Analytical mechanics: computational project

Use the Euler method to solve a classical mechanics problem that has no analytical solution.

Structure for the presentation and report

State the problem.
Describe the system. Use text and one or two diagrams. Bonus points if you motivate your problem: there a specific application? why is this otherwise interesting?

Use Lagrangian or Newtonian methods to determine the equations of motion.
Explain the logic behind important steps. Include a diagram with the generalized coordinates and parameters. It can be the same diagram from the problem statement.

Discuss the equations.
Does it recover simple behavior in certain limits? What are those limits and what do you expect to happen? Are there equilibrium points?

Briefly show your code and demonstrate that it works.
Show that your code provides the expected results in certain limits. (That is, show graphs of behavior you expect to happen. See above.) Or, show that your code provides the same values as hand-calculated values for the first few (3) time points.

Present your findings; highlight interesting or systematic results.
Explore the motion of your system. For example, try to:

- Vary a parameter systematically, while keeping initial conditions fixed. For example, change the mass from small to large. Keep the initial position, initial velocity and other parameters (like length) the same. See how the behavior evolves.
- Vary an initial condition systematically, while keeping parameters fixed. For example, change the initial velocity from small to large (and from positive to negative). Keep other initial conditions and all parameters fixed. See how the behavior evolves.
- Investigate how the behavior evolves from (or goes to) a known behavior. For example, going from simple harmonic oscillation to something *not* harmonic. Or if a system oscillates around a local minimum (stable equilibrium), at some point it will probbaly escape that minimum.
- Find different classes of behavior; or find something interesting to talk about.

Present your results as graphs, for example $x(t)$, $v(x)$, or whatever best shows what's going on. You can make a movie, if that sounds appealing. Describe and explain what you find; don't just say "here are the results." Report two results per person.

Dates and format of presentation and report

Work in groups of 2. There may be one group of 3; or one person can choose to work on their own. You will give a group presentation and submit an individually written report.

Presentations on Tue May 16. 12 minutes each group.

You can present all of it in a presentation application (Powerpoint/Google Slides/Prezi), or you can use the board for part of it (description of problem, equations of motion). The code and a demonstration that it works should be done live (Matlab).

Report due Fri May 19. 2-3 pages single spaced, additional space for graphs.

Use LaTeX. Email me a pdf. Reports must be written individually. Of course, the initial statement and equations will have the same content, and you can consult with whoever you're working with. However, use your own words for everything and the results section should be entirely different.