Howitzer Firing Simulator
ENSE 375 PROJECT

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Howitzer Firing Simulator - Kinematics and Dynamics Training

The Howitzer Firing Simulator educates soldiers about kinematics and dynamics, essential for accurate howitzer operations. Kinematics focuses on projectile motion (position, velocity, acceleration), while dynamics considers forces influencing the flight.

Requirements and Rationale

- The simulator needs a robust physics-based modeling approach which involves implementing equations for rigid body kinematics and dynamics.
- To provide an effective training tool, the simulator requires real-time visualization of the projectile's trajectory.
- The simulator needs to have scenario customization, where a user can account for fluid density and external forces.
- As this helps to create specific training exercises and also help learn operational contexts to soldiers.
- The simulator needs to undergo thorough testing and validation using various techniques like boundary value testing, equivalence class testing, and others in order to handle operational errors.

Problem Statement

The main problem this project is trying to solve is the need for an effective and interactive training tool for soldiers operating howitzers. By creating a, project aims to provide a virtual environment where soldiers can learn and understand the kinematics and dynamics involved in firing a projectile accurately. The simulator will help soldiers understand the impact of various factors such as barrel pose, projectile mass, drag coefficient, initial speed, force applied, and gravity on the trajectory of the projectile.

FUNCTIONS

- Users have the freedom to adjust essential parameters like barrel pose (position and orientation), projectile mass, projectile radius, initial speed, drag coefficient, and applied force.
- The simulator should be able to allow the user to apply external forces to the projectile, simulating factors like wind or other external factors, allowing soldiers to observe how drag forces impact trajectory and distance traveled.
- The simulator should use precise physics modeling based on rigid body kinematics and dynamics equations. This focus on accuracy ensures that the simulator is a dependable training tool, helping soldiers develop their skills effectively.
- To ensure a smooth learning experience, the simulator gracefully handles invalid inputs and exceptional scenarios.

OBJECTIVES

- Provide a realistic and immersive training environment to understand the kinematics and dynamics involved in firing a Howitzer.
- Allow experiments with different variables, such as barrel pose, projectile mass, drag coefficient, etc., to observe their impact on the projectile's trajectory.
- Enable users to analyze and learn from the simulation results, gaining insights into how various factors affect the Howitzers' firing accuracy.

CONSTRAINTS

- Numerical Accuracy: The accuracy of the simulations might be limited by numerical precision in representing floating-point numbers.
- Economic Factors: The simulator should be developed within a reasonable budget and within a specified time frame.
- Effective Feedback: Design the simulator to provide clear, real-time feedback on the projectile's trajectory
- Reliability: Design the simulator to be highly reliable and available, minimizing downtime and technical issues during training sessions.

Solution 1

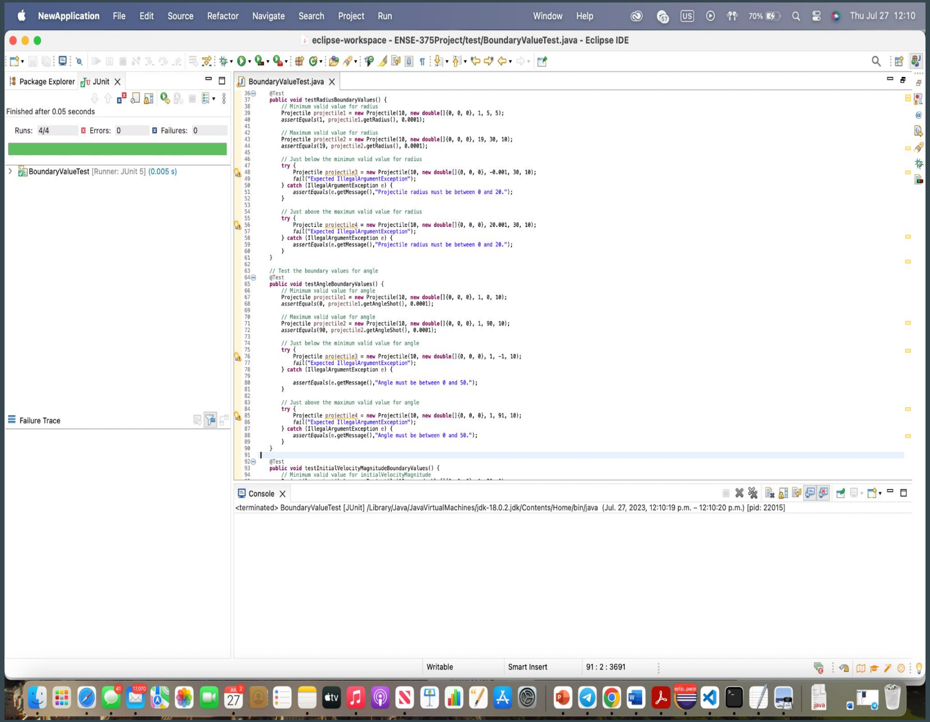
- Solution 1 was quite basic where we made a howitzer simulator to take barrel position, barrel orientation, initial velocity, gravity, radius, and mass of the projectile and made a simple howitzer.
- We carried out Boundary value testing and equivalence class testing to ensure the values are correct.
- Solution was not desirable and code needed a lot of refactoring.

Solution 2

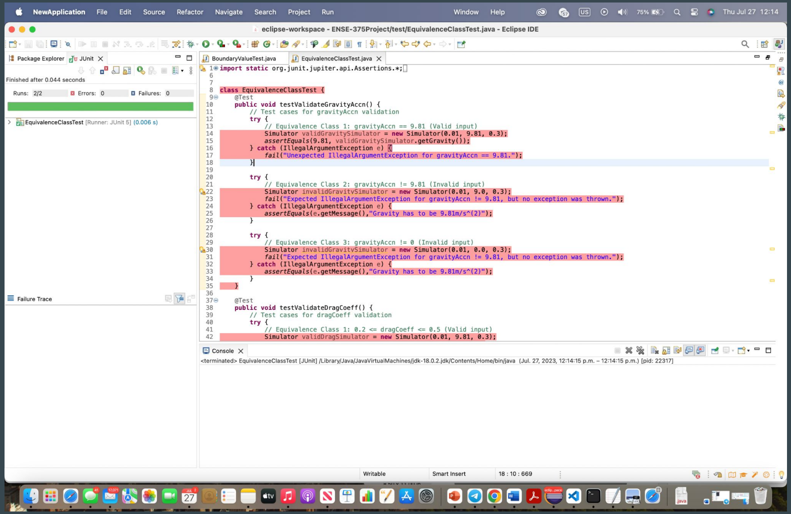
- Solution 2 was an incremented version on Solution 1. We trimmed out lots of complexities and refactored some code.
- We added some additional factors to consideration for our simulator such as, drag coefficient and fluid density to our calculations. Our calculation seemed a bit realistic with plenty of errors.
- We carried out Boundary value testing and equivalence class testing to ensure the values are correct. Further, we conducted path test using eclipse Emma to find out the code errors.
- Solution was not desirable, code needed a lot of refactoring, and external force needed to be taken into account.

Solution 3

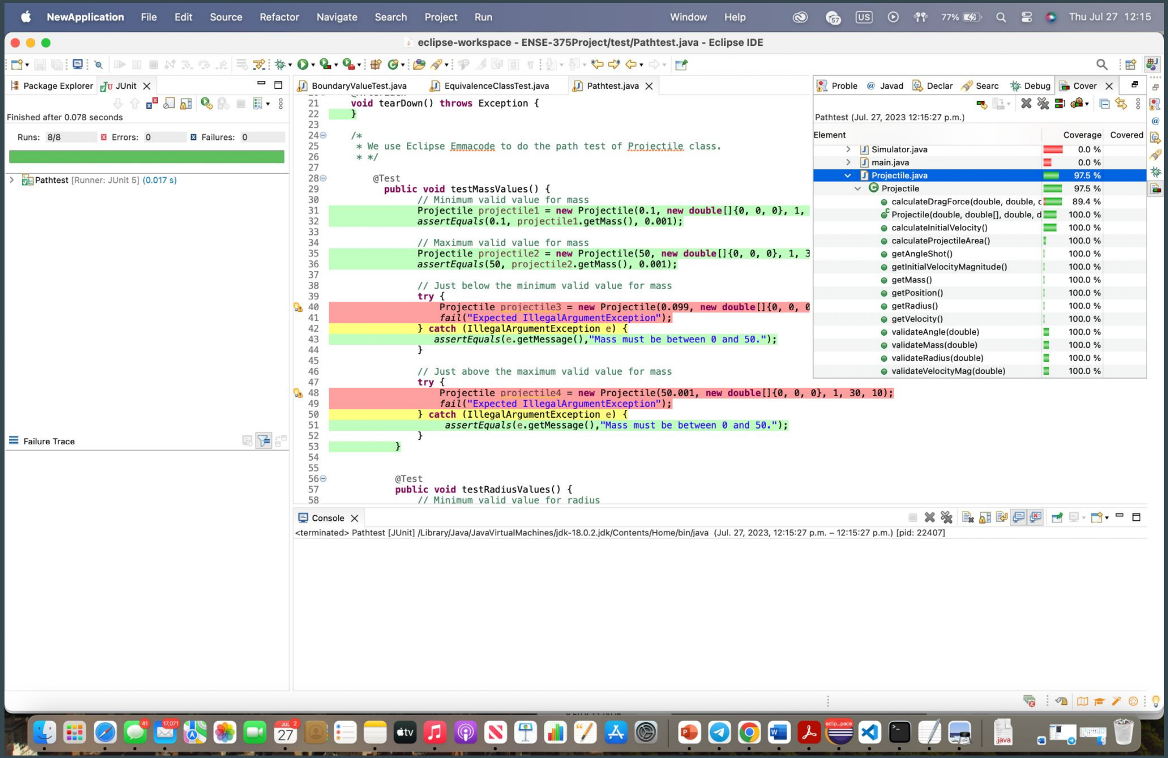
- Solution 3 is the final solution for the howitzer simulator. We made our design for application a lot simpler and refactored most of the code.
- We added some additional factors to consideration for our simulator such as, external forces. We also fixed some of the conversions that were causing errors.
- We carried out Boundary value testing and equivalence class testing to ensure the values are correct. Further, we conducted path test using eclipse Emma to find out the codes. Lastly, we carried out data flow testing, to get rid of issues related to variable usage.
- Solution seemed desirable when carried out decision table testing combined with others.



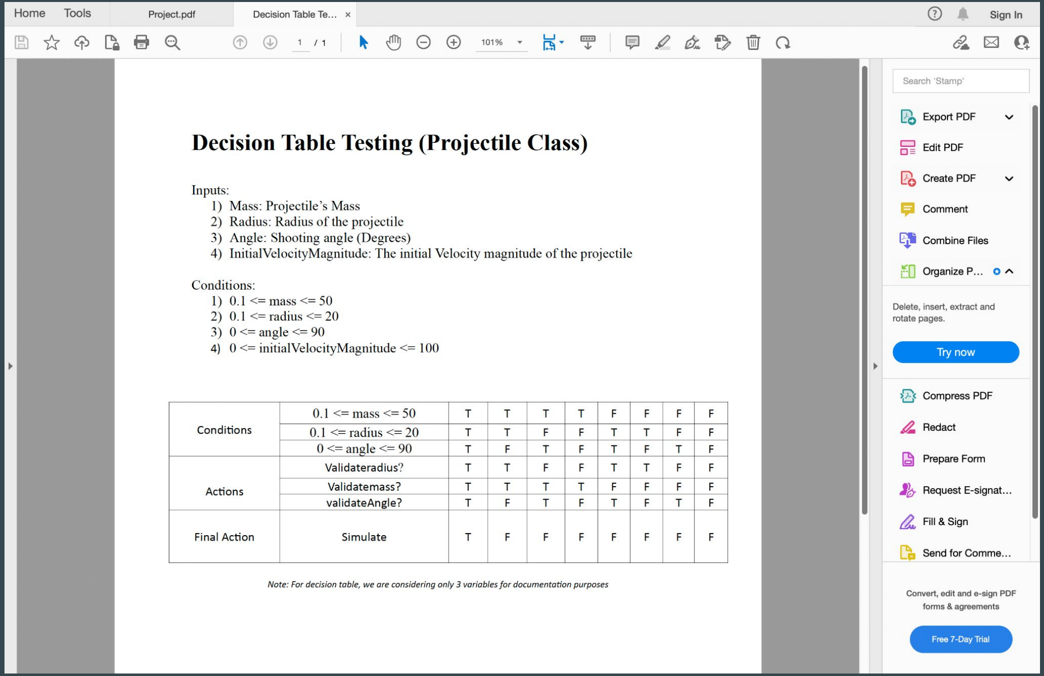
Above is an image of Boundary Value Test from Solution 3



Above is an image of Equivalence Class Test from Solution 3



Above is an image of Path Test from Solution 3 for Projectile Class



Decision Table Testing (Projectile Class)

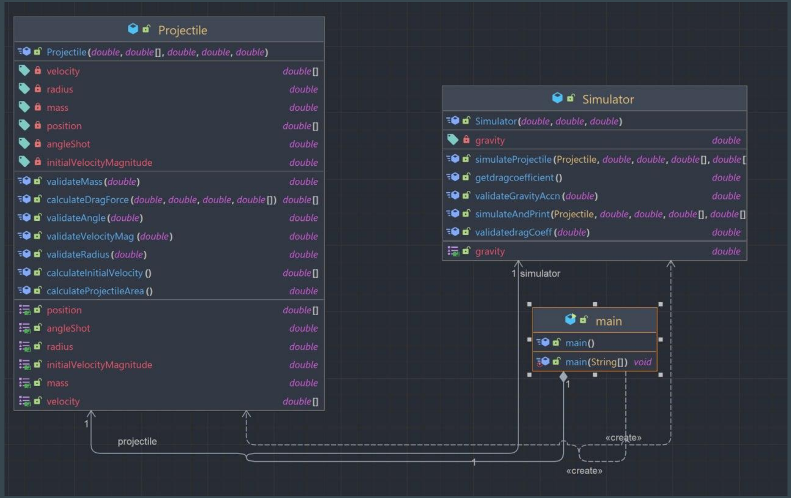
Inputs:
1) Mass: Projectile's Mass
2) Radius: Radius of the projectile
3) Angle: Shooting angle (Degrees)
4) InitialVelocityMagnitude: The initial Velocity magnitude of the projectile

Conditions:
1) 0.1 <= mass <= 50
2) 0.1 <= radius <= 20
3) 0 <= angle <= 90
4) 0 <= initialVelocityMagnitude <= 100

Conditions	0.1 <= mass <= 50	T	T	T	T	F	F	F	F
	0.1 <= radius <= 20	T	T	F	F	T	T	F	F
	0 <= angle <= 90	T	F	T	F	T	F	T	F
Actions	Validateradius?	T	T	F	F	T	T	F	F
	Validatemass?	T	T	T	T	F	F	F	F
	validateAngle?	T	F	T	F	T	F	T	F
Final Action	Simulate	T	F	F	F	F	F	F	F

Note: For decision table, we are considering only 3 variables for documentation purposes

Above is an image of Decision Table Testing from Solution 3

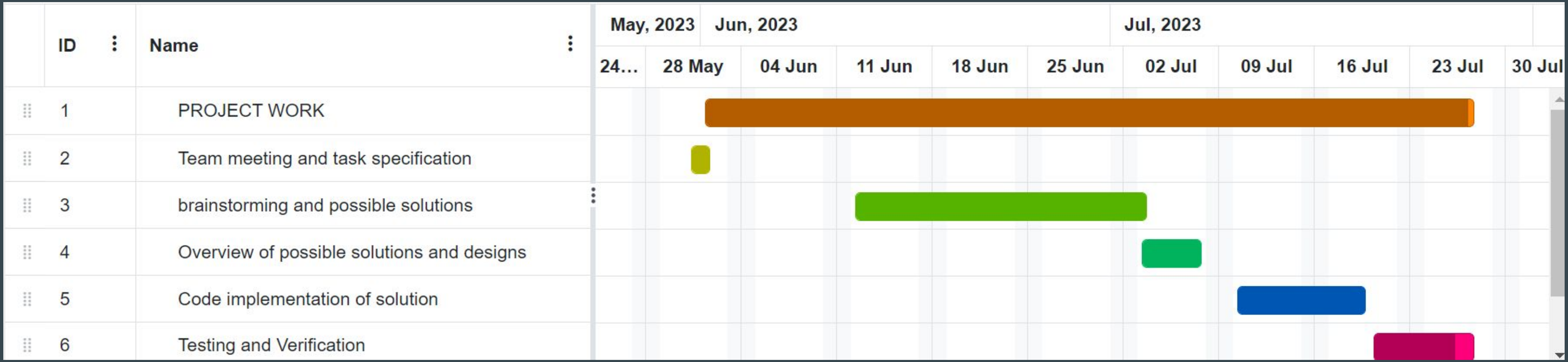


Above is an image of application design for Solution 3

MVP Comparison

Solution 1	Basic calculation model, with basic parameters for howitzer simulator. Unorganized code and full of errors.
Solution 2	Added drag coefficient and fluid density, in addition to basic parameters for howitzer simulator.
Solution 3	Added external forces to calculation, in addition to basic parameters for howitzer simulator. Executed tests including system testing and integration testing to make sure code returns intended results.

Project Management



Conclusion and Future Works

- To conclude, we as a team got to learn so much from this project about software development, software testing, software planning, designing and documenting the whole process. We also faced some difficulties in managing project but we were able to overcome them and build a Howitzer Simulator successfully.
- Future works include such as including a graphical user interface and some animations to make simulator more interactive and user friendly, include some advanced physics model to incorporate terrain and environment around the howitzer.

Questions?