A First Course In Mathematics For Technical Students

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IN

MATHEMATICS

FOR TECHNICAL STUDENTS

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PREFACE.

THIS little book is intended to meet the growing demand for a simple and practical course on the rudiments of mathematics suitable for students who are preparing for a course of technical study. It is modelled on a scheme covering all the usual requirements of a First Year's Course in Preliminary Technical Classes.

The authors have endeavoured to insure that the atmosphere of the workshop should pervade the whole book. Wherever possible the problems deal with concrete quantities which refer to actual working conditions. The necessary reference which the student must make to the drawings accompanying many of the problems should form a good introduction to the art of "reading" machine drawings, plans, etc.

Graphical methods have been introduced into almost every chapter, as the necessity for the correlation of technical drawing and mathematics cannot be too strongly insisted upon.

When studying the common solids it is important that the student should *make* paper models of them. Full instructions are given in the text.

Special emphasis has been laid on the importance of approximate calculations. From the practical point of view it must be remembered that although accuracy is essential in all cases it differs in degree. The rough estimate may, in the end, be quite as near the truth as the calculation made at leisure, for in most cases the data are only approximate to begin with.

The student should be encouraged to apply a rough check to every example he works. This rough mental estimate of a result is not only a useful check in itself, but it is invaluable as forming a habit essential to successful workshop practice.

The scheme of work will be found to cover all the requirements of the first year examination in Mathematics in the Preliminary Technical Course of the Lancashire and Cheshire Union of Institutes, the Education Committee of the County Council of the West Riding of Yorkshire, the National Union of Teachers, and other similar examining bodies.

As the authors are lecturers in the employment of the London County Council it is necessary for them in accordance with recent regulations to state explicitly that the London County Council are in no way responsible for the contents of this book and have taken no part in its publication.

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CHAPTER I.

MEASUREMENT : DECIMAL FRACTIONS.

Measurement.—If we were asked to determine the length of the line shown in Fig. 1, we should apply some kind of graduated scale to it. In this country we are accustomed to the length called an "inch," and if an inch scale were applied to this line it would reveal the fact that the length lay between two inches

Fig. 1.

and three inches (a length measured in inches, say three inches, is frequently written thus: $3''$). If the inches were subdivided into quarters we could say that the required length lay between $2\frac{1}{2}''$ and $2\frac{3}{4}''$.

Now it is readily seen that whatever be the subdivisions of the inch, it is very unlikely that they will exactly fit the line in question, and even if they did it would be unreasonable to suppose that they would meet every case which was likely to arise.

By far the most convenient way out of this difficulty is to have the inch divided into ten equal parts called "tenths." The application of such a scale to the line would show that its length was $2'' + \frac{6}{10}'' +$ a small piece, less than $\frac{1}{10}''$. Now suppose we had a tenth of an inch subdivided into tenths, each of these would be equal to one hundredth of an inch. By this means the length of the small piece which was "left over" from our former measurement could now be determined. Suppose its length were $\frac{7}{100}''$ this would bring the total length of the line to

$$2'' + \frac{6}{10}'' + \frac{7}{100}''.$$

This is about as far as we can go with the unaided eye, but if by some mechanical means (*e.g.* a microscope or a micrometer) a hundredth of an inch could be subdivided into tenths (the latter being thousandths of an inch), it is more than likely that we should find that the length of the small piece just measured was not *exactly* $\frac{7}{100}''$ at all, but there was still another small piece left over (or perhaps under), this time less than $\frac{1}{100}''$. Let us suppose that there was a length of $\frac{3}{1000}''$ in excess of the last measurement. The measured length of the line now becomes

$$2'' + \frac{6}{10}'' + \frac{7}{100}'' + \frac{3}{1000}''.$$

Decimals.—Now this is a very convenient means of measurement, but we must have a simpler method of setting down a result. The length given above might be written 2·673″, which should be read "two, decimal six seven three." The dot between the two and the six simply indicates that the figure or figures on the left constitute a "whole number," while those on the right successively indicate the number of tenths, hundredths, thousandths, etc., of the unit.

Think of a number such as 444·4444. Here we have seven fours, but we know quite well that they have not all the same value, for the first has a value of 400 and the second of 40 only. Each four has only one tenth the value of its neighbour on the left hand. This rule holds good both before and after the decimal point is passed. The values might be written down thus:—

$$\begin{array}{cccccccc} 4 & 4 & 4 & \cdot & 4 & 4 & 4 & 4 \\ \| & \| & \| & & \| & \| & \| & \| \\ 400 & 40 & 4 & & \frac{4}{10} & \frac{4}{100} & \frac{4}{1000} & \frac{4}{10000} \end{array}$$

We thus see that the decimal point is no more than a dividing line between the digits whose values are not less than unity and those whose values are less than one.

The student should now make an inch scale in which at least one of the inches is divided into ten equal parts. The method of doing this is now described.

Ex. 1. *Construct a scale of inches and tenths*

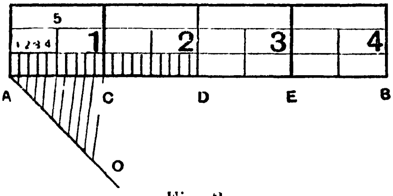

Fig. 2.

Draw a line *AB* 4″ long and then rule three parallel lines $\frac{1}{4}''$, $\frac{1}{2}''$ and $\frac{3}{4}''$ respectively from *AB*. (See Fig. 2, which is drawn to half the proper size.) Mark off with the aid of the rule the positions of the vertical lines at *C*, *D*, and *E*, each one inch apart. Draw through the point *A* a line *AO* of any length making an angle of about 45° with *AB*, take your compasses and step along this line any ten equal divisions. Join *O* and *C* and draw 9 lines parallel to *OC* through the divisions just made, then draw vertical lines where these sloping lines cut *AC*, as shown.

An inch is the unit by which small distances are measured in this country, but in many other parts of Europe the unit used is called a centimetre. By the aid of the centimetre scale on his ruler the student should now make a scale for himself one centimetre of which is divided into tenths by the same method as that just adopted in making the inch scale.

The centimetre is one unit in a system known as the **Metric System.** The standard unit of length in this system is known as a **Metre** (it is rather over a yard in length). Multiples and submultiples of this are taken and named as follows:—

kilo-metre = 1000 metres
hecto-metre = 100 metres
deca-metre = 10 metres.

METRE.

deci-metre = $\frac{1}{10}$ metre
centi-metre = $\frac{1}{100}$ metre
milli-metre = $\frac{1}{1000}$ metre.

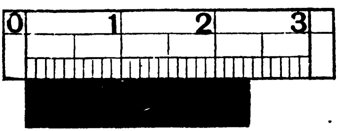

Fig. 3.

It will be noticed that the names differ only in the prefix, those printed in heavy type being most frequently employed.

Fig. 3 (which is drawn to half size) shows a scale of inches applied to a length to be measured. We see at once that the length lies between 2·3″ and 2·4″ and this is sometimes written 2·3 +. It is very important that the student should persevere in *mentally* dividing up the last tenth into ten equal parts and so "estimating" the value of the second figure after the decimal in the above measurement. On examining the case shown in Fig. 3 it is seen that the length passes over more than half of the last division and hence the required figure is greater than 5. Now if its distance appears to be nearly $\frac{3}{4}$ of the whole distance we might estimate it to be 7, but in this case it seems to fall short of this so we put down a 6, and hence the whole length is estimated to be 2·36″.

With a little practice this second figure after the decimal is obtained with great accuracy in measurements and the student should make serious efforts to get into the habit of estimating it.

Exercises 1a.

For the following exercises the student requires a rule divided on one edge into millimetres and centimetres and on the other edge into inches and tenths of an inch. The other side of the rule should be divided into inches, $\frac{1}{8}$ and $\frac{1}{16}$.

1. Draw the following lines; each line must be set out separately, the lengths being:—0·5″, 1·5″, 1·55″, 0·15″, 1·15″, 3·15″ 0·75″, 0·25″, and 0·712″.

2. Rule a line 5″ long and upon this line mark off consecutively the following distances starting from the left hand end. 0·5″, 1·25″, 0·4″, 0·35″, 0·2″, 1·51″, and 0·5″. Measure the total distance with the rule, estimating the final length to $\frac{1}{100}$″.

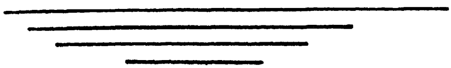

Fig. 4.

3. Estimate the length of the lines given in Fig. 4 to the nearest $\frac{1}{100}$ centimetre.

4. Rule a line 6 inches long and set out from the left hand end lengths of:—2·15″, 0·85″, 1·43″, 0·35″, 0·23″ following each other. Measure the total length and the remainder from the six inches and write the answers down to the nearest $\frac{1}{100}$″.