

Teaching Computation with MATLAB and GenAI

Linear Algebra through the Lens of Code

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Why chemical reactions?

Students consistently chose chemical balancing.

They described it as interesting, accessible, and meaningful.

Compared with traffic flow, city–suburb migration, and linear transformations.

Instructor summary of end-of-semester feedback, S22–F24.
Six prior offerings; two sections in F26.

Photosynthesis connects linear algebra to life.

Teaching with code at A&M-SA

- Since S21: computing in courses and student research.
- NSF grant: coupling of nonlocal and local models improved by ML.
- Educational goal: create STEM career pathways for students.
- Led a faculty initiative in F25; campus-wide MATLAB license in S26.

A worked example: propane combustion



Encode the molecule by $\begin{bmatrix} \text{C} \\ \text{H} \\ \text{O} \end{bmatrix}$; mathematical modeling (math), data structure (CS).

$$x_1 \begin{bmatrix} 3 \\ 8 \\ 0 \end{bmatrix} + x_2 \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} = x_3 \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix} + x_4 \begin{bmatrix} 0 \\ 2 \\ 1 \end{bmatrix} \quad \text{mathematical equation}$$

$$x_1 \begin{bmatrix} 3 \\ 8 \\ 0 \end{bmatrix} + x_2 \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} - x_3 \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix} - x_4 \begin{bmatrix} 0 \\ 2 \\ 1 \end{bmatrix} = 0 \quad \text{standard form}$$

$$A = \begin{bmatrix} 3 & 0 & -1 & 0 \\ 8 & 0 & 0 & -2 \\ 0 & 2 & -2 & -1 \end{bmatrix} \xrightarrow{\text{R=rref(A); format rat;}} R = \begin{bmatrix} 1 & 0 & 0 & -\frac{1}{4} \\ 0 & 1 & 0 & -\frac{5}{4} \\ 0 & 0 & 1 & -\frac{3}{4} \end{bmatrix}$$

$$\mathbf{x} = s \begin{bmatrix} \frac{1}{4} \\ \frac{4}{5} \\ \frac{4}{3} \\ \frac{4}{4} \\ 1 \end{bmatrix}, \quad s > 0.$$

Is the free variable a blessing or a curse?

Choose $s = 4$, molecule quantity integer-valued. The value of $s = 4$ vs $s = 8$.

Photosynthesis 1: one free parameter



$$A_1 = \begin{bmatrix} 1 & 0 & 0 & -6 \\ 0 & 2 & 0 & -12 \\ 2 & 1 & -2 & -6 \end{bmatrix}_{3 \times 4}, \quad \mathbf{x} = s \begin{bmatrix} 6 \\ 6 \\ 6 \\ 1 \end{bmatrix}, \quad s > 0$$

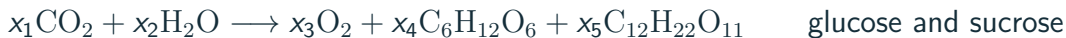
Make connection to the rank-nullity theorem.

Rank=3, Nullity=1, hence $4 = 3 + 1$.

`x = [6;6;6;1]; A1*x % returns zero vector`

Part of project: students complete code (Symbolic Math Toolbox) and verify the balance.

Adding sucrose changes the solution space



$$A_2 = \begin{bmatrix} 1 & 0 & 0 & -6 & -12 \\ 0 & 2 & 0 & -12 & -22 \\ 2 & 1 & -2 & -6 & -11 \end{bmatrix}_{3 \times 5}, \quad \mathbf{x} = s \begin{bmatrix} 6 \\ 6 \\ 6 \\ 1 \\ 0 \end{bmatrix} + t \begin{bmatrix} 12 \\ 11 \\ 12 \\ 0 \\ 1 \end{bmatrix}, \quad s, t \geq 0.$$

Make connection to the rank-nullity theorem.

Rank=3, Nullity=2, hence $5 = 3 + 2$. Nullity changes from 1 to 2.

What freedom does the second free variable add?

Glucose only: $t = 0$, s free.

Sucrose only: $s = 0$, t free.

Glucose and sucrose together: both $s > 0$ and $t > 0$ free.

What I can assess next

Established observation

Students repeatedly preferred chemical balancing.

Planned assessment

Can students explain why nullity changes from 1 to 2?

Teaching challenge

Correct output alone does not show understanding.

Written explanations accompany the MATLAB scripts.

My goals for this workshop

- Adjust the scaffolded photosynthesis assignments.
- Use Copilot to help draft exercises and feedback.
Use MATLAB Grader to test submitted code.
- Assess students' reasoning alongside code correctness.
- Improve the GUI for the horizontal shear application.

Want students to explain what their code reveals.