AN INTRODUCTION TO GRAPHICAL ALGEBRA: FOR THE USE OF HIGH SCHOOLS

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BY

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PREFACE.

THE author has been asked to present a paper for the consideration of the Trans-Mississippi Educational Convention, to be held at Omaha on June 28, 29, and 30, 1898. The subject assigned was the greater efficiency of science instruction.

It did not seem desirable to merely suggest in a general way what appears to the author the most desirable change in high-school instruction in order to increase the efficiency of college work. The aim has been rather to show how such changes may be accomplished without radical departures from present methods.

By injecting here and there into the ordinary instruction in algebra such material as is found in the following text, new meaning will be given to the operations involved in the solution of equations, and new interest in the subject may be aroused. The study of geometry by Euclid's method requires a large amount of time which for the average student might be more usefully employed. The study of algebra and geometry as wholly distinct subjects having no relation to each other, gives to the pupil a false idea of the intellectual situation of to-day. The scientific investigator has, since Newton's time, very largely abandoned Euclid's methods as applied to scientific investigation. It does not therefore follow that Euclid's geometry should be banished from our schools, but it does seem proper to consider whether some of the time given to it might not be more usefully spent in elementary analytical geometry or graphical algebra.

The devotees of geometry and mathematics often seem impatient that these subjects should be studied except for themselves alone, and for the intellectual enjoyment and mental development which they afford. But while this may be a very proper mental attitude for such men, it does not follow that we should all adopt this view of the matter. The laws of the physical universe are equally worthy of human consideration. And these laws are most impressively presented to the mind in the symbolic language of algebra or the graphical language of geometry.

We may forgive a civil engineer if he confines his admiration to the beauties of a properly designed truss; nevertheless we may find new beauties in a graceful building of which the truss forms a useful and necessary part.

The cross-ruled paper needed for the student's use in graphical solutions may be obtained from any dealer in draughtsmen's supplies.

F. E. N.

ST. LOUIS, MO., June, 1898.

AN INTRODUCTION

TO

GRAPHICAL ALGEBRA.

WHEN two physical quantities are so related to each other that a definite change impressed upon one is always accompanied by a corresponding definite change in the other, such relation is called a physical law.

The statement that the weight of a cylindrical rod of iron is proportional to its length is a simple example of a physical law.

Every such law may also be stated in an algebraic equation.

It may also be completely expressed in the graphical language of geometry.

The examples that follow are designed to show the physical and geometrical significance which may be attached to the ordinary equations usually discussed in the algebra of the preparatory schools.

1. *The weight of a wire or rod is directly proportional to its length.*

Let a represent the weight per foot of the wire or rod. Then the weight m of l feet will be

$$m = al. \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This equation asserts that m and al are equal. If the wire is of uniform size, then it must follow that if one piece of it is twice as long as another it must have twice the weight, or that m increases in a direct ratio with l. However the values of l may differ in different pieces of the same kind of wire, the weights also so differ that $m \div l$ is always the same and is equal to a. The equation may be written

$$\frac{m}{l} = \frac{a}{1},$$

or

$$m : l = a : 1.$$

The direct ratio represented in (1) between m and l is the most common of all physical laws.

The value of merchandise is directly proportional to the amount. The compensation due to a workman is proportional to the time-interval of his service. The distance traversed by a body moving at uniform speed is proportional to the time. Within proper limits, the yielding of a bridge is proportional to its load, etc.

2. If squares of metal be cut from a uniform sheet, *the weight is proportional to the square of the length of the side.*

Let b represent the weight per square foot of the metal sheet, and let $l =$ the length of one side of any square. Then the weight m of any square is

$$m = bl^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This equation teaches that if l^2 be doubled (that is to say, if the area of the plate be doubled), the weight will be doubled. If, however, l be doubled, the weight will become four times as great.

Let us assume by way of example that $a = 8$ and $b = 2$. The wire is in that case to be a rod weighing 8 lbs. per foot, and the metal sheet is to weigh 2 lbs. per square foot. Equations (1) and (2) then become

$$m = 8l, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)'$$

$$m = 2l^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)'$$

We may now compute the weights m of rods of various lengths l, and of squares of such metal having various lengths l. They are given in Table 1.

Let us now assume that l has the same numerical value in the two equations. Physically this would mean that we are to associate with any rod l feet in

TABLE I.

l.	m = Weight of	
	Rods.	Squares.
0	0	0
1	8	2
2	16	8
3	24	18
4	32	32
5	40	50
6	48	72
7	56	98
8	64	128
9	72	162
10	80	200

length a square having a side of l feet. Then in general m would not be the same in the two equations. If, for example, $l = 10$, the weight of the rod would be 80 lbs., while the weight of the square would be 200 lbs., as the table shows. A similar assumption of equality in the values m would enable us to eliminate m, but we must distinguish between the two values l thus:

$$2l'^2 = 8l.$$

If, however, we also simultaneously assume that the l of one equation is the same as the l of the other, we may write the last equation

$$2l(l - 4) = 0.$$

Here is an equation in which the product of two factors is zero. This will be possible if either factor