Due

Friday, Oct. 31, 2025, 11:59PM. This is an individual assignment. You are bound by the policies outlined in the course syllabus.

Part 1

Only **handwritten** answers are accepted for this part. Show **all necessary intermediate steps** leading up to your solutions. Scan and upload your work as a **pdf** file in the myCourses assignment dropbox "Homework 4".

Problem: A physical phenomenon is described by the quantities P, ℓ, m, t, and ρ, representing pressure, length, mass, time, and density, respectively.

(a) If there is a unit-free physical law $f(P, \ell, m, t, p) = 0$ relating these quantities, show that there is an equivalent physical law of form $G(\ell^3 \rho/m, t^6 P^3/m^2 \rho) = 0$.

(b) Find P in terms of an arbitrary function.

Part 2

Final Project. You will carry out an individual independent research on an application of interest to you, in which mathematical modeling can be used to help address/analyze/solve a problem in that application area. The selection of the topic is up to you, subject to being in good taste and requiring mathematical modeling techniques that are at the level commensurate or above the methods covered in class. If you are doing any undergraduate research or doing a related project in another class, you are welcome to choose a topic related to your research or other project; however, this project should require you to do NEW work on that topic; recycling research or project work to package it for submission here is not acceptable.

The purpose of this project is to give you hands-on experience with mathematical modeling. Hence, it will not be sufficient to simply write a report that summarizes an existing paper or book section. If you wish to write a paper that is based on an existing mathematical model that has been applied to an existing problem, you will be expected to contribute new work, for example, by relaxing one or more of the assumptions to modify the model or by changing existing assumptions that allow you to draw new conclusions about the problem that have not already been reported.

Your Task. As the first step toward your individual final project, you will develop 3 project ideas (part 2 of this homework assignment). Each idea should be described in specifics, rather than as a vague scenario (see outline below). The main point of the assignment is to make

sure you are thinking of ideas for a project and have ample time to consider what specific question or problem you would like to address. We would like to encourage you to think about problems that you could passionately talk about in an interview setting.

For each idea, please write 1-2 paragraphs that address the following points:

- Briefly introduce the application field.

- Identify a specific problem worth studying, most likely in the form of a question to answer.

- List the variables and parameters you expect to be important in addressing the problem you have identified.

- Identify any variables you might initially treat as constants or neglect and explain why.

- Identify any data you would want to collect to inform the model and explain how it would be used.

- Briefly discuss a mathematical approach that would help to answer your question (1-2 sentences are fine). For example, you might consider what type of equations would be useful along with what mathematical questions you would want to answer.

Note. You do not need to address the points in exactly this order - do whatever works best for your ideas. Upload your document with 3 ideas as a **pdf** file in the myCourses assignment dropbox "Homework 4".

Material.

- Some examples of real-world problems where mathematical modeling can be applied are found here: https://www.contest.comap.com/undergraduate/contests/matrix/index.html.

- A pdf file containing pages from a textbook (Giordano, Fox, Horton) with COMAP contest problems is uploaded in myCourses (under Contents/Technical Report Related).

Feedback Process. We will provide feedback on which of the 3 ideas would be acceptable for your final project and any potential changes/additions to consider as soon as we can.