Lab 08 Artillery Design

Class Diagrams:

Simulator:

The class has a fidelity of complete because it completely matches and represents the needs of the design concern.
Robustness level is fragile because it is currently not tested only reviewed by two engineers.
Convenience is seamless because the client needs only call one function Simulator :: Run to use the class.
Abstraction is complete because no implementation details are leaked to the client, everything is wrapped in simulator :: run.

Simulator
-ptUpperRight: Position -howitzer: Howitzer -projectile: Projectile -ground: Ground -physics: Physics - time: double -keysIndex: enum
+Simulator(ptUpperRight: Position) +Run(pUI: interface, gout: ogstream) -doInput(pUI: interface) -update() -draw(gout: ogstream) -getKeys() : [bool] -applyKeys(keys : [bool]) -getDrag() : double -getGravity() : double -checkCollisions() -drawText(gout: ogstream)

Ground:

The class has a fidelity of complete because it completely matches and represents the needs of the design concern.
Robustness level is fragile because it is currently not tested only reviewed by two engineers.
Convenience is seamless because all the needs of the ground class are handled and data is returned in a valid and easy to use state to the client.
Abstraction is complete because there are no implementation details revealed to the client as we provide all necessary methods the client needs.

Ground
-ground: [double] -posUpperRight: Position -posTarget: Position
+Ground(posUpperRight: Position) +reset(posHowitzer: Position) +draw(gout: ogstream) +hitGround(posProjectile: position) : Bool +hitTarget(posProjectile: position) : Bool +getElevationMeters(pos: position) : Double

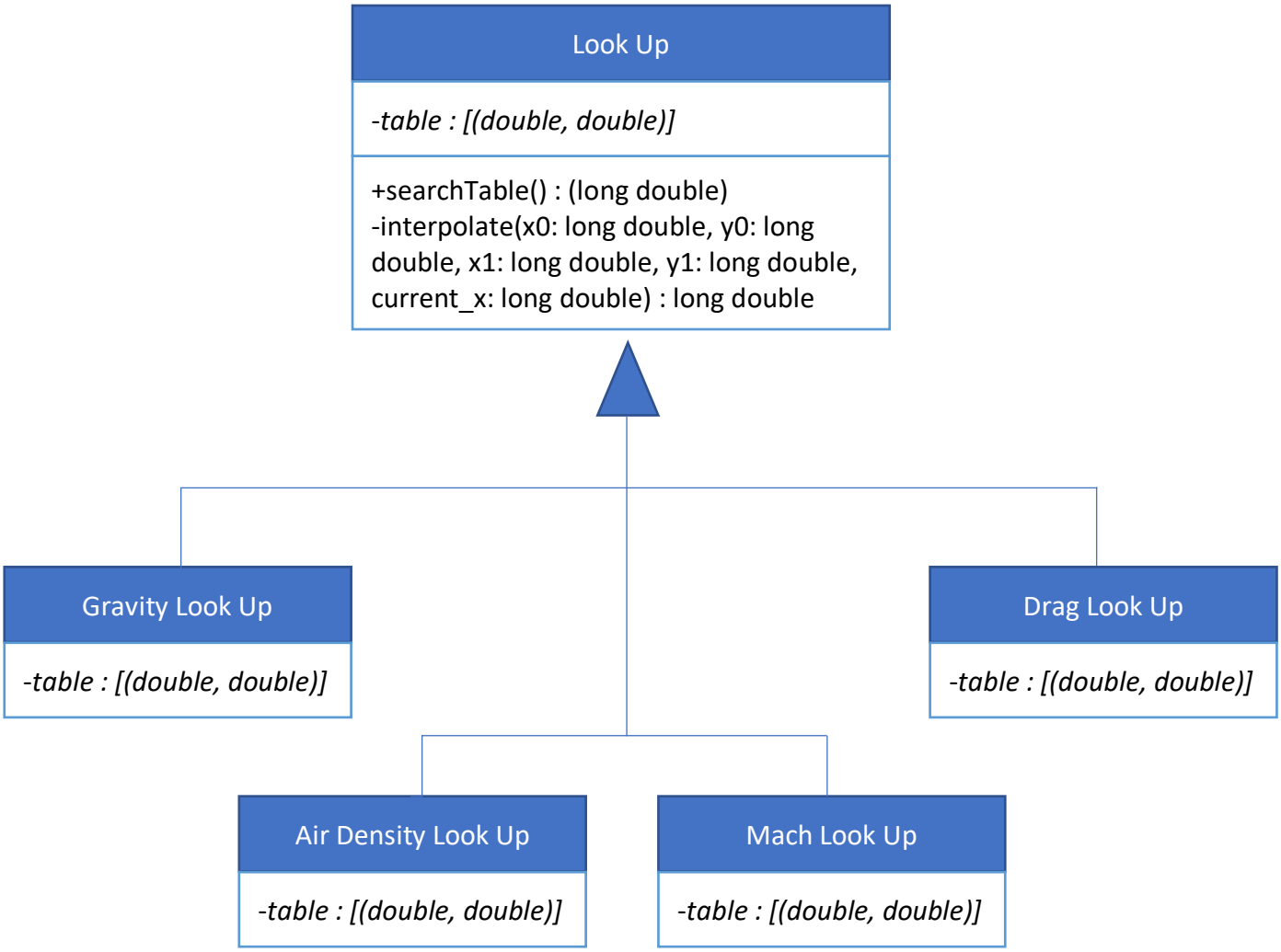
Physics

Fidelity: Complete. The LookUps represent all values that this game could possibly have.
Robustness: Fragile. No testing has been done.
Convenience: Easy. The arguments for getGravity and getDragForce need to be acquired, but they are easy to get from the Projectile.
Abstraction: Complete. It is not possible to know how the class is implemented from the methods.

Physics
-dragTable : DragLookUp -gravityTable : GravityLookUp -airDensityTable : AirDensityLookUp -machTable : MachLookUp
+Physics() +getGravity(altitude : double) : double +getDragForce(altitude : double, speed : double, area : double) : double

Look Ups:

The class has a fidelity of complete because it completely matches and represents the needs of the design concern and nothing extra is done.
Robustness level is fragile because it is currently not tested only reviewed by two engineers.
Convenience is seamless because all the extra work to interpolate and is done by the class and returned conveniently to the client.
Abstraction is complete because the client does not know anything about how the values are stored or found. They only know that the interface returns a tuple of long doubles.



Angle:

Fidelity: Complete. The choice of double for degrees allows for precise calculations. The value will be limited to the range -180 to +180 so that it is easy to maintain good state.
Robustness: Fragile. No testing has been done.
Convenience: Easy. All desired adding, setting, and getting is implemented.
Abstraction: Complete. The only possible way for the user to know how this class is implemented would be to do a performance test.

Angle
-degrees : double
+Angle() +Angle(angle : Angle) +Angle(x : double, y : double) +setDegrees(degrees : double) +setRadians(radians : double) +addDegrees(amount : double) +addRadians(amount : double) +getDegrees() : double +getRadians() : double -radiansFromDegrees(radians : double) : double -degreesFromRadians(degrees : double) : double -degreesFromXY(x : double, y : double) : double

Vector2D

This is a base class that Acceleration and Velocity will inherit from
Fidelity: Complete. X and Y being doubles give good precision, and also covers all possible values.
Robustness: Fragile. No testing has been done.
Convenience: Seamless. All the main actions a Vector2D could take are represented here.
Abstraction: Complete. It is not possible to know how this class is implemented from the methods.

Vector2D
-x : double -y : double
+Vector2D() +Vector2D(vect: Vector2D) +Vector2D(x : double, y : double) +Vector2D(angle : Angle, magnitude : double) +getAngle() : Angle +getMagnitude() : double +getX() : double +getY() : double +addVector2D(otherVect: Vector2D)

Velocity

Velocity privately inherits from Vector2D.
Fidelity: Complete. This class is a Vector2D, so it has an x and y as a double that exactly cover the values this class needs to have.
Robustness: Fragile. No testing has been done.
Convenience: Seamless. All the main actions Velocity needs to take are represented here.
Abstraction: Complete. It is not possible to know how this class is implemented from the methods.

Velocity
None
+Velocity() +Velocity(velocity : Velocity) +Velocity(dx : double, dy : double) +Velocity(angle : Angle, speed : double) +getDirection() : Angle +getSpeed() : double +getDX() : double +getDY() : double +addAcceleration(acceleration : Acceleration, time : double)

Acceleration

Acceleration privately inherits from Vector2D.
Fidelity: Complete. This class is a Vector2D, so it has an x and y as a double that exactly cover the values this class needs to have.
Robustness: Fragile. No testing has been done.
Convenience: Seamless. All the main actions Acceleration needs to take are represented here.
Abstraction: Complete. It is not possible to know how this class is implemented from the methods.

Acceleration
None
+Acceleration() +Acceleration(acceleration : Acceleration) +Acceleration(ddx : double, ddy : double) +Acceleration(angle : Angle, magnitude : double) +getDDX() : double +getDDY() : double +addAcceleration(acceleration : Acceleration)

Projectile

Fidelity: Complete. The Position object will handle all possible locations the projectile could be in, Velocity will handle all possible velocities, the age of the projectile is a float because it does not need to be very accurate but it does need to handle decimal values, the weight is stored as a double for precision and is constant because it won't change (same for the shell's area), and the status is limited to the only four states the projectile could be in.
Robustness: Fragile. No testing has been done.
Convenience: Seamless. All methods take no parameters besides exactly what the Simulator has to offer, and they all do exactly what the Simulator needs.
Abstraction: Complete. It isn't difficult to tell what some datatypes being used are, but it would not be difficult for me to change what datatypes are being used and the user wouldn't know.

Projectile
-shadows : [Position] -position : Position -velocity : Velocity -age : float -WEIGHT : double -AREA : double -status : enum{LOADED, FLYING, ON_TARGET, OFF_TARGET}
+Projectile() : Projectile +Projectile(point : Position) : Position +move(dragForce : double, gravityAcceleration : double, time : double) : void +fire(velocity : Velocity) : void +hitTarget() : void +missedTarget() : void +getPosition() : Position +getLastPosition() : Position +getSpeed() : double +getVelocity() : Velocity +getAngle() : Angle +getArea() : double +getAge() : float +isLoaded() : bool +isFlying() : bool +isImpacted() : bool +isOnTarget() : bool +draw(gout : OGStream) : void -shiftShadows() : void

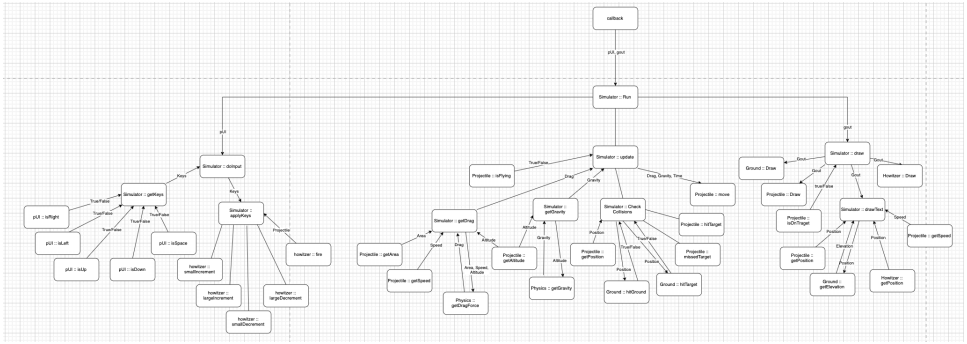
Howitzer

Fidelity: Complete. Position covers all places Howitzer could be, and the constants are as precise as they need to be, though Angle does allow for more angles than the Howitzer needs. Some limiting will need done in the changeAngle function to make sure it is not in an extraneous state.
Robustness: Fragile. No testing has been done.
Convenience: Easy. Passing age to the draw function takes a tiny bit of effort, but it would be more difficult to pass in the elapsed time between each draw and have the Howitzer keep track of its own age.
Abstraction: Complete. It is not possible to know how this class is implemented from the methods.

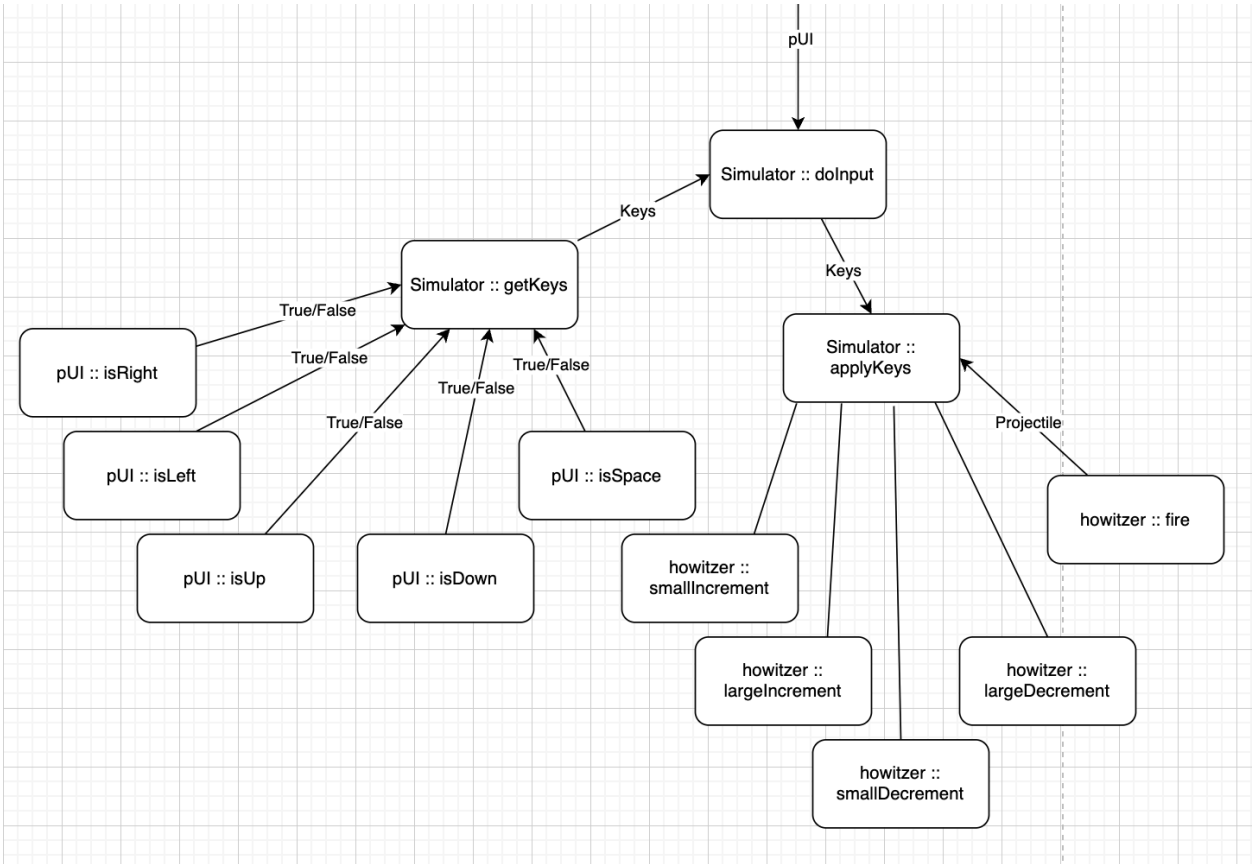
Howitzer
-angle : Angle -position : Position -MUZZLE_VELOCITY : double -SMALL_ANGLE_CHANGE : double -LARGE_ANGLE_CHANGE : double -FLASH_TIME : int
+Howitzer() : Howitzer +Howitzer(position Position) : Howitzer +fire() : Projectile +draw(gout : OGStream, age) : void +getAngle() : Angle +setPosition(position : Position) : void +smallIncrement() : void +smallDecrement() : void +largeIncrement() : void +largeDecrement() : void -changeAngle(radians : double) : void

Structure Chart:

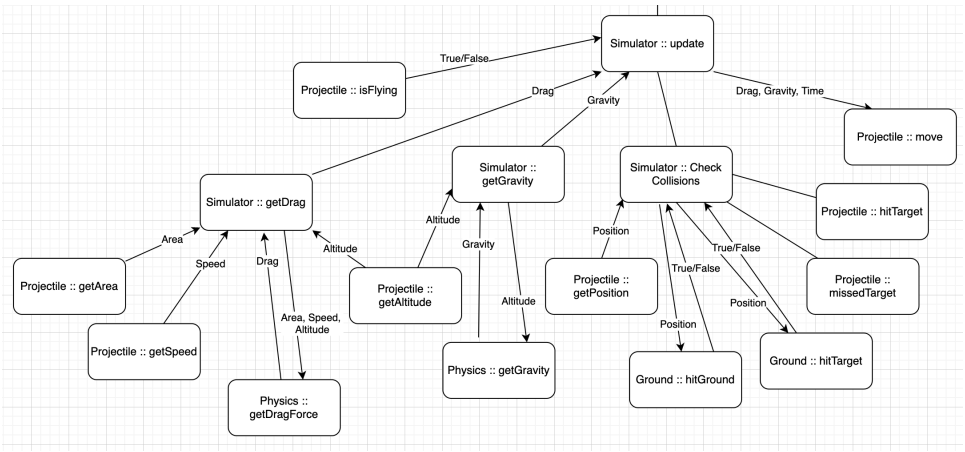
The whole structure chart



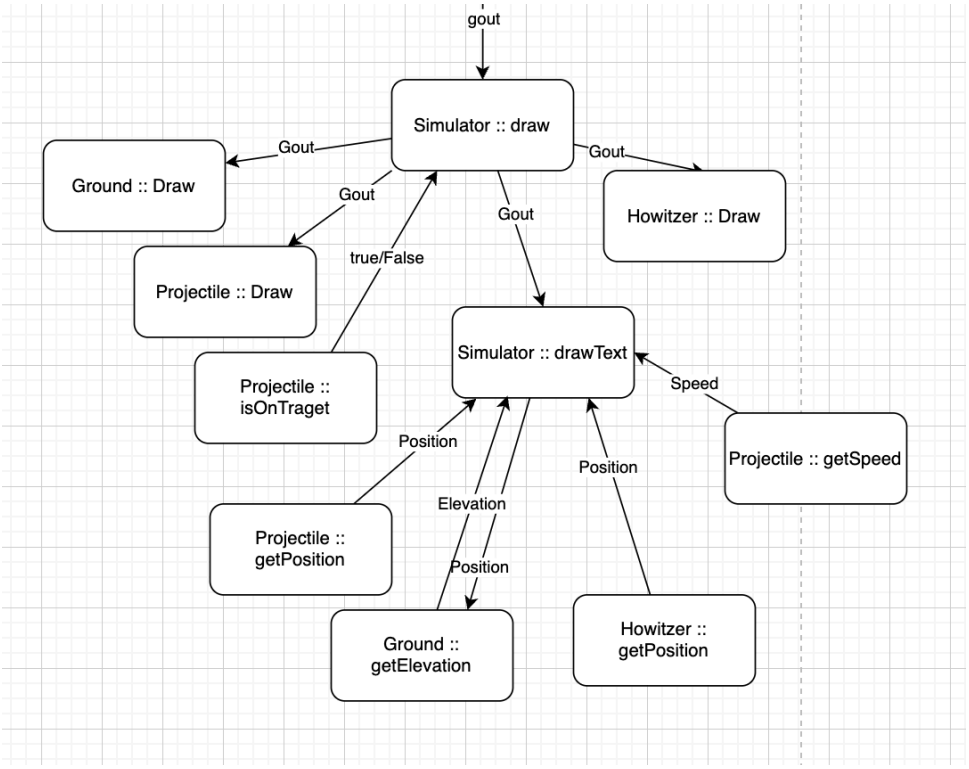
Simulator :: doInput



Simulator :: update



Simulator :: draw



Pseudocode:

```
LookUp::SearchTable(notContainedKey, lookUpTable)

     iterator ← lookUpTable [0]
     high ← lookUpTable [0][0]
     low ← lookUpTable [0][0]
     searching ← true

     WHILE iterator != lookUpTable[-1] and searching = true
          IF iterator[0] < notContainedKey
               IF iterator[0] > low
                    low ← iterator

          ELSE
               high ← iterator[0]
               searching ← false
          iterator++

     keys ← (low, high)
     return keys
```

```
Projectile::move(dragForce, gravityAcceleration, time)
  shiftShadows()

  oppositeAngle <- Angle(velocity.getAngle())
  oppositeAngle.addDegrees(180)
  dragAcceleration <- Acceleration(oppositeAngle, dragForce / WEIGHT)

  totalAcceleration <- Acceleration(0, -gravityAcceleration)
  totalAcceleration.addAcceleration(dragAcceleration)

  position.addVelocityAcceleration(velocity, totalAcceleration, time)
  velocity.addAcceleration(totalAcceleration, time)
```

Test Cases

Test cases for Projectile::move()

Name	Precondition	Inputs	Outputs	Rationale
Stationary	position = (0, 0), velocity = (0, 0), WEIGHT = 1	df = 0 ga = 0 t = 1	position = (0, 0) velocity = (0, 0)	If the projectile is not in motion and no forces act on it, it should stay at rest.
Inertia Only	position = (1, 1), velocity = (3, 4), WEIGHT = 1	df = 0 ga = 0 t = 1	position = (4, 5) velocity = (3, 4)	If the projectile has a velocity and no outside forces act on it, it should maintain that velocity.
Gravity Only	position = (1.7, 2.5), velocity = (0, 0), WEIGHT = 1	df = 0 ga = 3 t = 0.5	position = (1.7, 2.125) velocity = (0, -1.5)	If only gravity acts on the object, then only the y-values should decrease.
Inertia and Drag	position = (-3, -2), velocity = (1, 1), WEIGHT = 1	df = 1 ga = 0 t = 1	position = (-2.354, -1.354) velocity = (0.2929, 0.2929)	The drag force should directly oppose the velocity.
Inertia and Gravity	position = (10, 20), velocity = (-1, -2), WEIGHT = 1	df = 0 ga = 2.5 t = 2	position = (8, 11) velocity = (-1, -7)	The acceleration due to gravity should only affect the y positions, posX can still be affected by velocityX.
Base Case	position = (15, 7), velocity = (50, 42), WEIGHT = 46.7	df = 25 ga = 9.8 t = 0.5	position = (39.957, 29.723) velocity = (49.828, 31.790)	All values used, and all updated.

Test cases for Physics::getDragForce()

Name	Precondition	Inputs	Outputs	Rationale
Zero Velocity	None	altitude = 0 speed = 0 area = 1	0.0	If you have zero velocity, then there's nothing to resist and drag will have no effect.
Simple Case	None	altitude = 0 speed = 340 area = 1	30,148.769	With these inputs, there is no interpolation necessary and the equation will be 1/2 * .4258 * 1.225 * 340 * 340 * 1 = 30,148.769
Interpolate	None	altitude = 500 speed = 135.2 area = 1	1755.715	With these inputs, mach, drag coefficient, and density all need linearly interpolated and the equation will be 1/2 * .1644 * 1.1685 * 135.2 * 135.2 * 1
Max Table Values	None	altitude = 40000 speed = 1620 area = 1	1392.687	With these inputs, the maximum altitude still on the two charts and the maximum speed are used and the equation will be 1/2 * .2656 * .003996 * 1620 * 1620
Off The Charts	None	altitude = 100000 speed = 5000 area = 1	Error	Inputs are not allowed to be outside the range of table values.
Standard	None	altitude = 0 speed = 827 area = .018843	2048.854	With the values for a just-fired shell, the equation will be 1/2 * .25956 * 1.225 * 827 * 827 * .018843