NEW APPROACH TO GRAPHICAL SLOPE ERROR DETERMINATION IN PHYSICS

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Abstract

Accuracy is paramount in any physics experiment which cannot be compromised. However errors are bound to occur, be it human or instrumental. Consequently, it is usual for the experimenter to want to estimate the extent of errors introduced especially in to the slope of a straight line. This paper approached the estimation of slope error in another more conservative way termed least and greatest slope method. The method considered the contribution of all the plotted data points in the slope error calculation using a mathematical relation developed for the purpose. The results from the new method compared well with those from the old maximum deviation method. The characteristic low error value compared with the former method is also a proven superiority of better representation of all the data in so far as all their contributed, errors were considered.

Introduction

Experimental errors result in the uncertainties associated with observations and calculations during physics experiments. This culminates in a difference between the values obtained by observation or calculation and the true value. Experimental errors can be erratic, random or systematic in nature.

Erratic error arises from mistakes committed by the observers and affect the observation in an irregular way. It may occur once throughout the course of an experiment. This error can only be prevented by carefulness on the part of the observer. Random error arises from equipment problems in addition to observer mistakes. It equally affects observation in an irregular way. This can be corrected not only by painstaking of the observer but by repeated readings and later taking a mean value. Systematic error also results from equipment and mistakes by the observer. However, it affects the observations in a regular and consistent manner throughout the period of experiment. Carefulness on the part of the observer in addition to the usage of a good equipment aids corrections.

In the past, experimental errors were calculated / determined from linear graphs plotted for Physics experimental observations by maximum derivation method (Avery and Ingram, 1971). In this method only four plotted points on the graphical Cartesian plane are usually considered in the calculation irrespective of how many points are plotted. That is error contributed by four points only is considered as representation of all errors that might have occurred in all the data points obtained. This is considered correct to make works easy but may not be absolutely true. The zeal for accuracy in physics experimental endeavour prompted this research work. A new method called least and the greatest slope in which all the plotted points were involved in the final slope error calculation was mathematically developed, tested and found adequate in this paper. In spite of the tediousness of the new method developed its pride manifests in the higher accuracy, in so far as errors contributions in all the data points were considered.

Mathematical Derivations Steps

- Determine and draw a best straight line to fit the plotted scattered points following the conventional method and obtain the slope of the line as >M=.

- Determine the coordinate of a point called centroid >C= by calculating the means of the ordinate and abscissa data; Plot >C= on the graph plane.
- Draw a straight line through the centroid >C= and a farthest plotted point due left of the best straight line of fit; Obtain the slope of the line mi (i.e. greatest slope) by extending the triangle used in obtaining M to meet the line.
- Draw another straight line through the centroid and the farthest plotted point due right of the best straight line and find the slope m_2 (i.e. least slope) also, by extending the triangle used to determine M, to meet the line.

The slope error is given by the ratio of the absolute difference between m, and m_2 to M. That is:

better result. However should it not be practically possible, then different triangles can be drawn for each line to determine m, and m_2.

Application

The reliability, suitability and accuracy of the method are tested as follows: Four different laboratory methods of obtaining acceleration due to gravity were used to obtain four sets of straight line graph data. Straight line graphs were then plotted. The slope errors were then determined for the graphs using both the newly developed method and the conventional maximum derivation method. This makes for precise comparation of results from the two methods.

A computer software named >Grapher= developed by Golden Software Inc.,(1988), is used to plot the straight line graphs in all the cases. Typical plots are shown in figures 2 and 3.

The slope errors for all the graphs are determined following the process in the figure 3 using the relation:

(2)

where:

W = vertical separation, as traced on the vertical axis, between the two lines dawn through the farthest plotted points on the best straight line, n = number of plotted points, and

R = horizontal separation between the first and the lest plotted points as traced on the horizontal axis.

The summary of the slope errors obtained with the newly developed method and the pre-existing method for all the graphs is shown in Tablel.

Table : Slope Errors from the Graphs

S/n	Methods	Slope Errors		Difference
		New Method	Old Method	
1	Simple pendulum length variation	0.22	0.24	0.02
2	Simple pendulum angle variation	0.05	0.06	0.01
3	Helical spring vibration	0.42	0.69	0.27
4	Helical spring constant determination	0.20	0.22	0.02

Table 2: Percentage Error Difference

Method	Measured Slope (in S. I. Unit)	Percentage Error		Difference(%)
		New Method	Old Method	
1	4.0	5.5	6.0	0.5
2	1.88	2.7	3.2	0.5
3	5.85	7.2	8.5	1.3
4	6.17	3.2	3.6	0.4

Discussions

The deviation of the newly developed method is 22%, which is less than that of the old method that deviated 33% from the actual value as inferred from Table 1.

Testing for the accuracy, out of the old and newly developed slope error determination method, the one with a smaller slope error percentage is considered very accurate. This is shown in Table 2. In most cases the error difference obtained from the newly developed method and the pre-existing one is less than 1 %(Table 2). However, the new method appears to have smaller percentage error compared with the old method. Thus values obtained from it are more reliable and accurate.

Conclusion

The uniqueness of the new method developed revealed in the fact that error contribution by every datum obtained is considered in the final slope error calculation. On the final note, with the high reliable and accuracy level shown the new method in the result of this work there is no iota of fear in recommending the method for slope error calculation for any form of a straight line graph where high level of accuracy is required.

References

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