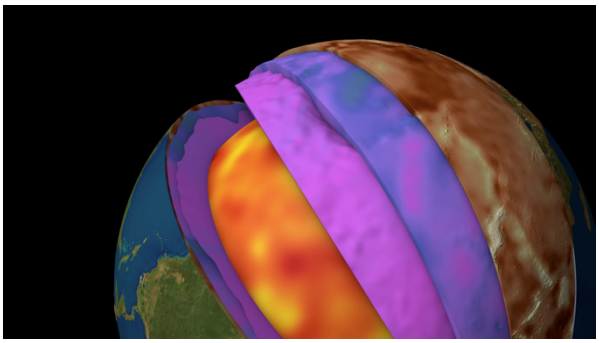
TUDelft **AE4893 (2025) – PHYSICS OF PLANETARY INTERIORS**

Assignment 1 – bulk vs. 1D profile of a planetary interior



Responsible instructors
Dr.ir. Bart Root

Email: b.c.root@tudelft.nl

Group Size: **1** Student (one report)
Due: 17:00h, Friday 28th November, 2025
Estimated time: 30 hours
Page limit: 6 pages

General introduction/background

The interior structure of a planetary body is the background for all you numerical modelling analysis. It is therefore the first element you need to construct and validate to any observations and literature you have on the body. For this assignment you may chose a planetary body and start the assignment. On Brightspace we have added a planetary datasheet with observations of the body from the book *Fundamentals of Planetary Sciences*. Try to add or revise this database for your body with values from literature.

At the end of this assignment, you will be able to develop a model of the radial interior structure of the body for the pressure, density, gravity, temperature, composition. Moreover, you will be able to assess the validity of your model with respect to literature and new observations.

Assignment description

You are building three different interior models (M1, M2, M3), from simple to complex and assess their validity with respect to the observed values of the chosen planetary body.

***A** Code used:*

- Matlab/Python propagator,
- BurnMan: layers and planets,

***B** Literature to be found:* Find at least 2 different scientific papers describing the interior structure of your chosen body. The models should include the radial structure of density, gravity, pressure, temperature, and composition.

***C** Data to be used:*
Radius, Mass, Moment of inertia (factor), surface temperature, tectonic state, (meteorites) and their uncertainties.

Deliverable
Your report should contain (answers to) the following:

1) Collect 2-3 models of your chosen planetary body from literature to validate your model with. Describe and reference them in your report. Discuss differences between them. **Hypothesis/Validation**

2) Use partials for pressure, gravity, and mass from the lecture slides. Program a python/matlab script to propagate them using an Euler integrator. Check your code with an analytical solution. **Physical model /Numerical model/Verification**

Model 1
3) Select a multiple layered homogenous density structure that resembles models from question 1). Calculate your own internal pressure and gravity profiles. Check if your model fit with the observed: Mass, Radius and Moment of Inertia. Selected the least known parameter (layer thickness or density) and study the sensitivity of that parameter with respect to Mass and Moment of Inertia. Make 3 models that fit the observations (min/mean/max). **Model Setup/Validation**

Model 2

4) Use 3 bottom core (r = 0) temperature values from literature (min/mean/max) for your planet in the assessment of thermal characteristics of the interior. Determine if each interior layer is conductive or convective. Do this by calculating the Rayleigh number for each spherical shell. Then, construct 3 possible thermal profiles for your planet using the appropriate thermal models. **Numerical model**

5) Choose a temperature/pressure dependent density model based on the suspected composition of each layer. Select the appropriate bulk modulus and thermal expansivity factor. Report on them and motivate your choice. **Physical model**

6) Construct profiles of the pressure, gravity, density, chosen composition, and temperature for the three thermal scenarios. Iterate if necessary. Check if the observations fit with your model: Mass, Radius, and Moment of Inertia **Production Run**

Model 3
7) Use the BurnMan software to build a planetary profile with a typical planetary composition. Modify the Burnman tutorial listed in work lecture week 2. Discuss similarities and difference and comment on their implications. **Validation**

Analysis of the different models
8) Make figures where your compare model(s) M1, M2, and M3 to interior models found in literature. Discuss similarities and differences **Analysis and validation**

9) Conclude on the most valid model and give recommendations for observations to improve on the structure. **Communication**

Prerequisites for report to be assigned a grade.

Please check if report includes:

- your name
- study number
- write how many hours you approximately spent on the assignment.
- Use proper referencing of literature
- Send your code as a zip file or single python/matlab file or upload it to a public github page and report on link.
- Check that your report stays within the page limit