRAWING ENLARGED EXPERIMENTAL CURVE

Pramode Ranjan Bhattacharjee †

Abstract

This paper identifies the flaw existing in the traditional procedure of drawing enlarged experimental curves. The usual practice of obtaining an enlarged curve by making use of proper scales with maximum enlargement along the two axes of coordinates has been found to be in conflict with the fundamental concept of "Enlargement" in Transformation geometry and is therefore flawed. With a view to getting rid of the aforesaid flaw and to establish a rationality between theory and practice, this paper emphasizes the need of using two similar proper scales with maximum enlargement along the two axes of coordinates for drawing enlarged experimental curves.

Key Words: Experimental graph; Transformation geometry; Enlargement.

INTRODUCTION

Experimental study of Science and Engineering is based on well-defined Laboratory guidelines/instructions. While working in a laboratory, students are always advised to follow the standard guidelines/instructions [3-12]. Now what about those guidelines/instructions which have no resemblance with the well-known theoretical concepts? It is a high time to think of such guidelines/instructions and to get rid of them with alternative flawless replacements, if possible or to get rid of them forever.

An examination of the traditional guidelines/instructions [3-12] in respect of drawing experimental graph has been made in this paper. In order to enhance graphical reliability or to minimize the value of one smallest division of the graph paper, the traditional concept [3-12] involved in experimental graph drawing is to make use of proper scale with maximum enlargement so as to cover up almost the entire portion of the graph paper used for drawing graph. Sometimes use of two different scales, each of which is a proper scale, is also insisted upon [4, 7, 12]. This very practice of artificial enlargement of a graph (figure) using dissimilar scales (each of which is a proper scale) in drawing experimental graph is flawed and it violates the fundamental concept of "Enlargement" in Transformation geometry [1, 2]. Such a curve is never an exact enlarged replica of the original curve (figure). In order to get rid of the aforesaid flaw and to establish a parity with the fundamental concept of "Enlargement" in Transformation Geometry, this paper emphasizes use of *two similar proper scales with maximum enlargement along the two axes of coordinates* in drawing experimental graphs.

DEFINITION

Enlargement: Let O be a fixed point and μ be a non-zero real number, positive or negative. If for any point P, there exists one and only one point P'on the ray OP such that $OP'/OP = \mu$, then the point P' is called the image of the point P and this transformation is called an enlargement. The point O is called the center of enlargement and the number μ is called the scale factor of the enlargement.
As shown in Fig. 1(a) and Fig. 1(b), when $\mu > 0$, the points P and P' lie on the same side of the point O. In Fig. 1(a), $\mu > 1$ and in Fig. 1(b), $0 < \mu < 1$

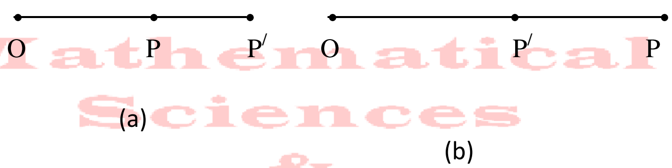

Figure 1
Diagrams showing enlargement of the ray OP with the scale factor $\mu > 0$

Again as shown in Fig. 2(a) and Fig. 2(b), when $\mu < 0$, the point O lies in between P and P'. In Fig. 2(a), $\mu < -1$, and in Fig. 2(b), $-1 < \mu < 0$.

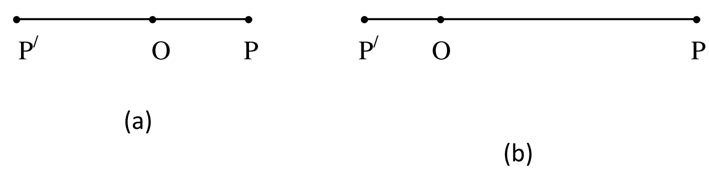

Figure 2
Diagrams showing enlargement of the ray OP with the scale factor $\mu < 0$

A BRIEF LOOK AT THE TRADITIONAL INSTRUCTIONS/GUIDELINES REGARDING GRAPH DRAWING

This section reveals a collection of the procedure to be followed in drawing experimental graph and it resulted from the search of the traditional literature [3-12].
The following lines regarding graph drawing exist in Pages 10-11 of [3]. "**How to Plot a Graph?** The following points will be found useful for drawing a proper graph: 1. Examine carefully the experimental data and note the range of variations of the two variables to be plotted. Also examine the number of divisions available on the two axes drawn on the graph paper. After doing so, make a suitable choice of scales for the two axes keeping in mind that the resulting graph should practically cover almost the entire portion of the graph

paper. Introductory Concepts **11** 2. Write properly chosen scales for the two axes on the top of the graph paper or at some suitable place. Draw an arrow head along each axis and write the symbol used for the corresponding variable along with its unit as headings of observations in the table, namely, d/mm, R/W, l/cm, T/S, I/A etc. Also write the values of the respective variables on the divisions marked by dark lines along the axes."

The following procedure exists under the heading "**How to construct a line graph**" in [4]. "Determine a scale, (the numerical value for each square), that best fits the range of each variable. Use a scale that allows your data to be graphed as large as possible in the space provided. **The range of each axis *may* be different**. They should each be large enough to cover the needed range without lots of extra space. They do not need to start at zero but it is recommended as this allows you to extrapolate. **The scale of each axis *may* be different**, but **each one must be consistent**. If one box represents one metre at the beginning of the graph, one box *always* represents one metre."

The following lines in regard to selection of "**Scales**" in Physics Graphing Guidelines exist in [5].

"**Scales** – Choosing an appropriate scale is important to make the graph as precise and meaningful as possible and yet easy to read and interpret. For these reasons choose for each axis a scale where each square equals 1, 2, or 5 × 10^n and where the data cover as large a span of the page as possible. In other words, choose a scale that will make the data cover most of the page but which is also convenient and easy to use and read. It is best for the scales to extend to and include the origin. Only use a break in a scale and/or omit the origin if this will result in a more meaningful graph that better displays the data. It is not necessary to label every single line on the scale."

The following lines exist under the heading "Graph Plotting" in [6].

"Choose a convenient scale for each axis so that the plotted points will occupy a substantial part of the graph paper, but do not choose a scale which is difficult to plot and read, such as 3 or ¾ units to a square. Graphs should usually be at least half a page in size."

The following lines exist in [7] in regard to "Choice of Scales" in graph drawing.

"In drawing graphs, choose scales such that the data points are spread over the graph paper. Do not cramp your graph into one corner or a small section of the sheet… . The scale need not be the same for both axes, but make them convenient, i.e. have each division equal to 1, 2, 5, 10, etc. units. Do not use 3, 7, 9, etc. The numbers increase from left to right and from bottom to top. It is customary to plot the independent variable as abscissa (x-axis) and the dependent variable as ordinate (y-axis)."

The following lines exist under the section **"Scales, Axes and Proportions"** of [8].

"The upper and lower limits of the scales should be selected so that there is minimal blank space in the plot area. There should be at least one data point near each end of each axis, so that the data encompass the full two dimensional range of the plot area. If there are no data near the origin, it may be preferable to start one or both scales at a non-zero value."

The following instruction has been emphasized under the section "Drawing of graphs" in [9].

"In choosing the units care should be taken that almost whole of the graph utilized."is

The following lines exist under the section "Graphs and how to plot them" in [10].

"In choosing the unit, care should be taken that the larger part of the graph paper is being utilized and unit of length on the graph paper and the unit of the quantity to be plotted, should Bear to each other a simple ration."

The following instruction is available for drawing graphs in [11].

"Choose an appropriate scale so that the graph fills most of the page. It doesn't matter which way round you position the graph paper."

The following guideline exists under the section "Elements of a good graph" in [12].

"Choose scales such that the graph occupies most of the page. The two scales need not have the same size units. Also, the scales need not begin at zero."

GETTING RID OF THE FLAW EXISTING IN THE TRADITIONAL PROCEDURE OF GRAPH DRAWING

An examination of the aforesaid procedure of drawing experimental graph prevailing in the traditional instructions/guidelines [3-12] can now be made to find that use of proper scales with maximum enlargement has been emphasized in most of the instructions/guidelines [3-12]. Some of them [4, 7, 12] also emphasize on the need of using dissimilar proper scales along the two axes of coordinates.

In order to show that this long-running concept of using dissimilar scales along the two axes to obtain enlarged curve is in conflict with the fundamental concept of "Enlargement" in Transformation geometry, it would be better to draw the simplest (Voltage versus Electric current) graph for a metallic conductor based on the following data.

Voltage in Volts	1	2	3	4	5
Electric current in Ampere	1	2	3	4	5

By choosing a particular scale for both the axes, the above data points are plotted on the graph paper to obtain the straight line shown in Fig. 3. Again by choosing another scale for both the axes, the same data points are plotted on a similar graph paper to obtain the straight line shown in Fig. 4. Finally the above

data points are plotted on a third graph paper of the same type by making use of dissimilar scales along the axes so as to obtain the straight line shown in Fig. 5.
It can now be readily verified that the straight line obtained in the graph of Fig. 4 by considering a particular type of similar scale for both the axes is an exact enlarged replica of the straight line obtained in the graph of Fig. 3 by considering a different type of similar scale for both the axes. This is because these two straight lines are exactly parallel and they satisfy the fundamental property of Enlargement, viz. *the image of an interval is parallel to the original interval*, in Transformation geometry. On the other hand, this type of compliance in respect of parallelism has been totally violated by the straight line obtained in the graph of Fig. 5, that resulted by making use of two dissimilar scales along the axes. Thus the straight line shown in the graph of Fig. 5 could never qualify itself as an enlarged replica of the straight line shown in the graph of Fig. 3 as far as the validity of Transformation geometry is concerned.

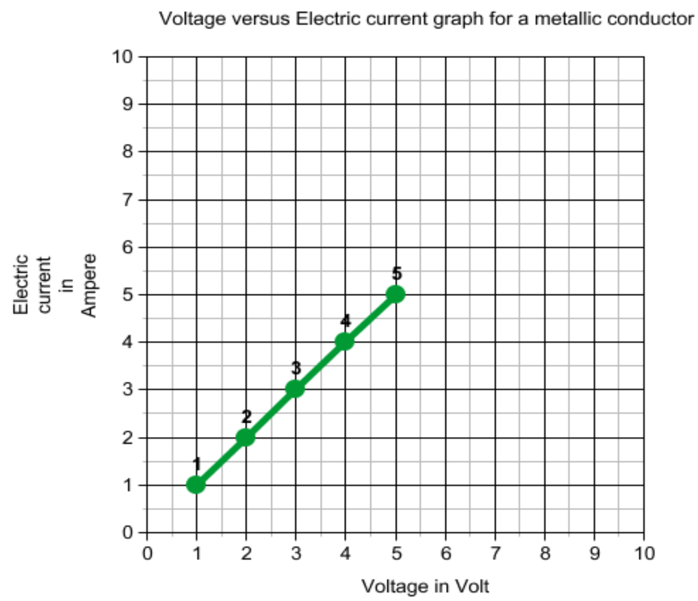

Figure 3
Diagram showing Voltage versus Electric current graph of a metallic conductor using well-defined similar scales along the two axes

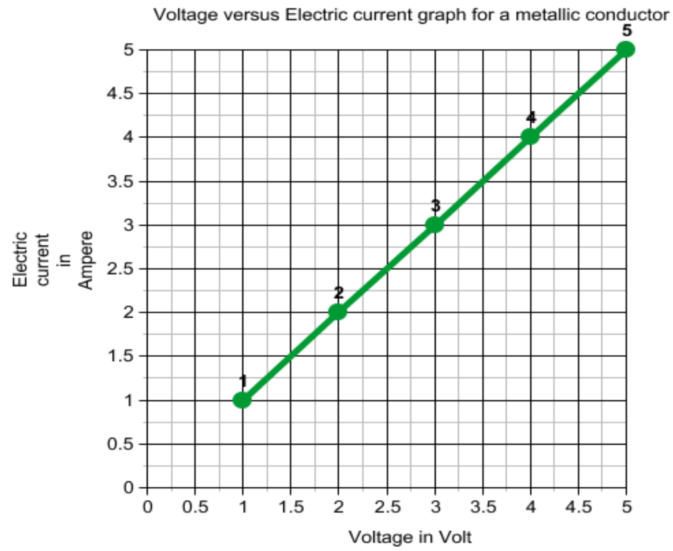

Figure 4
Diagram showing Voltage versus Electric current graph of the same metallic conductor using a second type of well-defined similar scales along the two axes

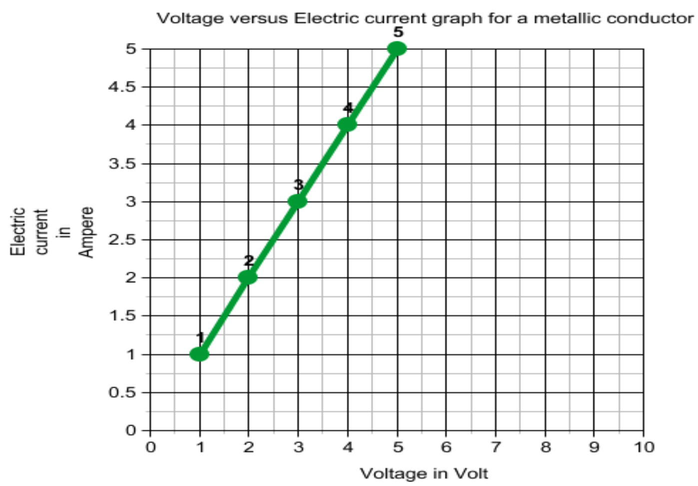

Figure 5
Diagram showing Voltage versus Electric current graph of the same metallic conductor using two well-defined dissimilar scales along the two axes

Thus the traditional concept of artificial enlargement of a curve by making use of dissimilar proper scales along the two axes of coordinates always leads to enlarged curve, which is not at all an exact enlarged replica of the original curve and hence does not have any resemblance with the fundamental concept of "Enlargement" in Transformation geometry. On account of this reason, the aforesaid long-running procedure of drawing experimental graph is fundamentally flawed.

As has been stated above, the only way to bring rationality between theory and practice is to get rid of the aforesaid flaw by making use of two similar proper scales with maximum enlargement along the two axes of coordinates.

CONCLUSION

This paper examines the traditional procedure of drawing experimental graph in which the use of two dissimilar scales (each of which is a proper scale) along the two axes of coordinates with maximum enlargement is always encouraged. This very concept of artificial enlargement of a curve (figure) using dissimilar scales (each of which is a proper scale) in drawing experimental graph leads to enlarged curve (figure), which is not at all an exact enlarged replica of the original curve (figure) and hence does not have any rationality with the fundamental concept of "Enlargement" in Transformation geometry. Thus the aforesaid long-running procedure of drawing experimental graph has been discovered to be flawed. With a view to getting rid of the aforesaid flaw and bringing rationality with the fundamental concept of "Enlargement" in Transformation Geometry, the paper emphasizes use of *two similar proper scales with maximum enlargement along the two axes of coordinates*.

† ***Pramode Ranjan Bhattacharjee, Ph.D.*** Kabi Nazrul Mahavidyalaya, Sonamura, India

REFERENCES

[1] M. Jeger, Transformation geometry, 1966, London: George Allen and Unwin Ltd.
[2] www.benjamin-mills.com/maths/Year11/enlargement.pdf
[3] R. K. Shukla, A. Srivastava, Practical Physics, 2006, New Age International (P) Limited, Publishers, New Delhi, India.
[4] *www.iitg.ernet.in/scifac/qip/...manual/Physics_Lab_manual.pdf*
[5] *www.farraguttn.com/science/milligan/physics/GraphGuid.htm*
[6] *phys.columbia.edu/~preceptor/1291Manual_FA12.pdf*
[7] *www.physics.nus.edu.sg/~ephysics/documents/graphs.doc*
[8] www.owlnet.rice.edu/~labgroup/pdf/Using_figures.htm
[9] K. G. Mazumdar, B. Ghosh, Advanced Practical Physics, Vol. I, 2000, Sreedhar publishers, Calcutta, India.
[10] S. K. Ghosh, A Text Book of Practical Physics, 2001, New Central Book Agency (P) Ltd., Calcutta, India.
[11] www.cyberphysics.co.uk/general_pages/plottinggraph.htm
[12] *www.lhup.edu/~dsimanek/scenario/contents.htm*