Embedding Online MATLAB Teaching Tools in Courses
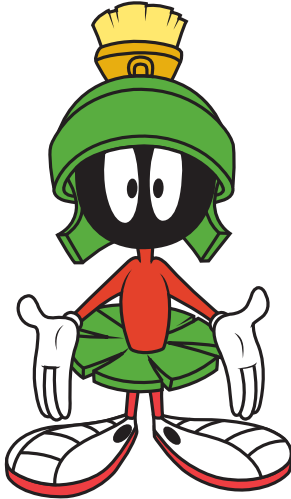## Virtual Workshop: Teaching Computation Online with MATLAB

Jérémy A. Riousset, Ph.D.

Aerospace, Physics, & Space Sciences Department
Florida Institute of Technology, Melbourne, FL
(jriousset@fit.edu)

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Outline

Motivations

Why creating Research Techniques?

- "Science has not changed as much as the tools to perform it."
- The limits of Introduction to Software Engineering.
- The limits of Microsoft Excel.
- A request from Alumni.

Why MATLAB?

- **Overcoming the prejudices & starting early**.
- Algorithmic vs. programming/coding.
- All-inclusive platform (Editor-Compiler-Debugger-Visualization).
- A gateway to other languages (Scratch, Python, FORTRAN, C/C++).
- Training independent learners... from guided exercise to independent project.

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Building confidence: In-Class Exercises

- Using the students' tools:
  - Online calculators (MATLAB online).
  - Tablet access (MATLAB App).
  - Familiar environment (CANVAS integration).
- Conquering blank page anxiety:
  - Using hands-on approach with incomplete scripts.
  - Stating clear objectives.
  - Working with peers and/or instructor.
  - Focusing on implementation over theory.
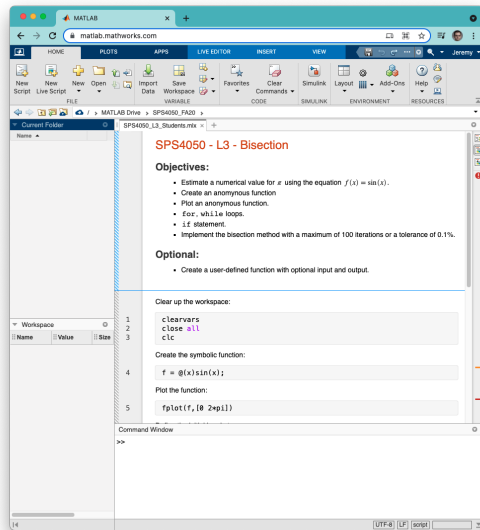
Letting Go: Homework Assignments

- Creating a playful & stimulating environment:
  - Online exercises using [Gilat and Subramaniam, 2013].
  - Immediate feedback.
  - Instant gratification.
  - Sticking to familiarity (**CANVAS+Grader**).
  - Removing grade pressure (unlimited attempts).
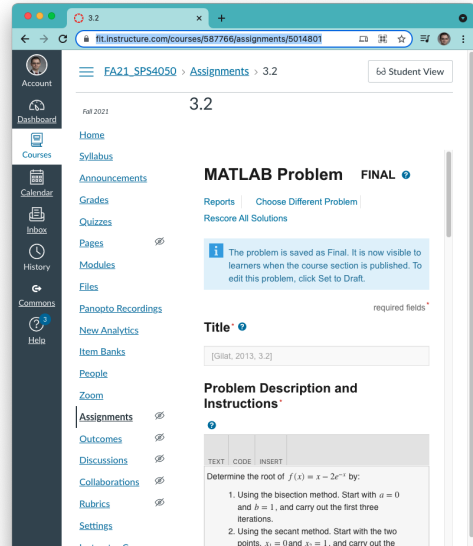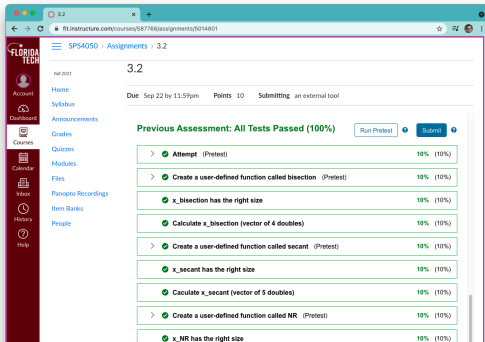
On One's Own: Project

- Maintaining structure.
- Supporting autonomy.
- Anchoring in real science problems.
- Adapting to the students' level.

FLORIDA TECH Department of Aerospace, Physics & Space Sciences
J. A. Riousset, Ph.D.   Project-PHY1001H

INSTRUCTIONS

Download the MATLAB LiveScript PHY1001H_pendulum.mlx required for this assignment from CANVAS. You can use the (502)OPS228 lab computers for all assignments related to this class. Alternatively, you may download a campus license for MATLAB from https://www.mathworks.com/downloads/web_downloads or make use of the online MATLAB accessible at https://matlab.mathworks.com. Start MATLAB and run PHY1001H_pendulum.mlx, choose the length of the string, radius and density of the ball, as well as its initial position and angular velocity. You can change the parameters and initial conditions in the top part of the file. Some forces are already implemented. You will add others in the later sections of the project.

Please submit your computer lab report on CANVAS. Include this cover sheet, with your name and assignment questions. For each separate computer exercise, please provide:

1. The files which you used (highlight the changes you made from the supplied file).

2. The outputs from yourStokes' computer experimental runs. Answer the assignment questions on your output sheets including all calculations, indicating times, lengths, frequencies, directions of rotation, etc. directly on the plots.

FORMULÆ

$$\omega_0 = \sqrt{\frac{g}{l}} \qquad\qquad T_0 = \frac{2\pi}{\omega_0}$$

$$\vec{D} = -\frac{1}{2}\rho_{air}C_d A v \vec{v} \qquad\qquad \vec{S} = -6\pi R\mu \vec{v}$$

QUESTIONS

(P1) *(6 points)*
Consider the motion of a golf ball with mass density $\rho = 1124.5\,\mathrm{kg/m^3}$, and radius $R = 2.132\,\mathrm{cm}$ hanging from a massless string of length $\ell = 1\,\mathrm{m}$. Assume that you are at the surface of the Earth ($\vec{g} = 9.81\,\mathrm{m/s^2}$). Include the effect of Stokes' friction ($\vec{S}$) but not the drag ($\vec{D}$).

(1.1) Use Newton's second law to write the equation of motion in cylindrical coordinates.

(1.2) Use the angular momentum conservation to obtain the equation of motion again.

(1.3) Using energy conservation obtain the equation of motion one more time. Do your calculations agree with the previous parts?

(1.4) Ignore $\vec{D}$ as well as $\vec{S}$ and use a small angle approximation to obtain the natural frequency of the pendulum oscillations.

(P2) *(6 points)*
In this section, assume that you are at the surface of the Earth ($\vec{g} = 9.81\,\mathrm{m/s^2}$). Ignore all drag effects ($\vec{S}$ & $\vec{D}$). Assume that the ball is initially at rest $\omega_0 = 0\,\mathrm{rad/s}$.

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What's Next?

Updating UG curriculum:

- Physics 1: Pendulum.
- Physics 2: Particles in Field.
- Orbital Mechanics: Perturbations & Non-Impulsive Maneuvers [Curtis, 2019].
- Computational Methods for Scientific Research:
  - JetCurry & Active Galactic Nuclei [Li et al., 2017].
  - Periodicity of Binary Star Systems (in dev.).
  - Data Reconstructions via Fourier Methods.

Updating G curriculum:

- Electromagnetism: Wave Propagation & Yee Algorithm [Taflove and Hagness, 2000].
- Comparative Planetology: Ionospheric Currents [de Pater and Lissauer, 2015].
- NEW SPS5050: Computational Methods for Scientific Research (Graduate Level).

Keep building on overly positive feedback!

Curtis, H. B. (2019). *Orbital Mechanics for Engineering Students*. Elsevier, Oxford, UK, fourth edition.

de Pater, I. and Lissauer, J. J. (2015). *Planetary Sciences*. Cambridge Univ. Press, Cambridge, UK; New York, NY, updated second edition.

Gilat, A. and Subramaniam, V. (2013). *Numerical Methods for Engineers and Scientists*. Wiley, Hoboken, NJ, third edition.

Li, K., Kosak, K., Avachat, S. S., and Perlman, E. S. (2017). The JetCurry code. I. Reconstructing three-dimensional jet geometry from two-dimensional images. http://arxiv.org/abs/1702.00534v1.

Taflove, A. and Hagness, S. C. (2000). *Computational Electrodynamics: The Finite-difference Time-domain Method*. Artech House antennas and propagation library. Artech House, Boston, MA, second edition.