MESA mini case study

ASBE course 2025 – 2026

In this final assignment, you will apply what you learned during the practicum by exploring one of MESA's test suites and using it to answer a self-defined question about (binary) stellar evolution.
You have gained experience running single and binary stellar models. In this assignment, you will build on that experience by selecting and analysing an existing MESA test suite, investigating what physical question it allows you to address, and presenting your findings in a short written report

Collaboration with your fellow students is strongly encouraged. You can do steps 1 (the execution of the project) in teams of two students. However, the report (step 2) should be written, and will be evaluated, individually.

1. Choose a MESA Test Suite and Formulate a Question

Browse the list of available test suites in MESA.
The test suites are located in `$MESA_DIR/star/test_suite` (single-star evolution) and `$MESA_DIR/binary/test_suite` (binary evolution). You can also consult the documentation at `https://docs.mesastar.org/en/r15140/test_suite.html` ; note that some test suites may not yet be fully documented in this version, even though more complete descriptions exist for newer releases of MESA.

Your task is to formulate a clear, concise scientific question that can be answered using this test suite. Examples include:

- How does the evolution of a star depend on the initial composition (metallicity)?
- How does the evolution change with different assumptions about mixing?
- How does the evolution of a binary star depend on the mass ratio of the stars, or on the orbital period?

Feel encouraged to come up with your own questions! Think about what you want to do, and to *plan* the calculations to be done, before you *start* doing them. Also keep in mind that there is not much time for the calculations (only 2 computer sessions), so keep it simple!

2. Run and Analyse the Test Suite

Run the chosen test suite and perform the analysis needed to answer your question. You may work together in pairs for this part of the assignment.

To understand how to use a test suite to address your science question, read through the instructions at: `https://docs.mesastar.org/en/r15140/test_suite.html`

Pro Tip

Carefully read how to use test-suite examples! In particular, to use them outside the `test_suite` directory.

- **Copy the entire test-suite directory** to a local working directory (in the same way you worked with the provided session3 and session4 folders from Brightspace). You should never run or modify the test suites directly inside the MESA installation.

Once you copy the test suite to your own directory, you must remove any hard-coded references to the MESA installation. I.e., delete all lines containing

- `MESA_DIR = ../../../..`
- `mesa_dir = '../../..'`
- `MESA_DIR=../../..`

from the `make/makefile`, the `rn` script, and in all the inlist files. After removing these lines, your setup should run correctly use the `MESA_DIR` defined in your shell environment.

- **Perform the MESA calculations** needed for your case study. There will be two designated practical sessions in the second quarter, starting on December 10. Of course, you can also work on the project by yourselves outside the scheduled sessions.

Your analysis should connect clearly to the course material. Depending on the test suite you choose, relevant figures may include:

- evolution in the Hertzsprung–Russell diagram,
- the central temperature–density diagram,
- Kippenhahn diagrams
- abundance profiles at key evolutionary stages,

or for binary test suites additionally:

- the evolution of the orbital period and eccentricity,
- the comparison between stellar radii and Roche-lobe radii,
- mass-loss or mass-transfer rates.

Select the plots that best support the question you aim to answer; not all diagrams are relevant for every suite, but at least several of these plots should be in your report. The more important aspect is that your plots contribute to answering your scientific question, and that you can explain them in terms of the physical processes covered in the course.

3. Write a Short Report

Each student submits an individual report. The report should contain approximately 3–4 pages of text and 3–4 figures (we care more about quality over lenght). If it is clear that your writing relied heavily on chat-GPT or other AI tools you will of course lose points.

Guidelines for the Report – a good report is:

- **Well structured.** Include a brief introduction (your question and its relevance), a short description of the chosen test suite and how you used it, and a concise conclusion.
- **Concise.** Focus only on what is necessary to answer your question.
- **Accessible.** Write for an astronomy master student who did not take this course. Introduce specific terminology where needed.
- **Clear and quantitative.** Use proper English, avoid overly long sentences, and define abbreviations. (e.g. *not* "isn't" but "is not")
- **Properly formatted.** Write the report in LaTeX. Use standard notation (e.g. $M_\odot$). Refer to figures with `\label` and `\ref`. Each figure must have a clear, informative caption.

Deadline: Monday 27 January 2026.