

Lesson 04 — Experiment Objectives

Simulating Newton's Law of Cooling with GNU Octave and GX-TXT

Course: GNU Octave with GX-TXT
Framework baseline: 0.9.8.10-dev-111 / P019
Reference commit: 3f516f5b726183ea8f53041888bd67438ee050ee
Date: 2026-10-25
Status: Proposed experimental specification; no runtime test completed.

1. Scientific question

How does a warm body approach ambient temperature over time, and how accurately does a simple iterative numerical model reproduce the analytical result?

2. Baseline experiment

Parameter	Proposed value
Initial temperature	80 °C (353.15 K)
Ambient temperature	22 °C (295.15 K)
Cooling coefficient	0.08 min ⁻¹
Time increment	0.5 min
Fixed simulation duration	60 min
Stopping tolerance	1 °C temperature difference (equivalent to 1 K difference)
Maximum iterations	120 for the fixed-duration experiment; a separate explicit safeguard for the threshold loop

Assume constant ambient temperature and a constant cooling coefficient. Results are simulated values, not laboratory measurements.

3. Learning objectives

- By completing the experiment, students will be able to:
- 1. **Write conditional statements:** validate physical/numerical inputs and classify cooling states using `if`, `elseif`, and `else`.
 - 2. **Use a for loop:** perform 120 Euler updates and construct aligned vectors containing 121 time and temperature samples, including the initial point.
 - 3. **Use a while loop:** stop when `abs(T - T_ambient) <= 1 K`, without risking an unbounded loop.
 - 4. **Define reusable functions:** implement a cooling-step function, an analytical-reference function, and a

simple state-classification function.

5. **Recognize numerical error:** compare the Euler approximation with the analytical solution at identical timestamps and examine the influence of a larger or smaller time increment.
6. **Handle units correctly:** keep the rate constant consistent with the chosen time unit and express published temperature values in kelvin.
7. **Use public GX-TXT APIs:** discover required Script Bridge operations, publish scientific result Datasets with metadata and provenance, and request a Plot Dataset v4 visualization from canonical Dataset identities.
8. **Document reproducibility:** record the fixed source commit, input parameters, actual executed script revision, output Dataset IDs, and observed runtime outcomes.

4. Expected numerical checkpoints

These are theoretical checks for the proposed baseline, **not measured GX-TXT execution results**:

- First Euler update: $T(0.5 \text{ min}) = 77.68 \text{ }^{\circ}\text{C}$ (350.83 K).
- Euler prediction at 60 min: approximately $22.43249 \text{ }^{\circ}\text{C}$ (295.58249 K).
- Analytical prediction at 60 min: approximately $22.47733 \text{ }^{\circ}\text{C}$ (295.62733 K).
- First Euler time step within a $1 \text{ }^{\circ}\text{C}$ ambient-temperature tolerance: 50.0 min.
- Analytical threshold-crossing time: approximately 50.756 min.

The fixed-step method approaches ambient temperature asymptotically. Reaching a tolerance does **not** mean reaching exact thermodynamic equilibrium.

5. Required experimental outputs

- One fixed-duration Euler cooling series: time versus absolute temperature.
- One analytical reference series evaluated on the same time grid.
- A clear termination report for the threshold-controlled loop, including elapsed time, final temperature difference, and iteration count.
- A comparison of numerical and analytical values, including a reported maximum absolute difference.
- Canonical GX-TXT Datasets published through a verified public publication operation, with meaningful Dataset/Variable IDs, scientific units, and provenance.
- A Plot Dataset v4 graph displaying the two published temperature curves when runtime support has been verified.

6. Acceptance criteria

- The simulation refuses invalid or inconsistent inputs with a clear diagnostic.
- Every output time vector is strictly increasing and aligned with its temperature vector.
- The simulated temperature decreases monotonically without falling below the ambient temperature for the baseline settings.
- The analytical reference matches the defining formula at each recorded timestamp.
- Both fixed-step and threshold-controlled loops terminate under documented bounds.

- Published Datasets remain accessible through their canonical GX-TXT identities; no private registry edits or unmanaged image exports occur.
- All public API calls are checked against the DEV111-P019 GitHub source and described in the lesson; the article states whether a live Session execution actually passed.
- All comments in the `.m` script are in English; the WordPress article will have Italian and English versions.

7. Optional extensions

- Repeat the calculation with `dt = 1.0 min` and `dt = 0.25 min` and compare errors.
- Change the ambient temperature or the cooling coefficient and discuss the physical effect.
- Compare a threshold-controlled run with a fixed-time run, including the difference in the number of iterations.

8. Reproducibility reference

Official GX-TXT repository: <https://github.com/giuxlab-hub/GX-TXT>

Pinned source: <https://github.com/giuxlab-hub/GX-TXT/commit/3f516f5b726183ea8f53041888bd67438ee050e>

Public API references: `OCTAVE_SCRIPT_BRIDGE_API_v1`, `DATASET_PUBLICATION_API_v2`, and `PLOT_DATASET_API_v4` in `docs/api/` at the pinned commit.