## Pobogals Science Challenge

## Minor Challenge Set \#1

STEM Field: Mathematics
Level: Senior
Challenge Name: A Mondrian's Art Puzzle
Project Cost: 0-20 USD
Materials Required:

- Paper
- Ruler
- Pen or pencil
- (Recommended) Colour pencils, highlighters
- (Recommended) Access to a printer to print pages


## Duration:

- The challenge takes approximately 2 to 3 hours to finish, however, the time guideline is an estimation only, and students and mentors can complete the tasks around their schedules.


## Introduction:

Piet Mondrian is a Dutch artist who is best known for his abstract paintings from squares and rectangles. His abstract paintings usually involve geometric shapes, three primary colours (red, blue, and yellow), and three primary values (black, white, and grey).

This mathematical problem is inspired by Mondrian's art pieces. The restriction is: you will divide a square grid into squares and rectangles with different dimensions. Your goal is to have the area of the largest shape and the smallest shape as small as possible. It may be difficult to
understand this aim, so let's look at concrete examples in the Instructions section.

## Instructions:

1) Print pages 8 to 11 with the grids. Alternatively, draw squares of sizes specified in the instructions below on a piece of paper.

Note: You can use coloured pencils, or highlighters for this activity. Alternatively, you can fill different patterns in different shapes using pens or pencils.
2) On an A4 piece of paper, draw a square with sides of 4 cm or 1.6 inch in length. Divide the top side into 4 equal parts of 1 cm or 0.4 inch each and draw 4 equal vertical rows inside the square. Divide the right side into 4 equal parts and draw 4 equal horizontal rows inside the square. Refer to the square in figure 1 for reference.

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| Figure 1 - Blank square with $4 \times 4$ grid | Figure 2 - Possible solution 1 | Figure 3 - Possible solution 2 |

3) In figure 2, the area of the red and dotted shape is 4 squared units, the blue and diagonal lines shape is 3 squared units, and the yellow and wavy lines shape is 9 squared units. (Note: All the coloured and pattern shapes inside the $4 \times 4$ square have different dimensions, which satisfy the restriction for this puzzle.)

This means the difference between the shape with the largest area and the shape with the smallest area is: 9-3=6 squared units.
4) Calculate the difference between the shape with the larger area and the shape with the smaller area in figure 3.
5) There is another possible solution that gives the difference between the largest shape and the smallest shape being 4 squared units. By using coloured pencils or drawing patterns for different shapes, can you figure out the solution?
6) Let's attempt this puzzle with a bigger square. Draw a square with sides of 5 cm or 2 inch long. Divide each side by 5 equal parts and draw the grids to get a blank square with $5 \times 5$ grid in figure 4 .


In the possible solution in figure 5, the largest shape and the smallest shape have a difference of 12 squared units. This is not the best solution. Can you find the solution with the smallest possible difference?
(Hint: The smallest possible difference is 4 squared units.)
7) Figure 6 shows the best solution for a square with a $6 x 6$ grid. Can you calculate the difference between the largest shape and the smallest shape?


Figure 6-Optimal solution for a square with a $6 x 6$ grid
8) Draw a square with sides of 7 cm or 2.8 inch long. Divide each side by 7 equal parts and draw the grids to get a blank square with a $7 \times 7$ grid, similar in figure 7 .


Figure 7 - Blank square with $7 x 7$ grid

Can you find 2-3 solutions that satisfy the restriction? (Restriction: Divide the $7 \times 7$ grid into different squares and rectangles with different areas).

Which solution gives the smallest difference in area between the largest shape and the smallest shape?
9) Let's attempt the final puzzle. Draw a square with sides of 8 cm or 3.2 inch long, and divide the square to have an $8 \times 8$ grid, similar to figure 8.

Can you find 2-3 solutions that satisfy the restriction? (Restriction: Divide the $8 \times 8$ grid into different squares and rectangles with different areas).

Which solution gives the smallest difference in area between the largest shape and the smallest shape?


Figure 8 - Blank square with an $8 \times 8$ grid

## Extension

The main difficulty with this maths puzzle is that no pattern or structure has been identified even when the dimensions of the squares are increased. The optimal difference score in bigger squares also fluctuates, and so, no "shortcut" has been identified to solve this problem.

However, you may have noticed a pattern in the difference you calculated when colouring in different squares. Let's see if this statement is true.

Find the optimal solution for squares with a $10 \times 10$ grid and an $11 \times 11$ grid. Is it true that there is a pattern with the difference as the dimension of the square increases? If so, what is that pattern?

You can print the provided squares on pages 12 and 13 for this extension activity.

## Reflection Questions:

- Are there any improvements you would make to this challenge?
- This maths puzzle was inspired by Mondrian's abstract art style. Conduct your research on how Mondrian's art is referenced in different applications, such as fashion design, games, shoes design, and more.
- Have you been able to identify any pattern about the difference score as the dimension of the square increases? If so, what pattern could you see?
(Optional, but highly recommended) Watch this video from TED-Ed about the Mondrian Squares Riddle. https://www.ted.com/talks/gordon hamilton can you solve the mondrian squares riddle?language=en


## Submission Guidelines:

- Submit your answers to the questions in the Instructions section, as well as your solutions. Include a short summary that addresses the reflection questions.

Note: Remember, if you want to upload pictures of your Minor Challenge that also include you, please check if it is OK with your parent or guardian first.

- The submission form is on the Minor Challenges page: https://sciencechallenge.org.au/index.php/minor-challenges/ Fill out the details and make sure you upload your submission.


## Learn More! Resources:

- This TED talk provides more details on the Mondrian Squares Riddle https://www.ted.com/talks/gordon hamilton can you solve the mondrian squares riddle?language=en


## Bibliography:

- Alley, R. (1981) "Piet Mondrian 1872-1944," in Catalogue of the Tate Gallery's Collection of Modern Art other than Works by British Artists. London: Tate Gallery and Sotheby Parke-Bernet, pp. 532-533. Available at: https://www.tate.org.uk/art/artists/piet-mondrian-1651 (Accessed: March 13, 2023).
- Barral, M. (2019) The (mathematical) problem of Mondrian's paintings, OpenMind. Available at:
https://www.bbvaopenmind.com/en/science/mathematics/the-mathematical-problem-of-mondrians-paintings/ (Accessed: March 13, 2023).
- Trushkowsky, M. (2017) Mondrian Art Puzzle, Community of Adult Math Instructors (CAMI). Available at: https://nyccami.org/mondrian-art-puzzle/ (Accessed: March 13, 2023).


## $4 \times 4$ grid



## $5 \times 5$ grid



7x7 grid

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$8 \times 8$ grid

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11x11 grid

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