GEOMETRIC EXERCISES IN PAPER FOLDING

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Geometric Exercises in Paper Folding by T. Sundara Row

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Trieste

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IN

PAPER FOLDING.

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INTRODUCTION.

THE *idea* of this book was suggested to me by Kindergarten Gift No. VIII.—Paper-folding. The gift consists of 200 variously coloured squares of paper, a folder, and diagrams and instructions for folding. The paper is coloured and glazed on one side. The paper may, however, be of self-colour, alike on both sides. In fact, any paper of moderate thickness will answer the purpose, but coloured paper shows the creases better, and is more attractive. The kindergarten gift is sold by Messrs. Higginbotham and Co.; but coloured paper of both sorts can be had in the bazaars. A packet of 100 squares of both sorts accompanies this book, and the packets can also be had separately. Any sheet of paper can be cut into a square as explained in the opening articles of this book, but it is neat and convenient to have the squares ready cut.

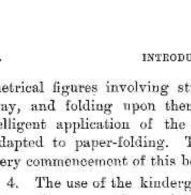
2. These exercises do not require mathematical instruments, the only things necessary being a penknife and scraps of paper, the latter being used for setting off equal lengths. The squares are themselves simple substitutes for a straight edge and a T square.

3. In paper-folding several important geometrical processes can be effected much more easily than with a pair of compasses and ruler, the only instruments the use of which is sanctioned in Euclidian Geometry; for example, to divide straight lines and angles into two or more equal parts, to draw perpendiculars and parallels to straight lines. It is, however, not possible in paper-folding to describe a circle, but a number of points on a circle, as well as other curves, may be obtained by other methods. These exercises do not consist merely of drawing geo

metrical figures involving straight lines in the ordinary way, and folding upon them, but they require an intelligent application of the simple processes peculiarly adapted to paper-folding. This will be apparent at the very commencement of this book.

4. The use of the kindergarten gifts not only affords interesting occupations to boys and girls, but also prepares their minds for the appreciation of science and art. Conversely the teaching of science and art later on can be made interesting and based upon proper foundations by reference to kindergarten occupations. This is particularly the case with Geometry, which forms the basis of every science and art. The teaching of Euclid in schools can be made very interesting by the free use of the kindergarten gifts. It would be perfectly legitimate to require pupils to fold the diagrams on paper. This would give them neat and accurate figures, and impress the truth of the propositions forcibly on their minds. It would not be necessary to take any statement on trust. But what is now realised by the imagination and idealization of clumsy figures can be seen in the concrete. A fallacy like the following would be impossible.

5. *To prove that every triangle is isosceles.* Let ABC be any triangle. Bisect BC in D, and through D draw DO perpendicular to BC. Bisect the angle BAC by AO.



(1) If AO and DO do not meet, they are parallel. Therefore AO is at right angles to BC. Therefore AB = AC.

(2) If AO and DO do meet, let them meet in O. Draw OE perpendicular to AC and OF perpendicular to AB. Join OB, OC. By Euclid I. 26 the triangles AOF and AOE are equal; also by Euclid I. 47 and I. 8 the triangles BOF and COE are equal. Therefore

$$AF + FB = AE + EC,$$

$$i.e.\ AB = AC.$$

It will be seen by paper-folding that, whatever triangle be taken, AO and DO cannot meet within the triangle.

O is the midpoint of the arc BOC of the circle which circumscribes the triangle ABC.

6. Paper-folding is not quite foreign to us. Folding paper squares into natural objects—a boat, double boat, ink bottle, cup-plate, &c., is well known, as also the cutting of paper in symmetrical forms for purposes of decoration. In writing Sanskrit and Mahrati, the paper is folded vertically or horizontally to keep the lines and columns straight. In fair copying letters in public offices an even margin is secured by folding the paper vertically. Rectangular pieces of paper folded double have generally been used for writing, and before the introduction of machine cut letter paper and envelopes of various sizes, sheets of convenient size were cut by folding and pulling asunder larger sheets, and the second half of the paper was folded into an envelope enclosing the first half. This latter process saved paper and had the obvious advantage of securing the post marks on the paper written upon. Paper-folding has been resorted to in teaching the XIth Book of Euclid, which deals with figures of three dimensions. But it has seldom been used in respect of plane figures. Mr. B. Hanumanta Row, B.A., has done it. In his First Lessons in Geometry, he has made frequent

allusions to it, but the hint has not been generally taken by teachers.

7. I have attempted not to write a complete treatise or text-book on Geometry, but to show how regular polygons, circles and other curves can be folded or pricked on paper. I have taken the opportunity to introduce to the reader some well known problems of ancient and modern Geometry, and to show how Algebra and Trigonometry may be advantageously applied to Geometry, so as to elucidate each of the subjects which are usually kept in separate pigeonholes.

8. The first nine chapters deal with the folding of the regular polygons treated in the first four books of Euclid, and of the nonagon. The paper square of the kindergarten has been taken as the foundation, and the other regular polygons have been worked out thereon. Chapter I. shows how the fundamental square is to be cut and how it can be folded into equal right-angled isosceles triangles and squares. Chapter II. deals with the equilateral triangle described on one of the sides of the square. Chapter III. is devoted to the Pythagorean theorem (Euclid I. 47) and the propositions of the second book of Euclid and certain puzzles connected therewith. It is also shown how a right-angled triangle with a given altitude can be described on a given base. This is tantamount to finding points on a circle with a given diameter.

9. Chapter X. deals with the Arithmetical, Geometrical, and Harmonic progressions and the summation of certain arithmetical series. In treating of the progressions, lines whose *lengths* form a progressive series are obtained. A rectangular piece of paper chequered into squares exemplifies A.P. For the G.P. the properties of the right-