# Maths in Action: Planetary Mini-Project

This is an overview document of the Planetary Mini-Project (PMP) created by the Deep Earth Explorers team in the University of Cambridge's Department of Earth Sciences.

This project is intended to take place over 3 lessons:

- **Lesson 1**: "Building planets with maths!.pptx", a recap of maths content with accompanying questions (on "Worksheet.docx")
- **Lesson 2**: "PMP Slides.pptx" and "For Students.docx" for the actual project information, with graphs provided in "(0) Density graphs.pptx" and answers/prompts in "(3) Final planet models"
- **Lesson 3**: Finishing off and presentation of student projects, with the potential to move on to extensions provided in "(4) Extensions to project.pptx".

  Overview Contents:

  1. Introduction - *What is this Mini-Project about?*
  2. Aims - *What do we want to achieve?*
  3. Preparation - *What will the students need to know?*
  4. Details - *What do students have to do?*
  5. Extensions - *What more can students do?*

## 1. Introduction

Maths is often a difficult subject to teach or learn, not least because it is so abstract. However, dealing with data, being numerically literate and understanding mathematical thinking are all key skills according to UK employer surveys. Our Planetary Mini-Project is an attempt to bridge these gaps between school and the workplace, and to create a novel, dynamic, project-based environment in which to gain key numeracy skills.

Our philosophy of learning comes from Case-Based Learning, developed for medical students in the USA who felt the gap between medical theory and clinical application was too great. As a result, medicine, and maths, can be taught through case-studies, projects, and problems. Not only does this highlight the importance of more 'abstract' knowledge to students, but we also include careers-based information to motivate students.

## 2. Aims

- Students should become more comfortable with: interpreting data, constructing graphs, the idea of a 'mathematical model', geometry, volumes, density & masses, and calculating percentages and proportions.
- Students should learn that numeracy is a very applicable, employable and lucrative skill and applies to many roles.
- Students should employ 'soft-skills' such as communication, time-management, teamwork, delegation, design, responsibility and presentation.
- Students should learn that mathematical thinking can be (and often is!) a collaborative process to which everyone can contribute ideas.

## 3. Preparation

As mentioned, the topics covered are all required knowledge from current GCSE syllabuses including: interpreting data, constructing graphs, standard form, the idea of a 'mathematical model', geometry, volumes, density & masses, and calculating percentages and proportions.

Attached in the lesson resources is a series of worksheets covering each of these sections. These worksheets can be completed in class in a lesson before the project as a revision exercise so all students are up to date with necessary concepts for the

project. They can also be completed after the end of relevant lesson blocks throughout the year.

We also provide a PowerPoint entitled “Building planets with maths!” that goes through all the relevant mathematical content to produce diagrams and presentations of a hypothetical Planet X.

It is up to the teacher and school how these resources are best used to consolidate student understanding.

We estimate there to be 3 lessons’ worth of content, but this structure is flexible:

- Lesson 1: Preceding the project, teacher will use PowerPoint “(1) Building Planets With Maths” to introduce all the mathematical content
- Lesson 2: Teacher will run the project with the students using PowerPoint “(2) PMP Slides”
- Lesson 3: Students will present what they have discovered about their planet.

## 4. Details

What will the students actually do during the project?

- Students would be split into about 4 groups[1]
- Each group is assigned “Earth”, “Moon”, “Jupiter”, or “Saturn”
- Each group will be provided with a graph of density as a function of depth inside their planet
- Within groups, students can split themselves up and assign roles such as “Project Manager”, “Designer”, “Data Scientist”, “Mathematician” and “Geoscientist/Planetary Scientist” [2]

[1] This is variable depending on class size; some groups can do the same planet, e.g. two groups studying Earth data.

[2] Again, these roles may be repeated within a group, not used at all, or other roles may be thought up. This is up to the individual case.

Students will be asked to:

- Interpret the graph they're given
- Draw (design & colour) the planet to scale using their interpretation of the graph
- Calculate volumes of layers
- Use approximate densities from graphs to work out masses of layers
- Calculate percentage or fraction of total mass and total volume in each layer
- Create a poster of their results and create a short presentation to communicate their results to the rest of the class
- Key questions in Slide 10 of PowerPoint "(2) PMP Slides" should be answered or thought about

Answers can all be found in the PowerPoint "(3) Final Planet Models" which can be used when and where relevant to help struggling students. This powerpoint explains all the processes involved above.

## 5. Extensions

There are a few ways to take this project further.

1) Look at models of earthquake velocities in the planets and interpret these with respect to the model they've produced. (Provided in the PowerPoint "Seismic Waves Graphs")
2) Given a table of approximate densities of Solid Rock, Solid Metal, Liquid Rock, Liquid Metal, Gas, assign the compositions of different layers of the planets.
3) Convert units from km/s to mph; from kg/m$^3$ to Tonnes/km$^3$, etc.

These are detailed in PowerPoint "(4) Extensions to the Project"

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