> This resource is part of a suite of materials and activities created to inspire entrants, and support teachers, and parents to enter *maths inside*: a photo competition open to everyone in Scotland. *maths inside*: see different, make connections, celebrate!

In this series of example submission journeys, you can find details of searching, questioning, and discovery of *maths inside* the things and spaces around us! Follow these stories and learn how to catch the beauty of a discovery in a photo, title and commentary (linked activities and resource pack).

Visit mathsinside.com for entry details, further information, and follow us for updates!

Below, this example documents the submission journey for an **Third/Fourth Level (S1–S3)** entry (credits).

Packing Pebbles | Third/Fourth Level example submission journey

Have you ever thought about the maths inside a beach? Perhaps in the motion of the waves or the height of the cliffs, or even in how kites fly overhead? Recently I was at the beach and found a square drawn in the sand, with a group of pebbles nearby. Pebbles on a beach form over time from ocean water washing over loose rocks, giving them their smooth and rounded appearance. I wondered how many of these pebbles I could fit in the square and decided to turn this into a little game!

This is a photo of the square in the sand and the pebbles nearby, with a maths inside sticker! You can see waves approaching to the left and a large bank of pebbles to the right.

To turn this into a submission for maths inside, we need to give this photo a title and some commentary. I chose

> “The maths of pebble arrangement”

with commentary

> “How many pebbles can we fit into this square? What is the best way to arrange them to fit as many as possible? Is there a particular shape of pebble that is easier to work with?”

What do you think of this title and commentary? Can we make it better and dig deeper into the maths inside? I think we can! I wonder what it means to “arrange” the pebbles, what happens if I change the arrangement to stack the pebbles on top of each other? I think it would make more sense to take a picture of the pebbles inside the square. How could this better illustrate the idea in our submission?

To make the pebble-fitting game fair, I decided only to use pebbles of roughly the same size. I’m sure we could fit a lot of tiny pebbles into this square. I wanted to do this without any part of the pebbles being outside the square. This got me thinking about density, the measure of how close together the particles are in an object. What would happen if we imagined the square as the base of a box with high sides and the pebbles as the atoms within this box? When would our object have the highest density?

What 3D shape do our pebbles most look like? They remind me of arrangements of atoms and molecules in chemistry! I was collecting pebbles of similar size and shapes from the pebble bank, and I wondered how well spheres fit together — like oranges on the supermarket shelves. Can you see wasted space in the arrangement of pebbles? What do you think is the best shape of pebble to pack into this square without any wasted space? What do you think is the worst shape?

All these questions got me started thinking with a new perspective. I placed all my collected pebbles neatly in the square as close together as possible. A pyramid shape seemed to be the most practical, containing fifty-eight pebbles in total. I then took a photo of the arrangement before the waves came in to wash away my hard work!

Inspired by the idea of packing a busy suitcase, the oranges in the supermarket, or the packing of spherical atoms in an object, I changed my title to:

> “Packing pebbles”

and expanded the commentary to:

> What is the best way to arrange spheres in a box? This is a maths problem known as sphere packing, and I decided to give this a go using similarly shaped pebbles when I was at the beach. The way the pebbles are packed together looks like the arrangement of atoms in a dense material. If we estimate the volume of each pebble, we can use maths to accurately calculate the density of our pebble packing!’

further things to think about

Can you write anything else in your commentary? Would things be different if we had tried to pack the pebbles into a different shape? What about packing inside a hole? Where else on the beach can maths be found? What photo will you take to discover the maths inside? What questions will you ask?

Learn more about the sphere pakcing problem with Numberphile: The Best Way to Pack Spheres (YouTube).

Open to all ages with prizes in each level. You only need a mobile, the internet & curiosity! Enter maths inside *on your own or as a team, mind to add the maths inside sticker, and submit in one, or in as many*

categories as you like. The photo should be your own, without changes, and for a chance to win, cannot be shared anywhere else. View the T&C for more information, and please do get in touch if you have any questions.

linked activities and resource pack

Complementing each journey is an example interdisciplinary learning (IDL) activity matched to Curriculum for Excellence experiences and outcomes (Es&Os). Also available are image banks containing images and questions to inspire interdisciplinary investigation and learning. These resources and activities are all available in a downloadable pack.

credits

This suite of resources are the fruit of a collaborative project between undergraduate and postgraduate students from the University of Glasgow — School of Mathematics & Statistics, Education Scotland, and Dr Andrew Wilson (*maths inside* Founder and Director).

The authors are Jordan Baillie, Nanette Brotherwood, Tanushree Bharat Shah, Lucas Farndale, Emma Hunter, Christopher Johnson, Harkamal Kaur, Christian Lao, Samuel Lewis, Kathleen McGill, Megan Ruffle, Yvonne Somerville, Andrew Wilson, and Yuanmin Zhu.

The photos above are credited to Samuel Lewis.