**Fluid Mechanics CHEG 341**
Department of Chemical and Biomolecular Engineering
University of Delaware Fall 2020
**Mini-Project #2**

**Project Statement:** In this project, you are tasked with designing a series of decorative fountains for a wealthy Delawarean who is a UD Chemical Engineer alumnus and an admirer of Pierre S. du Pont's work at Longwood Gardens.

**Learning Objectives:**

- Demonstrate macroscopic Mass, Energy Balance, & Momentum balance concepts, along with knowledge of pipe flow, learned in first 6 weeks of the course
- Create a viable design solution that meets specified needs and considers safety factors

**Deliverable:** You will prepare a brief written report detailing your design. A completed report will include the following components (see the rubric on the last page and in canvas for the exact grading details, summarized in the following):

1. Title page. Single page with your name, project information, date submitted
2. Executive Summary. A single paragraph briefly describing all of the enclosed components. Less than 1 pg.
3. Introduction. A brief introduction/objective statement to the problem (*do not* pull directly from project statement)
    - Must include clearly articulated design criteria
    - Must include any background literature used in the report (background on Longwood Gardens or other historical fountains, and/or Pierre S. du Pont's work)
4. Design Details. Systematically describe the key aspects of your design and the most relevant details that come from your calculations. These should be supported by relevant plots/graphics. Include any graphics, plots, schematics, and calculations that are most critical for the client to understand your design and describe them in the text. Include section subheaders to organize the different design components.
5. Discussion. Include general recommendations for implementing your design, potential pitfalls or challenges, next steps your client should take, and possible alternative approaches
6. References (if any)
7. Appendices. Include an organized appendix (or appendices) with any important calculations, software outputs. This should be clearly annotated; do not just data dump.

Additionally, the completed report must include the following formatting components

- Times New Roman or Arial Font size 11; single or 1.5 spacing
- Title page with three lines: your name, Mini-Project #2, the date submitted
- Page numbers in the bottom right corner of the footer
- Document has less than 5 glaring grammatical errors
- Section headers (#ed above) should be bolded. Subheaders bolded & italicized
- Any figures, equations, calculations, schematics that appear in the main report should be professional level figures and created with a computer. Anything appearing in the Appendix can be images of handwritten calculations.
- Any equations used must be listed and formatted in the document. They must be numbered sequentially
- Results should be summarized in graphs and tables. These should also be numbered sequentially
    - Figures/Tables should be mentioned in the narrative. Each mention should be bolded. Example: "*The height of fluid in the tank was calculated using Eq. 4 and varies with time, as plotted in **Figure 2**.*"
    - Every Figure/Table must be accompanied by a descriptive caption
    - Figures/Tables should be inserted either as "floating" objects (off to the side of the text) OR in line immediately following the first mention and appear next to the first mention
- References to any outside sources must be included and mentioned in appropriate places in the text. The full citation will be listed in the Reference section at the conclusion of the report. Follow the ACS style guide for reference formatting: https://pubs.acs.org/doi/full/10.1021/acsguide.40303

**Design details:** You have been hired to provide a scale schematic for the design of a series of decorative water fountains on approximately 1 acre of land. Since this is an aesthetic undertaking, your client appreciates creativity in your design. The dimensions of the design space can be seen below:

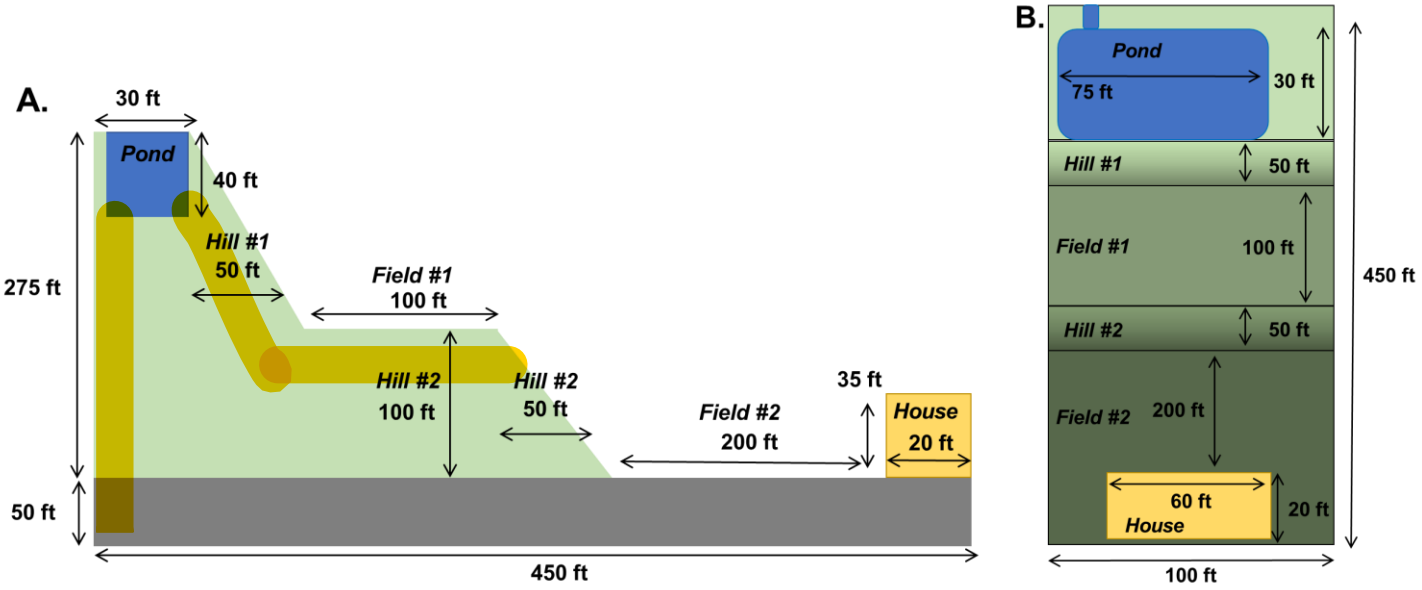


*Figure 1. Schematic of design area, showing the house and pond, as well as relevant landscaping features. A) Elevation view and B) area (plan) view.*

Your client is a graduate of the UD Chemical Engineering program and has always been inspired by the various pools and fountains the at Longwood Gardens. As such, your client has some specific requirements and expects your design to pay homage to Pierre S. du Pont's work:

- Your client wants at least one large fountain on field #2 directly in front of the house that is inspired by the Main Fountain Garden. At a minimum, the fountain should have one vertical jet able to reach 100 ft and no less than 3 angled jets that all collect into a single fountain pool.
- Your client also has a perfect view of hill #2 and would you to include either an elegant cascading waterfall stair in an arched retaining wall (like those on the east and south sides of the Main Fountain Garden in Longwood Gardens, which resemble the stairs in the water theatre at the Villa Torlonia in Frascati, or the Villa Aldobrandini, Frascati, Lazio, Italy) or a series of fountains along a terrace (like those on the south side of the Upper Canal in Longwood Gardens, which resemble the Avenue of a Hundred Fountains at the Villa d'Este near Rome).
- Finally, your client has a huge respect for his fellow Chemical Engineers and wants to see your creativity. He expects you to include at least one creative element in field #1 and/or any other locations of your choosing.

Given that your client is also a chemical engineer, he has made some other key requests:

- The fountain designs should be largely driven by gravity, using the pond at the top of the hill. However, in keeping with Pierre du Pont's work, you may use as many as two 100-horsepower supply pumps if needed, provided you choose the type of pump and place it somewhere that can be easily accessed for repairs.
- Your client expects that your system will be built with standard piping equipment available in DE. As a practicing engineer, he expects that final values in your report will be in U.S. imperial system of units.
- Your client expects that you will provide all of your calculations along with any schematics in your final report. Through AppsAnywhere, UD provides access to AFT Fathom, which may serve as a valuable resource (although not required).
- Your client does not want to see any above ground piping to carry the water to the various fountain locations; you are allowed to place all pipes underground within both hills and fields and up to 50 ft below the house, or provide some aesthetic covering (landscaping) to those above ground.
- The client encourages recirculating as much water as possible. You may assume the pond at the top of the hills can be maintained at a fixed height (supplied by a stream) and may neglect any evaporation that occurs in either the pond or the water elements.

- Your client also wants to be able to monitor the system and is concerned about safety. Your design should include recommendations for instrumentation to monitor system performance and include what types of instruments (*i.e.*, what should be measured) and where they should be located. Additional safety features (*i.e.*, relief values, overflow systems) should factor into your design.
- Fluid properties. Your client wants the fountain to be operational between May and September, estimating a temperature range from 50-90°F. Ensure that your design is appropriate based on the viscosity and density of water for all temperatures within this range.
- There are several methods of control (pump timers, electronic water level controls, etc.) that ease the operation and enhance the function of decorative fountains. Determining the electronic specifications of these controls is beyond the scope of this design; however, you should include a control panel location within your schematic and comment on what control mechanisms would be appropriate to include in your proposed design. Indicate the location and type of valves or fittings required for your proposed controls in your schematics.

**Rubric:** This is the rubric that will be used to grade your project. Only the items listed below will be considered when evaluating the project. A completed assignment must have all of the items confirmed as complete; thus a "no credit" in any one of the items will mean a no credit for the project. Use the listed items as a checklist prior to submission to make sure that you receive credit for the assignment.

***Overall Report***

| | **Complete** | **No credit** |
|---|---|---|
| Title page with your name, class section, date submitted and Mini-Project #2 | | |
| Executive summary is only 1 pg with at least >=1 sentence about design criteria and major design features | | |
| Formatting is correct (times/arial 11, correct pg 1 header, footer all pages, sections bold, subsections bold/italics) | | |
| Less than 5 glaring grammatical errors found | | |
| Equations, Figures, Tables formatted appropriately and computer generated | | |
| References included and formatted correctly in main text and the concluding reference section | | |
| Introduction clearly states design criteria and any relevant literature inspiration | | |
| Discussion includes >= general recommendation for implementing your design | | |
| Discussion includes >= 1 potential pitfall/challenges and >= 1 next step your client should take | | |

***Design Features***

| | **Complete** | **No credit** |
|---|---|---|
| One large fountain on field #2 with 1 vertical jet capable of reaching vertical 100 ft. Dimensions and locations of pipe networks, flow rates, angles, and locations for jet clearly indicated. | | |
| One large fountain on field #2 with >= 3 additional angled jets that all collect into a single fountain pool. Dimensions and locations of pipe networks, flow rates, angles, and locations for jet clearly indicated. | | |
| Calculations provided and generally accurate for the field #2 fountains, considering correct pipe friction, fitting, and pump equations | | |
| Equipment clearly specified for field #2 feature. | | |
| Either a cascading waterfall stair or vertical fountain terraces on hill #2 with at least 2 or more elements (stairs or jets). Dimensions and locations of pipe networks, flow rates, angles, and locations for jet clearly indicated. | | |
| Calculations provided and generally accurate for the hill #2 feature, considering correct pipe friction, fitting, and pump equations, | | |
| Equipment clearly specified for hill #2 feature. | | |
| Additional creative water element included in field #1. Dimensions and locations of pipe networks, flow rates, angles, and locations for jet clearly indicated. | | |
| Calculations provided and generally accurate for the field #1, considering correct pipe friction, fitting, and pump equations. | | |
| Equipment clearly specified for field #1 feature. | | |
| No more than two 100-horsepower pumps are used in total. If used, the type of pump and location is clearly indicated | | |
| Pipes used are standard US with schedule numbers indicated. Standard fittings are also indicated clearly throughout. | | |
| All values in main report are in US imperial units | | |
| Monitoring equipment for the 3 or more water features are clearly included, as well as a control panel and designated read-outs | | |
| At least 1 or more safety considerations have been included | | |