2 Strips and Tunnels

Themes	Basic polygons and their properties, quadrilaterals, collinearity, parallel, sides, 3-Dimensional objects, coplanarity.
Vocabulary	Rhombus, trapezoid (US English, used here) OR trapezium (UK English), collinear, coplanar, parallel.
Synopsis	Triangles are assembled into strips. Two strips are attached to make a double width strip. This is then folded to make a tunnel roof. Investigate how the tunnel can turn a corner.

Overall structure	**Previous**	**Extension**
1 Use, Safety and the Rhombus		
2 Strips and Tunnels		
3 Pyramids extends the transition from two to three dimensions		**X**
4 Regular Polyhedra		
5 Symmetry		
6 Colour Patterns		
7 Space Fillers		
8 Double edge length tetrahedron		
9 Stella Octangula		
10 Stellated Polyhedra and Duality		
11 Faces and Edges		
12 Angle Deficit		
13 Torus		**X**

Layout

The activity description is in this font, with possible speech or actions as follows:

Suggested instructor speech is shown here with

possible student responses shown here.
'Alternative responses are shown in quotation marks'.

1 From Rhombus to Trapezoid

As part of the introductory activity, show the students how to tie triangles. Break them into groups of four or five with three triangles per group. Have them tie two triangles to make a rhombus such as the pink ones below (figure 1) and then add a third triangle.

Figure 1 Pink rhombus in a trapezoid

First in their groups as they finish, then as a class discussion around one shape:

Ask what shape did you make? What are its properties? Can you describe the shape?

'it looks like a tub' or 'boat', or 'funny rhombus', 'trapezoid'

Questions on specific properties are in 1.1 and 1.2.

1.1 Collinear Sides Combine

Ask first how many sides does the shape have?

4 or 5

Then how many triangle sides are there on the outside?

5

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Indicate by touching the two triangles' sides that make up the long side of the trapezoid and ask:

> What can we say about these two sides of these triangles?
>
> *'the same length', or 'they line up'.*

Ensure they know, or teach them the term, 'collinear' which means they lie entirely along the same line. Tell them:

> The two triangle sides now make one long side of the whole shape, because they meet, they are collinear and the inside of the shape is all on the same side.
>
> So how many sides does the shape have?
>
> *4*

1.2 Properties of the isosceles trapezoid

Ask:

> What are the shape's properties?

Have them touch or run their hands over the things they mention, like sides or lines of symmetry, so everyone understands what is said.

'straight sides', '4 sides',
'has 3 triangles',' boat shape', 'symmetry',
'has a diamond inside'.

> What kind of symmetry is there?
>
> *Reflection*
>
> Show us the line of reflection with your arm.
>
> Yes, both sides are mirror images of each other.

To check for misconceptions, and to see everyone is paying attention ask:

> Are there any other lines of reflection?

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Yes

Deal with this incorrect answer as follows:

Show us the line of reflection with your arm

Is the part of the whole shape on this side of the line the mirror image of the part of the whole shape on this side of the line? (indicate the two parts by tracing around with your hand)

No

So that is not a line of reflection for the whole shape.

Is there a rotational symmetry?

No

If, for example, they mention it containing

'a rhombus' or 'diamond shapes'

someone trace all four sides of a rhombus with their hand, to ensure everyone can see. You could also see if they know that rhombus (plural rhombi) is the correct term and its definition is a quadrilateral with all sides congruent. Also you could see if they know the property that a rhombus has two pairs of parallel sides. Then ask:

Are there any more rhombi in the shape?

Yes, one more

What is the name of the whole shape?

'quadrilateral' 'trapezium ', 'trapezoid', 'tub', 'boat' or 'tent'

Direct the discussion towards the definition of trapezoid in your curriculum, such as a quadrilateral having at least one pair of parallel sides. Verify that the trapezoid has parallel sides, for example with more advanced students by using the properties of an inscribed rhombus. The additional properties of isosceles trapezoids are that non-parallel sides are congruent to each other and that a line of reflection bisects each side in a pair of parallel sides. Check how your curriculum defines different quadrilaterals.

2. Exploration

Let each group take an additional 8 to 10 triangles and ask:

> Can you find a way to tie the triangles together to make a tent or roof or tunnel that stands up?

Give them about 15 minutes

As they work, ask them:

> What have you been doing and what are you doing now?

They may well lay triangles on the floor in a hexagon and try to lift it up in the middle but find it does not form a tent. They may find they can make a tunnel roof part by folding the hexagon about a diameter.

If they do make a tunnel roof part this way, ask them

> Can you make it longer?

If they need help, suggest some students hold triangles upright in position while other students tie them.

3. Directed building of strips

Figure 2 A single strip, one triangle wide

Ask them in groups to make a long strip with two parallel sides, like the trapezoid but with more triangles, but still only one triangle wide (figure 2). You may need to clarify what 'parallel sides' means. Let each group try to make one.

Once the groups are running out of triangles, ask:

Can you think of a way to make a tunnel using strips?

Let them try their ideas. If there are no successful ideas, have all the strips put together to make two comparable length strips as in figure 3.

Figure 3 Aligning the two strips

As a class, have the students tie the two strips together along the long side, so it can be folded as in figure 4, but do not mention the fold yet. Once the strips are tied together ask the students to:

Point out different shapes they can see.

They may point out a 'diamond shape', parallelogram, hexagon, trapezoid.

As in 1.2 above, ensure they have the correct terminology, have them point around the outlines of the shapes they are referring to so everyone understands and ask:

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Are there more examples of hexagons/ rhombi/etc. that you can see here?

Note that there will also be side length 2 triangles that you could point out and ask students to find how many are there altogether.

4. The tunnel

Now fold the double width strip to make a roof as in figure 4.

Figure 4 A roof for the tunnel

If indoors it may be necessary to use something to stop triangles from sliding out flat, perhaps asking for ideas from students.

It is possible now to allow students to go inside and ask them to describe or draw what it looks like from the outside and also from the inside. Now ask them:

Try to find a way to make the tunnel turn a corner?

If necessary, without untying any sides, simply fold the end over to show them as in figure 5.

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Figure 5 The Tunnel turns a corner

When there has been enough description and discussion of how the tunnel turned a corner allow students to go through again. Try to avoid overcrowding or rushing.

In activity **13 The Torus** a flat roofed tunnel that goes round in a ring and that students can go through is created.

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