Dynamics Modeling of Complex Mechanical Systems: Final Project Proposal

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Fall 2025

FINAL PROJECT REMINDER

Recall from the syllabus that 25% of your grade in this class is a final project. See later sections of this document for a copy-paste of the final project specification from the syllabus, including my evaluation criteria and rubric.

The final project is due on Wednesday Dec. 10th, 2025, at 11:59pm (last day of class).

FINAL PROJECT PROPOSAL

It is important that you choose a topic which would realistically meet the project expectations. So, I am asking that you submit a **final project proposal** for my review. It is due, via Gradescope:

November 10th, 2025, 11:59pm

...which is one month before the project submission. I will review your proposals and give feedback within the week if I have concerns that the project may not be feasible.

Please write a proposal document that addresses the following five questions. Each question should take 2-4 sentences to respond; your overall proposal should not be longer than 1 page at most. No figures are needed.

1. <u>Problem Statement and Project Goal</u>

   If you are going to model a system, this should include a description of the system you plan to model, such as how many particles or rigid bodies will be included, and what motions you plan to simulate.

2. <u>Proposed Approach</u>

   This is typically "write Lagrange's equations of motion by hand, and perform a simulation in MATLAB." If this class project is part of a larger endeavor (such as a combination with other class projects), discuss what tasks will be unique to the final report you submit in this class.

3. <u>Experimental Design and Assessment</u>

   A description of how you will assess your success. For example, if you are running a simulation only, you should describe at least one method to test if you got it right. That may involve plotting or analyzing the total energy in the system vs. if you think it should be conservative or nonconservative, or different initial conditions that converge to the same equilibrium.

4. <u>Comparison Versus Project Specification</u>

   Why you think this will meet the criteria for the final project; specifically, if you believe your results are sufficient for 4 pages in two-column format. If not, propose a backup plan.

5. <u>Possible Challenges and Mitigation Plan</u>

   Any challenges you foresee. For example, "I have never written an equation on a report before / it will be my first time using LaTeX or MS Word's equation editor."

PROPOSAL SUBMISSION AND GRADING

Submit answers to these questions in any format you like via Gradescope, there is no template for the assignment.

There is no numerical score for this assignment and it does not factor into your final grade in this class. Yes, you could skip it entirely and still get an A. That is a poor plan, however: the more feedback you get from me, the more time you will save overall.

If you choose not to submit a final project proposal, I will be unable to offer flexibility, extensions, or individualized guidance closer to the deadline.

See the next page for the final project specification from the syllabus...

FINAL PROJECT

For the final project: Complete a task that demonstrates a skill you learned in this class.

Submit your final project results as a 4-page report in the two-column IEEE format.

The final project is mandatory to pass the class. Final projects are individual (no group work).

FINAL PROJECT SUBMISSION

Final project reports are due on the last day of class, **Wednesday, December 10th** at 11:59pm.

Please submit your report through Gradescope, no emails.

FINAL PROJECT GRADING

The final project is very open-ended on purpose, in order to accommodate the diversity of students taking this course. Consequently, the rubric for the final project will be flexible, and I will be generous when grading. You are welcome to show me an outline of your final project report at any point, and I can give the "OK" that your plan will get full credit.

Generally, your report should include:

1. Well-organized structure (25%). This includes a clear problem statement, an introduction, prior work or background on the problem, and references/citations to other attempts at solving it *or* the textbook/research paper you used for your equations.
2. Derivation, leading to some model of your chosen mechanical system (50%). Use the techniques we learned in class, somehow. Most commonly, you will derive the equations of motion.
3. Results and figures (25%). Simulate your results and write a discussion. You should anticipate including at least one or two figures, likely one that's a "problem setup" diagram of your system and one that is "simulation results." Please make all your plots clear and legible.

It is expected that equations appear in your final project. They will likely be extensive. Any equations you derive must be typeset in either LaTeX or the Microsoft Word Equation Editor. Do not include any pictures or photos of handwritten equations. Anticipate dedicating time to typesetting your equations. It would be challenging to demonstrate your learning in this class without writing equations, since that's how we will be spending most of our time.

You can include derivations we perform during class as part of your final project. The derivations must be typeset yourself rather than copy-paste from a resource online.

Hint: The equations in this class are typically long. If you use LaTeX, you have the choice of (a) using the `align` environment in LaTeX to split equations onto multiple lines, (b) using an environment that makes an equation span two columns, or (c) using a one-column version of the IEEE template and extending your report accordingly: it should be **twice as long, 8 pages**, if you use single column.

You will inevitably encounter issues in your concept! Explain them, discuss their implications, and suggest directions for the future.

It is acceptable to submit a final project with no working code or simulations as long as there is a strong mathematical derivation ("why it should work") and a discussion of the attempted simulation ("why it didn't work").

FINAL PROJECT IDEAS

You are allowed to use *anything you develop from August-December* as your final project. For PhD students, research results are a good idea. For MS students, this could be a class project for another course where you're now adding in a model / equations of motion. For undergraduates, consider modeling your senior design project.

Some past successful final project have included:

- Complete an additional problem from one of the textbooks (O'Reilly, for example, or Siciliano), with sufficient depth and detail to meet the length requirement (4 pages two column). People have done...
  - Robot arm with 3x links, in 3D
  - Race car with nonholonomic constraints for steering direction
  - Multiple tethered satellites with a flexible rope between them
- Add your own twist to one of the homework assignments: include some interesting force, or add another particle / body.
- Re-derive the equations of motion of some homework assignment using Newtonian instead of Lagrangian dynamics, and compare simulation results (which one is faster, more accurate?)
- Implement a simulation of some equations of motion from a research paper.
- Derive the equations of motion of your research project, and implement a simulation in MATLAB
- Re-implement one of the class' homework assignments in another programming langauge (e.g., Python or C++), and compare the results of the simulations (which one is faster, more accurate?)
- Perform a hardware experiment using a robot in the RASTIC center here at BU, record the trajectory of positions that the robot moved through in hardware, and compare against a simulation you implement
- ...or anything else creative!