ODEN INSTITUTE
FOR COMPUTATIONAL ENGINEERING & SCIENCES

FALL 2024

MEETING #5

Computational Modeling in Engineering and the Sciences
Computer Science Undergraduate Directed Reading Program

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AGENDA

- Discussion
- Project structure
- Formulation summary
- Demo: 2-body problem

Assignment: Play around with the 2-body problem for 30 minutes. Catch up if needed.

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Discussion: Skim the papers and articles posted in GitHub about Moriba Jah, an astrodynamicist and self-described "space environmentalist." You may also want to take a look at his website and recent publications. What kinds of tools are used in the field of astrodynamics? What problems are we trying to solve? Who are the stakeholders beyond academia?

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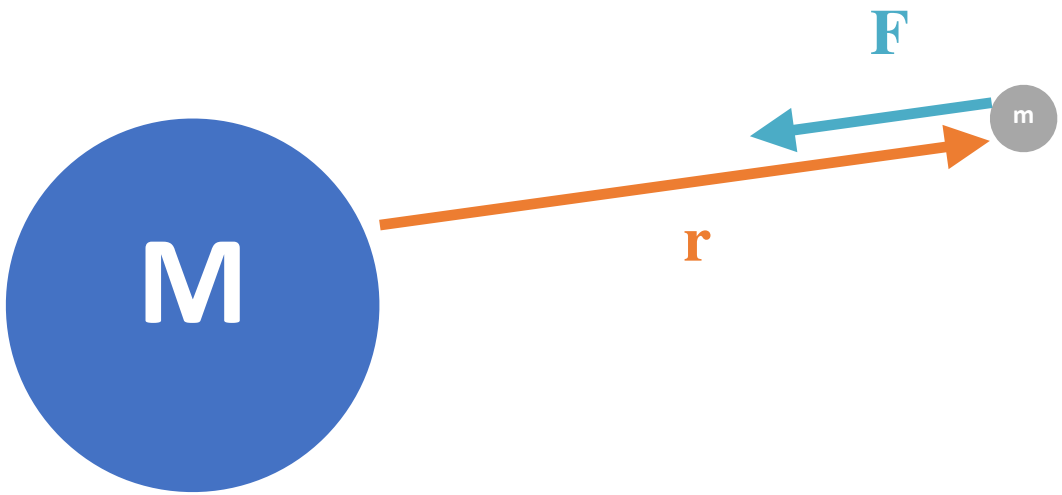
PROJECT STRUCTURE: SO YOU WANT TO BUILD A SIMULATION?

- Driver script: runs the show
- Problem setup
  - Parameter inputs (from “case” file(s)?)
  - Defining governing equations
  - Building your matrix
  - Applying constraints and boundary conditions
- Solution loop
- Output (to data file(s)?)
- Visualization and post-processing
- Error analysis and convergence studies
- Test scripts

FORMULATING THE 2-BODY PROBLEM



$$\mathbf{F} = -\frac{GM}{\|\mathbf{r}\|^3}\mathbf{r}$$

FORMULATING THE 2-BODY PROBLEM

Defining our differential equation

$$\frac{\mathrm{d}}{\mathrm{d}t}\begin{bmatrix} r_1 \\ r_2 \\ v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ -\frac{GM}{\|\mathbf{r}\|^3} r_1 \\ -\frac{GM}{\|\mathbf{r}\|^3} r_2 \end{bmatrix}$$

FORMULATING THE 2-BODY PROBLEM

Defining our differential equation

$$\frac{\mathrm{d}}{\mathrm{d}t}\begin{bmatrix} r_1 \\ r_2 \\ v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ -\dfrac{\mu}{\|\mathbf{r}\|^3} r_1 \\ -\dfrac{\mu}{\|\mathbf{r}\|^3} r_2 \end{bmatrix}$$

FORMULATING THE 2-BODY PROBLEM

Defining our differential equation

$$\frac{d\mathbf{U}}{dt} = \mathbf{f}(\mathbf{U})$$

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DEMO: 2-BODY PROBLEM

Demo time!

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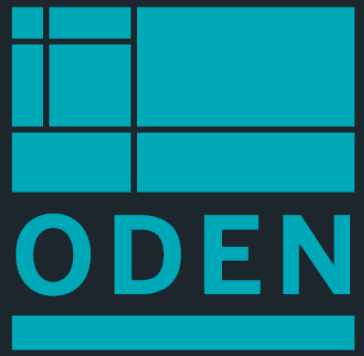
Assignment: Play around with the 2-body problem for 30 minutes. Catch up if needed.



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