1 Term Project

1.0.1 Developing a rich-context homework question

For this project, you will develop your own homework question, and write the model answer. You will be practicing an important skill: how to pose a tractable quantitative question that leads to interesting insights. You have freedom to choose a topic that you find especially interesting/intriguing. Within this topic, look for questions where a quantitative result can give insight. Think broadly about topics: many topics that you encounter outside of the physics classroom are full of interesting physics. Please talk with the instructor about your topic ideas.

This is a multi-step, multi-week project with many opportunities to get feedback from the instructor. The main steps are:

1. Propose some possible topics and questions - receive feedback.
2. Write a draft of the question and answer - receive feedback.
3. Write a revised version of the question and model answer and submit a final portfolio. The final portfolio will show how your project developed. Steps 1, 2 and 3 will be included in the final portfolio.

A good question will lead you into "the unknown" (an area of knowledge that is new to you). Your model answer will show how coarse-grained modeling of the system, followed by quantitative reasoning/calculations, can shed light on the unknown. For guidance on style and difficulty, look at examples of rich-context questions that are set by the instructor during the course.

The final version of your question should be posed in a way that is accessible to a well prepared PH315 student. The final version of your model answer should be written in a style similar to a physics textbook. Explain each step so that a PH315 student can clearly understand how you constructed your solution.

1.0.2 The schedule

1. Three ideas for the term project due a few weeks into the course.
2. Draft of Term Project due about halfway through.
3. Term Project due the last week of class.

1.0.3 Guidelines

The model answer should follow the mathematical communication guidelines, and the long-answer format, described in Writing answers to HW questions.

If you are typing your submission, be familiar with the 9 rules of Typography in Physics Guide to Professional Typography in Physics.

1.0.4 Rubric

The final portfolio will be graded based on the following components:

1. **The Question (30%)** *(start on a new page)*
   - Give context to motivate the question.
   - Include a visual aid, such as an image from the internet and/or a hand-drawn schematic.
   - A well prepared PH315 student should understand what the question is asking them to do. The question might need scaffolding into separate steps, part (a), part (b), etc.
   - The question should invite the application of physics concept(s) and physical reasoning. Ideally, the student will need to set up (or utilize) a physical model to answer the question.
   - Include any quantities that are needed to solve the question. Alternatively, you may decide that some quantities can be easily estimated or found on Google.
   - List any references you used when developing the question (for example a web address).
2. **The Solution (40%)** *(start on a new page)*
   - Explain your solution to the question (all steps) using clear communication and following the Mathematical Communication Guidelines (Writing answers to HW questions). A PH315 student should be able to understand how you constructed your solution. Your reasoning should be based on valid physical principles and consistent with the physics involved.
   - Include at least one diagram that helps explain some aspect of the physics in your solution.
   - Remember that calculations and physical reasoning are at the heart of your answer. If your calculations and physical reasoning are getting obscured by other details, you should consider a more concise way to explain things.
   - If you are typing up your solution, refer to the Physics Typography Guidelines (Guide to Professional Typography in Physics).
   - Interpret your answer: make sense of what your answer means.
   - If you gained insight/inspiration from an outside source, list any helpful references.
3. **Bonus points (10%)**
   - Bonus points may be earned if you worked on a particularly difficult/challenging problem. Bonus points will not enable you to score more than 100%, but may make up for other deficiencies.
4. **Appendix (15%)** *(start on a new page)*
   - The appendix serves as evidence that you engaged in the process of drafting and revising your work.
   - The appendix includes
     - Your first list of three project ideas, and the instructor comments.

  - Your first draft of the question/solutions, the peer reviewer comments and the instructor comments.
  - Other suggestions/comments your received from the instructor.

5. **Process Memo (5%)** Write a few sentences addressing each bullet point:
   - What went well? What do you like about your question and solution?
   - What technical knowledge did you gain while doing this term project?
   - In what ways did the project help strengthen your ability to make quantitative estimates about physical systems?
   - Do you give permission for the instructor to share your question (only the question, not the model answer) with the class? The question would only be accessible on this Canvas website. Authors of questions will remain anonymous.

1.0.5 Example topics

- https://what-if.xkcd.com/ What if... by Randall Munroe.
- Space travel
  - Freeman Dyson's idea for nuclear-blast-powered space travel (project Orion)
  - Electrically powered spacecraft propulsion
  - Moving the sun to a different part of the galaxy with a stellar engine.
  - Non-rocket space launch, including space tethers. (Word of caution: I have struggled to design a coarse-grain model for the space tether concept. I haven't found a good resource yet.)
  - Space elevators - why we care and what is needed to build one: Article in Physics World (Links to an external site.), Article in Am. J. Phys. (Links to an external site.)
- Nuclear power
  - Third-generation nuclear reactors that are "fail-safe", for example, the reactors made by NuScale power in Corvallis.
  - Using a particle accelerator to drive specific nuclear reactions, thereby solving many of the issues with conventional nuclear reactors, https://en.wikipedia.org/wiki/Energy_amplifier
  - Creative solutions to the nuclear waste storage conundrum
  - Thorium based nuclear power. (MacKay has section of this?)
  - A number of private companies are working on their own fusion reactors, using innovative technology, https://physicstoday.scitation.org/doi/10.1063/PT.3.3994 (Links to an external site.)
- Carbon sequestration:

  - Sustainable biochar to mitigate global climate change. (Journal article from 2010 (Links to an external site.) describing an estimate)
  - How much time, energy and money does it take to capture 1 ton of carbon dioxide from the air (if we used technology rather than trees) https://www.nature.com/articles/d41586-018-05357-w and https://doi.org/10.1016/j.joule.2018.05.006
  - Old-Growth Trees and Climate Change: https://www.wired.com/story/trees-plants-nature-best-carbon-capture-technology-ever/

- Renewable energy
  - Extracting power from temperature differences in the ocean (Scientific American, January 1987). Updated information from a government pilot project.
  - Wave energy on the Oregon coast.
  - Comparing the efficiency of photovoltaics to photosynthesis.
  - Geothermal power (Links to an external site.) in Oregon.
- Why some gas molecules are 100 times "more potent" as greenhouse gases
- Can medical x-rays be performed with less radiation exposure (are we close to the fundamental limit)?
- Passive cooling below ambient air temperature under direct sunlight, Nature 2014.
- Oil pipelines - for example, pumping oil (and keeping it warm) along the 800 miles of Arctic landscape.
- A magnetic levitation machine.
- Ion-drive aircraft
- Intercontinental quantum encryption
- Lasers with continuous-wave output power greater than 10 kW might be possible?
- The physics of baking a perfect pizza
- Energy to watch an online video (Minute Earth video (Links to an external site.)). Estimating a few picoJoules per bit (Links to an external site.).
- Extracting energy from black holes (Minute Physics video)