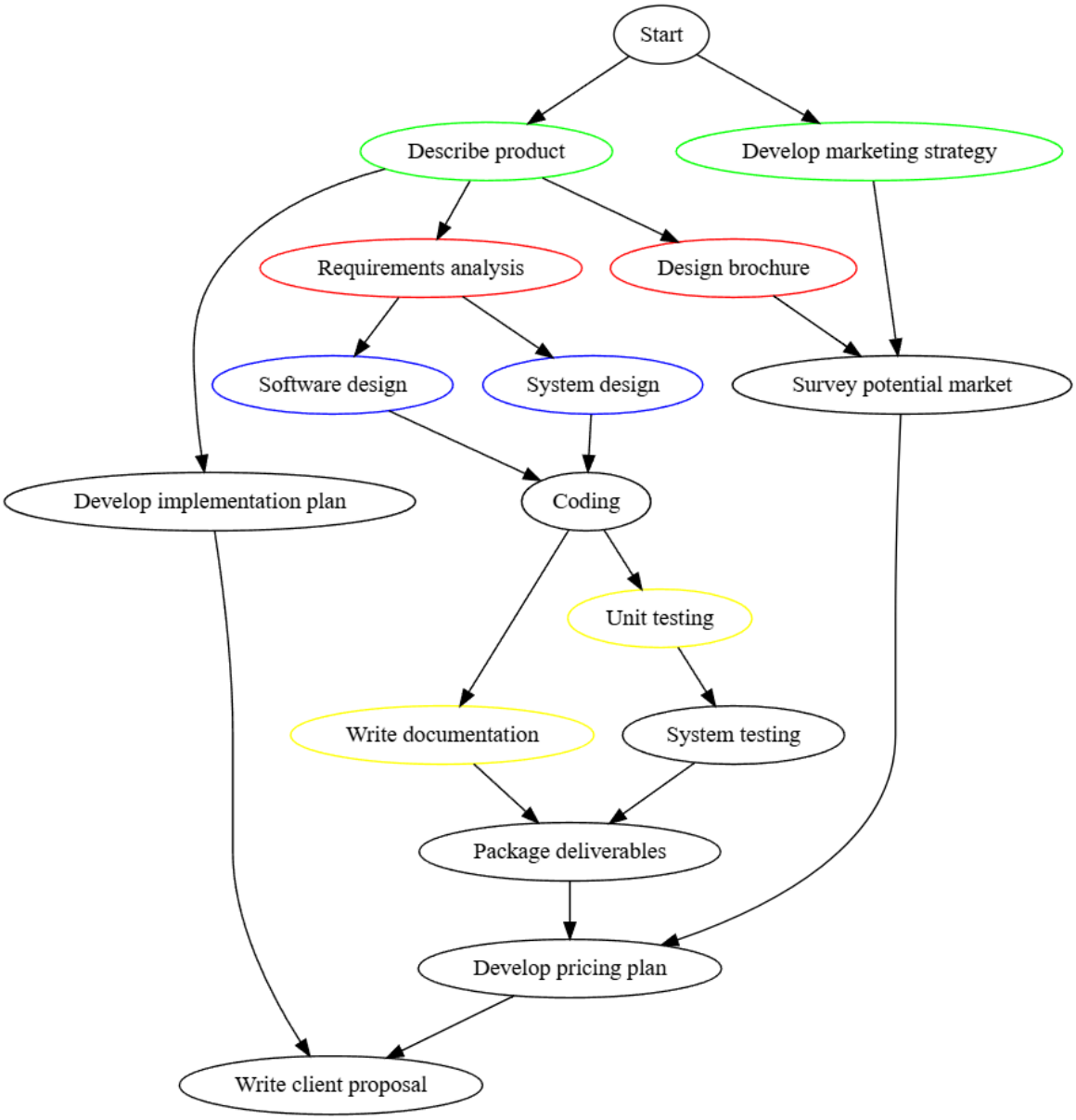
**Part 1: Problem Setup**

In the original project plan Excel spreadsheet, a list of 16 tasks was given along with a column indicating predecessor tasks. The best-case hours, expected hours, worst-case hours, and employee columns needed to be determined. ChatGPT was used to estimate these values based on industry standards for software development and data science projects. The full chat log can be found here and in the GitHub repository along with the updated project plan spreadsheet. Below is a directed graph showing each task and their dependencies:




Tasks with the same color border denotes tasks that can be worked in parallel.

Since ChatGPT used industry averages rather than real-world project data, the estimates may not reflect realistic performance. Tasks may be more complex than initially anticipated leading to longer completion times. Scope creep is also a factor that could add uncertainty to the estimates. This model also assumes all contributors charge the same rate and thus should have the same technical expertise. This assumption also affects the accuracy of the estimates.

**Part 2: Model specifications**

The problem can be set up as a linear programming minimization problem. The decision variables are each of the tasks with the lower bounds determined by the best-case, expected, and worst-case hours. The objective function is the sum of the hourly rate of each task multiplied by the duration.

**Part 3: Programming**

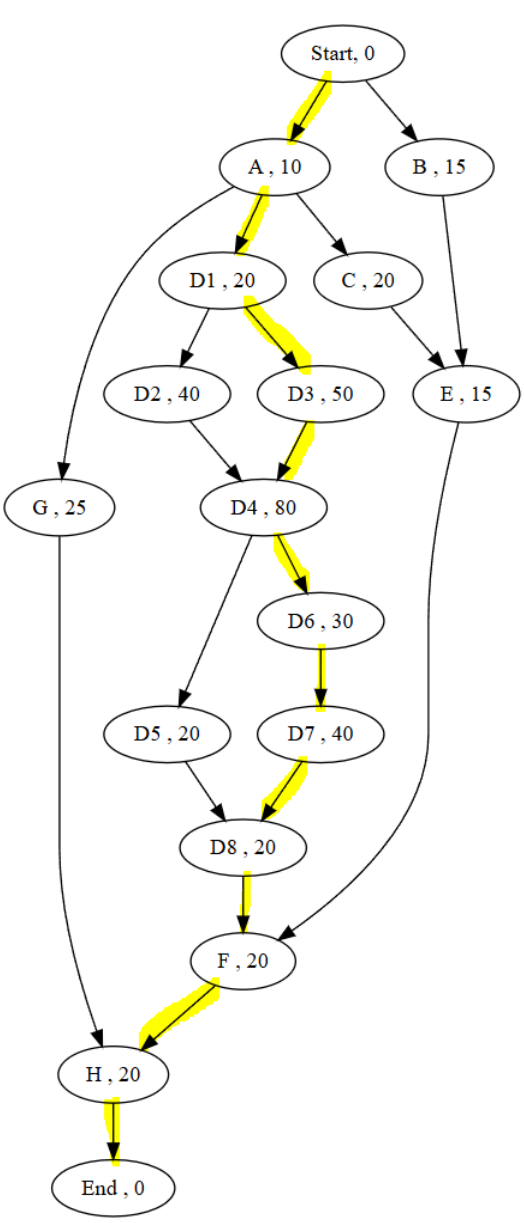
The PuLP module in Python was used to solve the linear programming problem for the best-case, expected, and worst-case hours. The full outputs for each scenario can be found within the GitHub repository.

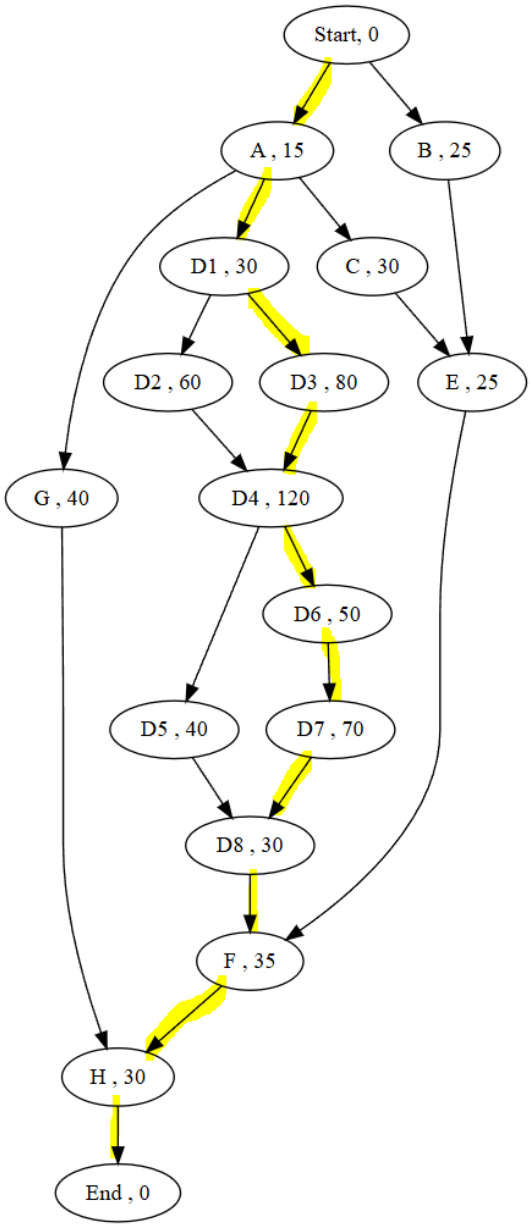
**Part 4: Solution**

The minimum cost of the project under each scenario is:

- Best-case: $188,000.00
- Expected: $298,000.00
- Worst-case: $476,000.00

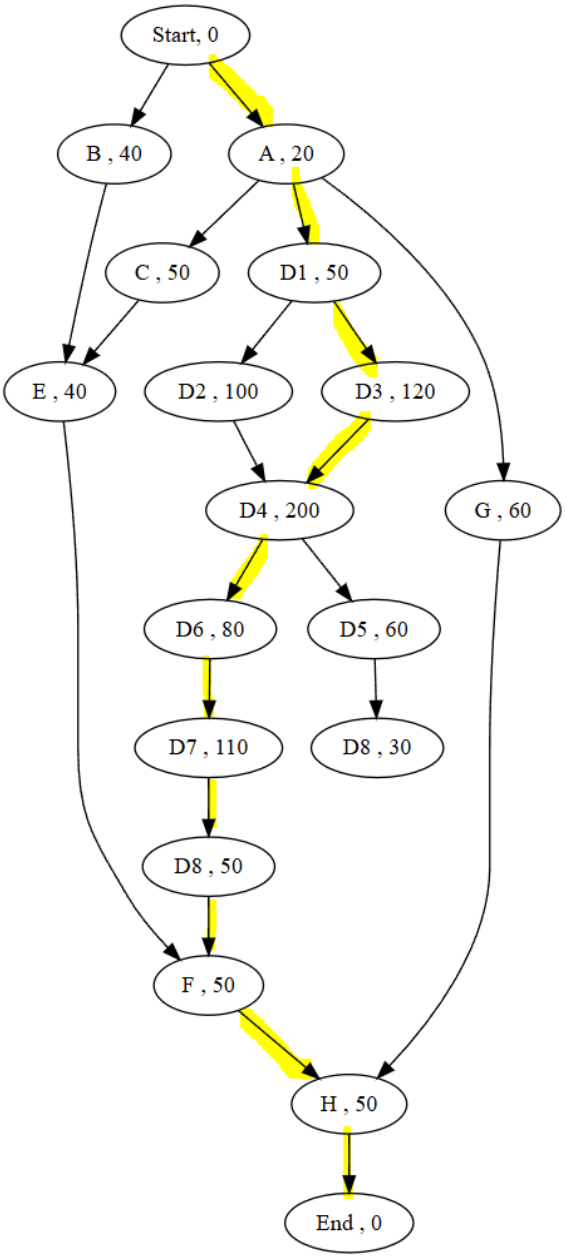
The critical path for each scenario was determined using each task's start and duration to determine which activities deserve the most attention (i.e., are "critical" for the project). From the critical path analysis, it is evident that the path through the development cycle is the critical path.



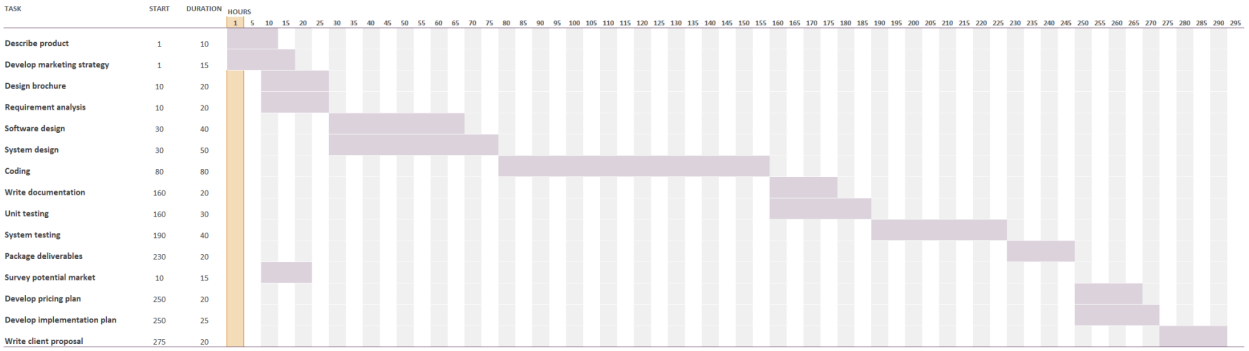



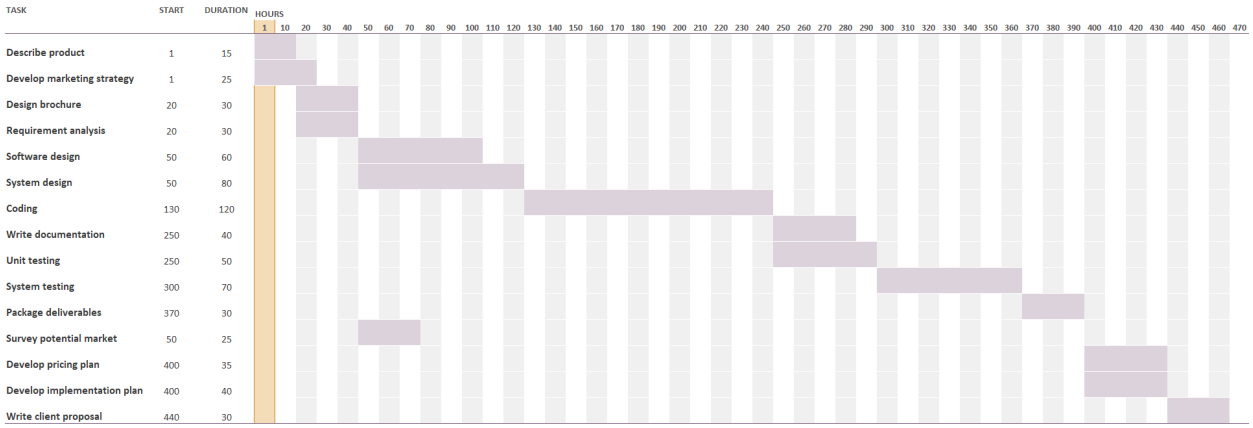

Left: Best-case scenario critical path

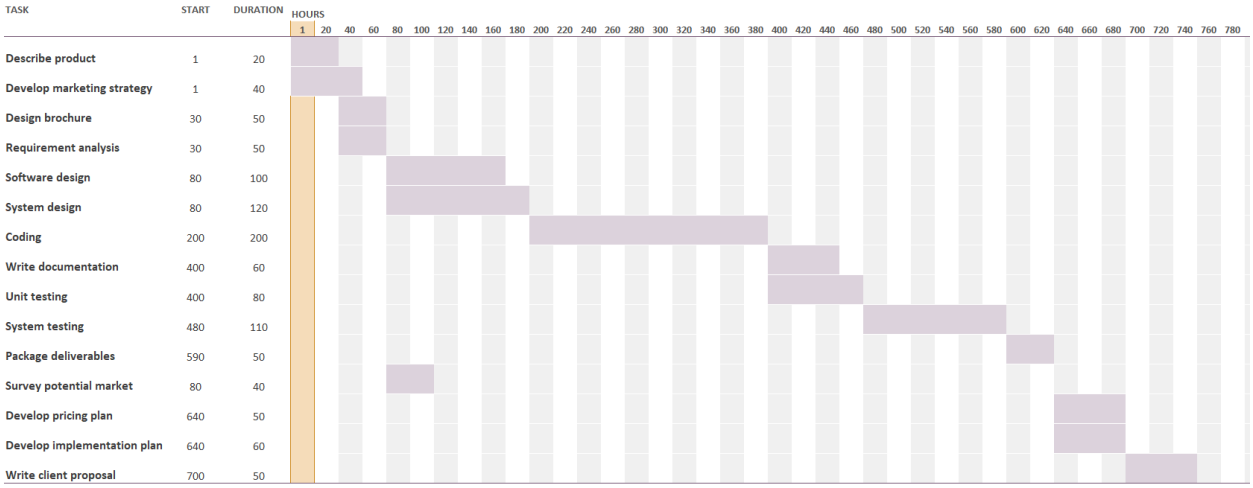
Right: Expected scenario critical path




Worst-case scenario critical path




Top to bottom: Gantt charts for best-case, expected, and worst-case scenarios

## Part 5: Overview

This project will develop a consumer-focused restaurant recommendation system for the Marlborough, Massachusetts restaurant community. A small but effective development team will

be assembled, including frontend developers, backend developers, data engineers, data scientists, and a project manager. Each team member will work at the hourly rate of $100. The estimated length of the project will be 12 weeks coming out to the cost of approximately $298,000. Additional independent contractors could be hired onto the development team to reduce the most time consuming portion of the project i.e. coding. While uncertainty is inherent in software development, Monte Carlo simulations and stochastic programming can be used to manage risks and improve delivery predictability. Monte Carlo simulations can use historical project data to estimate confidence intervals for task completion dates. Stochastic programming can create probabilistic models to optimize resource allocation under varying conditions.