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Dr. P.M. Mini,
Assistant Professor and Head,
Department of Mathematics,
M.A.M.O.College Mukkom,
Kerala

Correspondence:
Dr. P.M. Mini,
Assistant Professor and Head,
Department of Mathematics,
M.A.M.O.College Mukkom,
Kerala

Quadrilateral Geometry and the Significance of Trapezium in Jaina Mathematics- An Introduction

Dr. P.M. Mini

Abstract: This paper discusses the geometrical treatment of quadrilaterals in classical Jaina mathematics, specifically focusing on the works of Mahāvīra (*Gaṇitasārasaṃgraha*) and Śrīdhara (*Pāṭīgaṇita*). It examines the classification of four-sided figures, the evolution of area formulas from approximate rules to specific applications for cyclic quadrilaterals, and the significant analysis of the trapezium. Special attention is given to the Jaina "place of honour" for the isosceles trapezium, its appearance in cosmological structures (like the mountain frustum in *Jyotiṣkaraṇḍaka*), and advanced methods for calculating segmental widths and "deficient" areas formed by diagonal intersections.

Introduction: In ancient Jaina mathematics, the study of four-sided shapes (quadrilaterals) was vital for cosmology associated with science and religious. Famous scholars like Mahāvīra and Śrīdhara developed detailed systems to classify these shapes into five categories based on their symmetry. A major focus of their work was the trapezium, a shape that held a "place of honour" in Jaina faith because it was used to describe the dimensions of the universe and sacred mountains.

In GSS vv 7.54-59[I] Mahāvīra talks about five varieties of quadrilaterals namely samacaturaśra (equilateral quadrilateral), āyata caturaśra (longish quadrilateral), dvisamacaturaśra (equibilateral quadrilateral), trisamacaturaśra (equitrilateral quadrilateral) and viṣamacaturaśra (inequilateral quadrilateral). These names are mentioned by Mahāvīra as a part of discussion of certain mathematical concepts connected with geometry.

Mahāvīra in GSS 7.50 gives the formula for area of a quadrilateral figure.[2] This sloka means that four quantities represented by half the sum of the sides are diminished by the sides are multiplied by together and the square root gives the minutely accurate area. In mathematical terms it is

$\sqrt{(s-a)(s-b)(s-c)(s-d)}$ where a, b, c, d are the sides and. $s=\dfrac{a+b+c+d}{2}$

In Pāṭigaṇita v. 117[3] Śrī̄dhara also gives the same rule.

Śrī̄dhara made an error in declaring the above formula as applicable to all quadrilaterals and Mahāvīra in G.S.S. 7.50 notes that this expression is not applicable to viṣamacaturaśra. But it is applicable only to cyclic quadrilaterals. .

Pāṭigaṇita v. 115[4] gives the formula for area of quadrilateral figures with same altitude everywhere as. $\frac{\text{base+face}}{2}$ x altitude

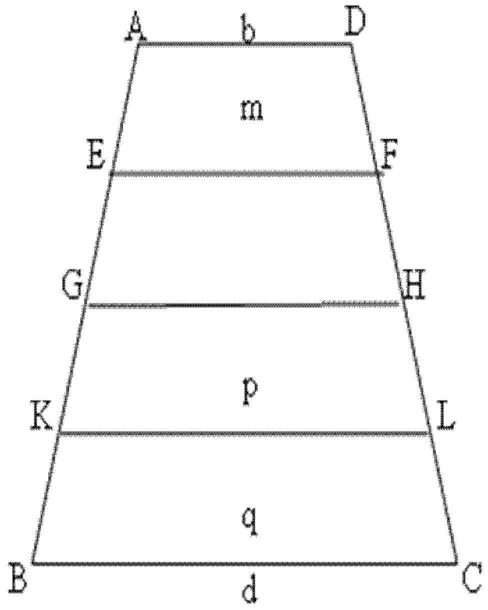
The Trapezium

The earliest jaina work to deal with the trapezium is Jyotiṣkaraṇḍaka. On describing the height of a mountain shaped like the frustrum of a cone we get the reference of trapezium indirectly since the vertical section of such a shape is a trapezium.

खण्डयुतिभक्तलमुखकृत्यन्तरगुणितखण्डमुखवर्गयुतम्।

मूलमधस्तलमुखयुतदलहृतलब्धं च लम्बकः क्रमशः॥[5]

Let a quadrilateral figure with two equal sides and given area be divided into any number of parts in some proportion in respect of area. Then from the above verse we get the bases of those parts



If EF, GH and KL divide the trapezium ABCD so that the divided portions are in the proportion of m, n, p and q in respect of area, then by the rule

The first four Mahādhikāras of Tiloyapannatti have a number of mathematical formulae connected with trapezium. In Tiloyapannatti v.165[6] the area of a trapezium is given as $\frac{\text{top + base}}{2} \times \text{height}$.

Also the increase in top side of trapezium at any depth

$$= \frac{\text{base - top}}{\text{depth of the base from the top}}$$

and the decrease in the base of a trapezium at a height above the base is

$$= \frac{\text{base - top}}{\text{height of the top above the base}}$$

Similarly the width of a trapezium at a height d_1 above the base is given as

Width = $a - \frac{a-b}{d} \times d_1$, where a = base, b = top, d = the height of the trapezium.

Areas of uni-deficient and di-deficient area

A quadrilateral is cut through its diagonals to form 4 triangles. The figure obtained by deleting 2 opposite triangles is called 'Ubhayanishedh' or di-deficient area. If only one triangle is deleted we get a figure namely 'Ekanishedh' or uni-deficient area[7]. If a and b are the length and breadth of the quadrilateral. Then the area of uni-deficient area = $ab - \frac{ab}{4}$ and

the area of di-deficient area = $ab - \frac{ab}{2}$.

Conclusion: The mathematical extracts from the GSS, *Pāṭīgaṇita*, and *Tiloyapaṇṇatti* reveal that Jaina mathematicians did not merely inherit geometric rules but actively refined them through rigorous classification and error correction. Their focus on the trapezium—and its internal divisions into uni-deficient and di-deficient areas—highlights a unique application of geometry to describe complex volumes and sections.

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