Bangalore Mathematics Teachers' Circle (BMTC) - 1

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Introduction to Flexagons

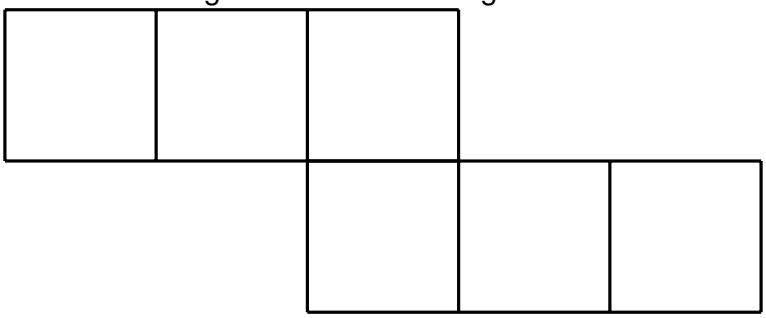
Hexaflexagons are very popular in recreational mathematics and were invented by four brilliant minds: Arthur Stone, Bryant Tuckerman, Richard Feynman and John Tukey. This was popularized by Martin Gardner in 1956. Its poor cousin Tetraflexagon is not as well known. However, recently Numberphile made a lovely video on the topic of Tetraflexagons[5] and many other people have been playing with it and writing about it in popular media. There is also a very good MAA article titled, "It is OK to be a square if you are a flexagon" published in 2004[1].

These explorations will help build spatial thinking and problem posing and problem solving.

1 Building and Exploring Tetraflexagons

Figure 1 shows a net of a (tri)tetraflexagon. Using this net, create a tetraflexagon. This is a simple flexagon that helps one understand the concept of a flexagon, and get familiar with the terms and actions related to it (faces, flexing, etc). This NRICH article is a useful aid to create a tetraflexagon: Making Maths: Tetra-flexagon | NRICH[4].

Figure 1: Tri-Tetraflexagon Net

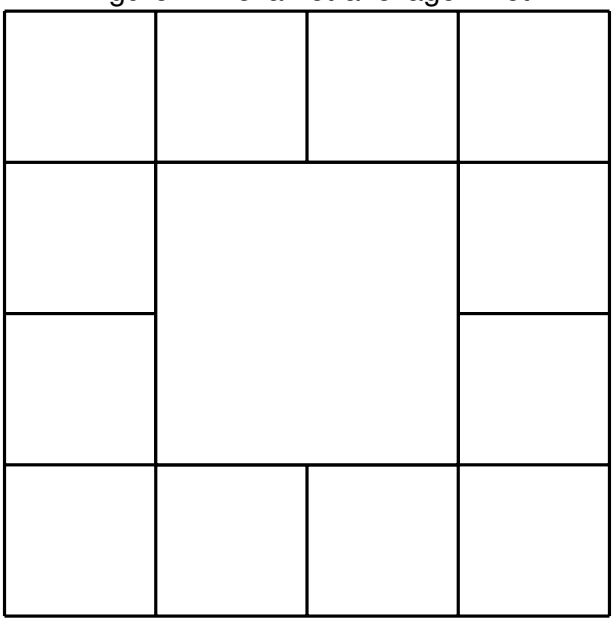


Create a tri-tetraflexagon and make a note of its initial state with two faces. Flex and reveal another face. What are the possible states? Why?

The net in Figure 2 is that of a hexa-tetraflexagon. This Numberphile video that you can use to help create the tetraflexagon[5].



Figure 2: Hexa-Tetraflexagon Net



1.1 Folding a Net

Task 1 Fold the ring net with 12 squares into a tetraflexagon square. Some of the squares are recessed (tucked) so that they do not fall apart.

Task 2 Open the folded flexagon to obtain the net. Number the squares from 1 to 24. Explore the kind of motions that can help us see all the squares.

1.2 Labelling the Net

Task 3 Start with an unlabelled ring net, mark the squares with 6 labels say A, B, C, D, E, F such that the tetraflexagon has the following property: in any state, each of the two faces must have all four leaves with the same label.

1.3 Relationship between States

Task 4 Find the shortest sequence of flexes that returns the tetraflexagon to its starting face.

2 Discussion in Small Groups

Going deeper into nets: Small group discussion. Choose any of the following questions and discuss it in your group.

2.1 Question

What is the best way to fold a strip of 10 squares from a given rectangular sheet of paper? Can you divide a length into five equal parts without using a ruler?

In the warm up activity we used a net that required a rectangular grid 2 (Figure 1). The question here is: can we make this without using measurements or approximation?



Hint: Finding one-third of a side - Diagonal and Corner-to-Midpoint

1. Create a diagonal crease from the top-right to the bottom-left.
2. Fold a line connecting the top left corner to the midpoint of the bottom edge.
3. The intersection of these two lines marks the $1/3$ point on the diagonal.

Can you explain why? Can you similarly find one-fifth, one-seventh, etc?

2.2 Question

A polyomino is a flat shape made of identical squares connected edge-to-edge, forming a connected figure, with the name indicating the number of squares.

A Hexomino is a connected shape with 6 squares. What are the possible hexominoes? This webpage has illustrations of various possible hexominoes[7].

Task 1 Which of these hexominoes fold into an *almost tetraflexagon*. An *almost tetraflexagon* is square constructed from a net that does not flex motion. Each of the small squares can be labelled to get a state. A state has two faces, that is all the four labels of the face are the same. The front and reverse face will have different labels.

(a) Experiment with different hexominoes. Some of them will not fold into a two by two square. For example the strip of 1 will not fold into a two by two square.

(b) For those that fold into a two by two square can you do a labelling to get faces? For example, see the hexomino cut out from a two by five strip. It has only two labels A, B. We get only one state.

(c) What are the similarities and differences in the nets that fold into an almost tetraflexagon?

Task 2 Rectangular grids to make Hexominoes. Starting with grids of dimension $2 \times 4, 3 \times 3, 3 \times 4, 2 \times 5$, we can make hexominoes (see the section on Rectangles around hexominoes here[3]). Which of these can be made into a cube? Are there nets common to cubes and tetraflexagons?

2.3 Question

What is Hexaflexagon? It is a flexible polygon with six sides. The most natural way to think about one is to find a net with equilateral triangles which folds into a Hexaflexagon. What is the number of equilateral triangles needed and how will the net look?

Task 1 Look up simple nets for hexaflexagons, with equilateral triangles. This is an interesting reference for hexaflexagons: Hexaflexagons and Other Mathematical Diversions[2]. Use these nets to create Hexaflexagons. Play around with the flexagons and understand the flexes. Figure out how to label the triangles to get states. (A state has two faces with different labels). Find the structure diagram for Flexagon created[5].

Task 2 The Cambridge Mathematics blog[6] provides a printable hexaflexagon net. Create a hexaflexagon with this net.

3 Group Presentations and Discussion

Various groups present their learning from the small group discussions.



References

[1] Ethan J. Berkove and Jeffrey P. Dumont. It's okay to be square if you're a flexagon. *Mathematics Magazine*, 77(5):335–348, 2004. URL: http://www.jstor.org/stable/3219198.

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[4] Centre for Mathematical Sciences NRICH. Making maths: Tetra-flexagon. https://nrich.maths.org. Accessed: 2026-01-19. URL: https://nrich.maths.org/making-maths-tetra-flexagon.

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[7] Eric W. Weisstein. Hexomino. From MathWorld–A Wolfram Resource. URL: https://mathworld.wolfram.com/Hexomino.html.

