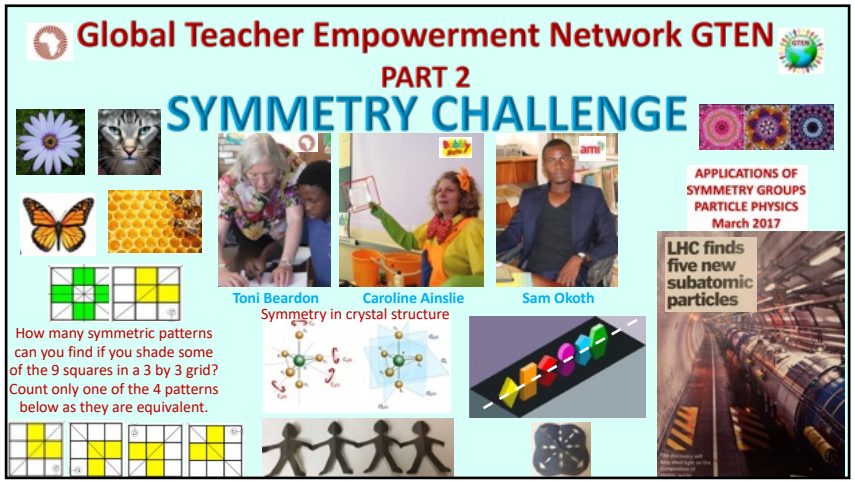
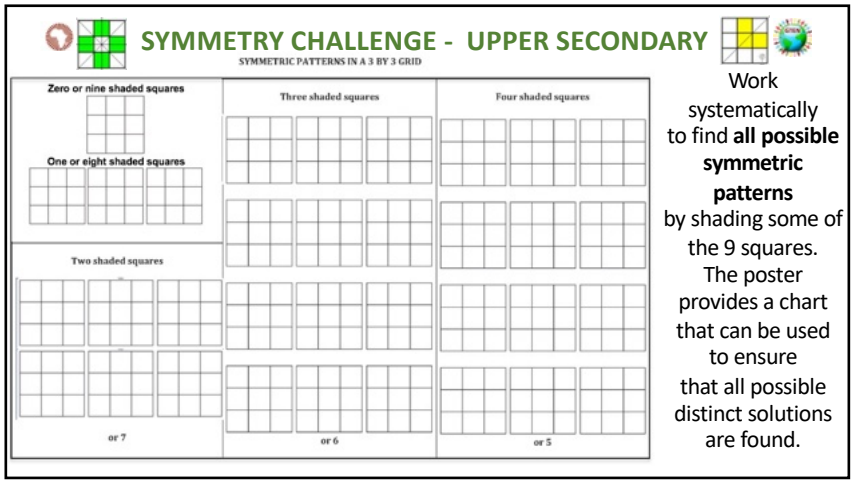
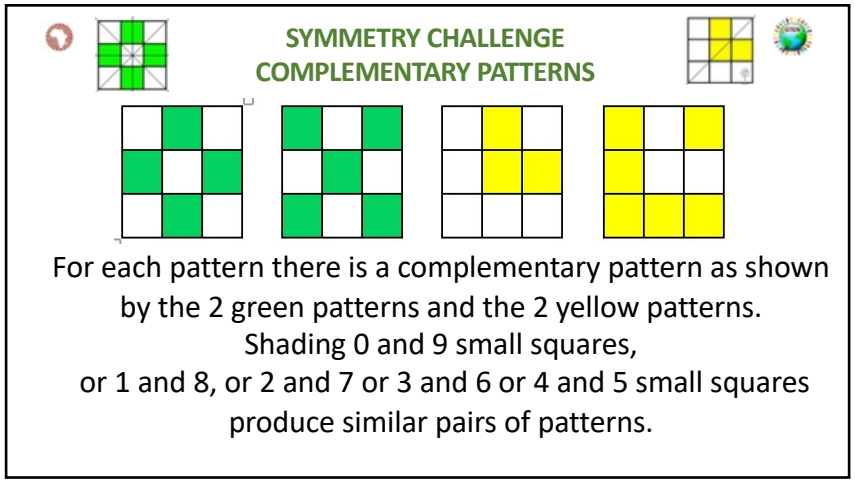

Global Teacher Empowerment Network GTEN
PART 2
SYMMETRY CHALLENGE
Toni Beardon
Caroline Ainslie
Sam Okoth
APPLICATIONS OF SYMMETRY GROUPS PARTICLE PHYSICS March 2017
LHC finds five new subatomic particles
Symmetry in crystal structure
How many symmetric patterns can you find if you shade some of the 9 squares in a 3 by 3 grid? Count only one of the 4 patterns below as they are equivalent.

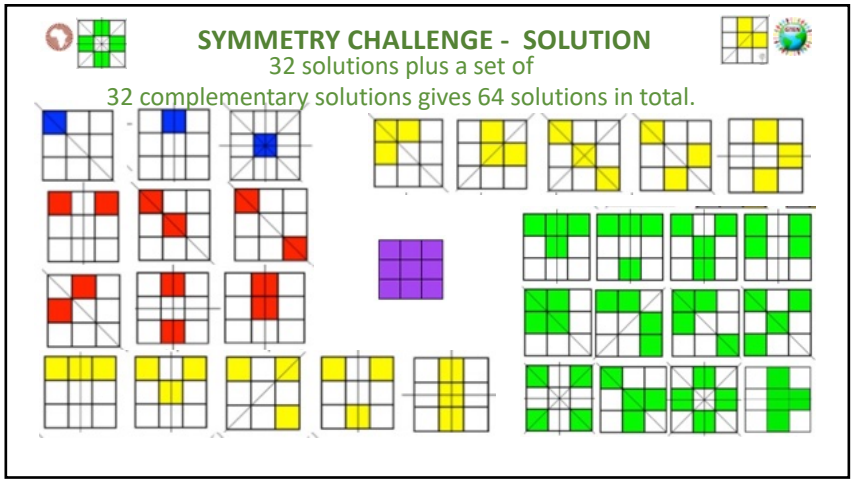
10


SYMMETRY CHALLENGE - UPPER SECONDARY
SYMMETRIC PATTERNS IN A 3 BY 3 GRID
Zero or nine shaded squares
One or eight shaded squares
Two shaded squares
or 7
Three shaded squares
or 6
Four shaded squares
or 5
Work systematically to find all possible symmetric patterns by shading some of the 9 squares. The poster provides a chart that can be used to ensure that all possible distinct solutions are found.

11


SYMMETRY CHALLENGE
COMPLEMENTARY PATTERNS
For each pattern there is a complementary pattern as shown by the 2 green patterns and the 2 yellow patterns.
Shading 0 and 9 small squares,
or 1 and 8, or 2 and 7 or 3 and 6 or 4 and 5 small squares
produce similar pairs of patterns.

12


SYMMETRY CHALLENGE - SOLUTION
32 solutions plus a set of
32 complementary solutions gives 64 solutions in total.

13

SYMMETRY CHALLENGE – WORKING SYSTEMATICALLY

Why is it an important skill in the workplace, and in life, to be able to make a good plan for working systematically to make sure that you take into account all possible cases.
Can you suggest some examples?

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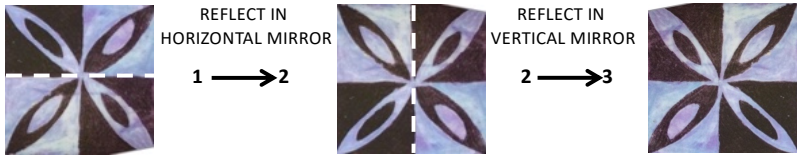
REFLECTIONS IN INTERSECTING MIRRORS

The diagrams show the design reflected in two intersecting mirrors
What do you notice?

REFLECTIONS IN 2 MIRRORS INTERSECTING AT 90^{o} GIVE A ROTATION OF 180^{o}



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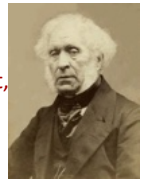
REFLECTIONS IN INTERSECTING MIRROR LINES

The kaleidoscope was invented and patented by Sir David Brewster (1781 – 1868) a British scientist, inventor, author and academic.
He did experimental work in optics, studied the polarisation of light, crystals under compression and photoelasticity leading to optical minerology.
He has been called the father of modern experimental optics.



The name **"kaleidoscope"** is derived from the Ancient Greek words
καλός (*kalos*) "beautiful, beauty"
εἶδος (*eidos*) "that which is seen: form, shape" and
σκοπέω (*skopeō*), "to look to, to examine", hence "observation of beautiful forms."
The patent that was granted on July 10, 1817.

16

TWO REFLECTIONS GIVE A ROTATION WITH ITS CENTRE AT THE INTERSECTION OF THE MIRROR LINES

Describe these symmetric patterns. What orders of symmetry do they have?
Give the angles between the mirror lines.

17

TWO REFLECTIONS GIVE A ROTATION WITH ITS CENTRE AT THE INTERSECTION OF THE MIRROR LINES

What do you notice about these pictures?

9-fold symmetry
angle 40°

6-fold symmetry
angle 60°

16-fold symmetry
angle 22.5°

18

REFLECTION IN PARALLEL MIRRORS

Describe and explain what you see in this picture.

19

REFLECTIONS IN PARALLEL MIRRORS

Hall of Mirrors Versailles *one reflection.*

Hall of Mirrors Versailles *many reflections.*

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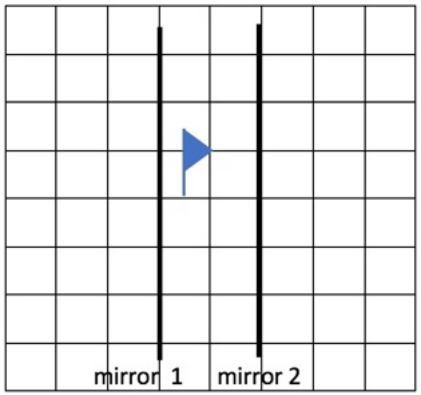
REFLECTIONS IN PARALLEL MIRRORS

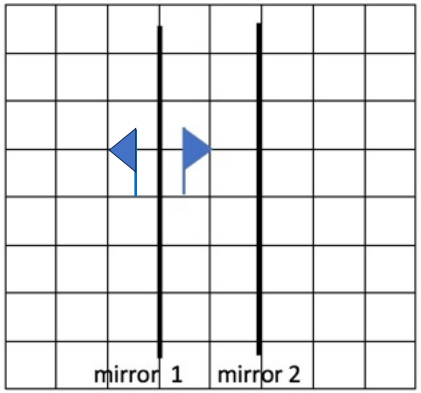


Copy the grid, the flag and the mirror lines.
Then draw a reflection of the flag in mirror 1
and a reflection of that reflection in mirror 2.

What do you notice about the combination of the 2 reflections?

21

REFLECTIONS IN PARALLEL MIRRORS

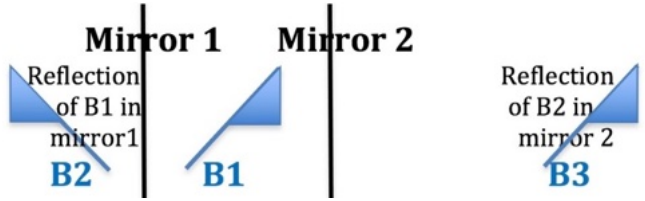


Copy the grid, the flag and the mirror lines. Then draw a reflection of the flag in mirror 1 and a reflection of that reflection in mirror 2.

What do you notice about the combination of the 2 reflections?

22

TWO REFLECTIONS IN PARALLEL MIRRORS GIVE A TRANSLATION OF TWICE THE DISTANCE BETWEEN THE MIROR LINES AND PERPENDICULAR TO THEM



Flag B2 is the REFLECTION of flag B1 in Mirror 1.

Flag B3 is the REFLECTION of flag B2 in Mirror 2.

Flag B3 is an image of flag B1 by TRANSLATION.

THE COMBINATION OF TWO REFLECTIONS IN PARALLEL MIRRORS IS A TRANSLATION.

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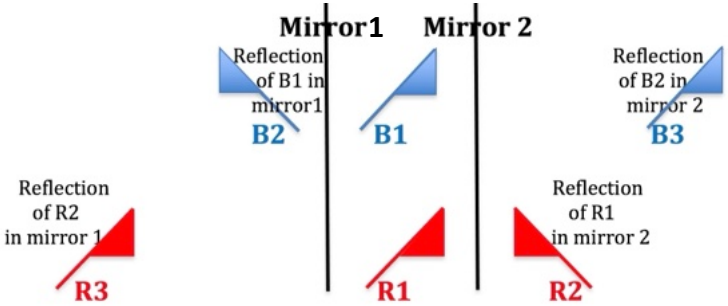
THE RED FLAGS SHOW REFLECTION IN MIRROR 2 FOLLOWED BY REFLECTION IN MIRROR 1



THE COMBINATION OF TWO REFLECTIONS IN PARALLEL MIRRORS IS A TRANSLATION.

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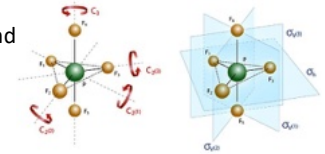
APPLICATIONS OF SYMMETRY GROUPS - CRYSTALLOGRAPHY

Mathematics provides the language needed to describe the symmetries of atoms, molecules and crystals. It explains exactly what symmetries enable a unit cell to pack neatly and repetitively to make a three-dimensional crystal.



See articles by Rachel Thomas in the Plus online magazine:
https://plus.maths.org/content/through-looking-glass

https://plus.maths.org/content/shattering-crystal-symmetries

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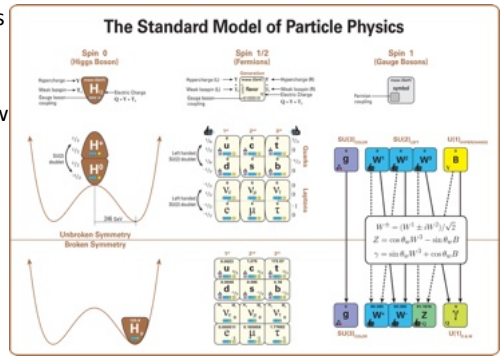
APPLICATIONS OF SYMMETRY GROUPS – PARTICLE PHYSICS

In 2013, Peter Higgs and Francois Englert were awarded the Nobel prize in Physics.

In 1964 they had predicted a new particle using the mathematics of symmetry groups and knowledge of physics.

The existence of the particle, called the Higgs Bosun, was verified in 2012 at CERN in Switzerland, the European Organisation for Nuclear Research.



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Global Teacher Empowerment Network (GTEN)

NEW SKILLS NEW HOPES NEW HORIZONS
for teachers and learners worldwide
SYMMETRY RESOURCES

Symmetry Challenge https://aiminghigh.aimssec.ac.za/symmetry-challenge/

Paper Dolls https://aiminghigh.aimssec.ac.za/paper-dolls/

Tangram Pattern https://aiminghigh.aimssec.ac.za/tangram-pattern/

Mirror Mirror https://aiminghigh.aimssec.ac.za/mirror-mirror/

Reflecting Squarely https://aiminghigh.aimssec.ac.za/reflecting-squarely/

Transformations and Art https://aiminghigh.aimssec.ac.za/transformation-art/

Flower of Life https://aiminghigh.aimssec.ac.za/flower-of-life/

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LET'S PLAY MATHEMATICALLY AND LEARN

Order from AMAZON or TARQUIN https://www.tarquingroup.com/products/aiming-

Play Mathematically

- to develop a love for mathematics
- to unlock knowledge and understanding
- to improve numeracy and visualisation skills
- to practise mathematical procedures
- to motivate concentration and critical thinking
- to boost confidence in mathematical ability.

This **first book** in this AIMING HIGH series provides 36 games that are easy to learn and enjoyable to play for any age. Each comes with reflective questions and materials designed to bring out mathematical thinking and provide a deeper understanding of the topic that underlies the game. Even for the youngest players, this can be transformational.

The **second book** offers suggestions for teachers for using games and puzzles in lessons to teach the regular curriculum with different ideas for different age groups.. It is due to be published in mid 2026.

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AIMS African Institute for Mathematical Sciences SCHOOLS ENRICHMENT CENTRE

GTEN

Thankyou for coming to this workshop.
Use the AIMSSEC ideas on AIMING HIGH
and add comments.
Share what you have learned
with other teachers.
Try to help all your learners to have a
'Yes I Can' attitude to mathematics.

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