ANALOG DRIVEN DEVELOPMENT

Harnessing the Conceptual Human Mind to Ensure Software Artifact Stability

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PROJECT ABSTRACT

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Harnessing the Conceptual Human Mind to Stabilize Software Artifact Design

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The purpose of this exploration is to dissect a software design paradigm that creates hand drawn visualizations of the artifact itself, Analog Driven Development. This is a test-first mechanism evolving from Test Driven Development. The effective purpose of the paradigm is to create a stable and well documented artifact. The groundwork for the mechanism lies in a pairing of known engineering practice and cognitive psychology. This combination of thought was used to craft a tool allowing the human mind to conceptually attack the design phase of an algorithm in a continuous space environment by juxtaposing code implementation until later in the development process. Analog Development was found to allow for pre-emptive refactoring in connection with support functionality, to assist in the design of multi-layered class structure through object normalization, to assist in the creation of flexible source and test code, and as a tool for testing the functional limits of the artifact itself.

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CHAPTER ONE – INTRODUCTION

This document explores the following perspective: the discovery of a software solution does not necessitate the presence of a computer. Though the implementation of such a solution requires a machine, the software itself is a logic game. Control structures, loops, and Boolean variables are all evolutions from logic. Mathematical computation is based in logic and reasoning. And logic is inherently a mental game. As such, the totality of a software solution can be forged without a computer. Of course, the solution must be run on the computer to indeed be software. But the solution itself may be worked out in the natural continuous space venue of the conceptual human mind.

1.1 – Of Predators and Prey

The process of software development can be described as a game of cat and mouse; however, it is likely more similar to the struggle between the road runner and that coyote who ceaselessly blows himself up. Whether the developer has found the bugs or not, they do exist somewhere in the code. Known issues or unknown bugs are instances of failure. Non-success in the realm of software engineering is a chronic illness, not a temporary cold.

It is easy to see the potential for this struggle when one acknowledges both the human mind and the human capacity for problem solving are analog in nature, while a machine requires the rules of a digital world. The mind does not store information in bytes. A computer has no random thoughts, but uses procedural execution. Stream of conscious thought is flighty. The manifestation of action is inherently different between the mind and the machine. Modeling continuous space into a discrete digital realm is a difficult transaction. Considering their respective definitions, perhaps analog and digital play like oil and water. This realization does not permit the translation to be any easier. Not directly. It may, however, be the most empowering consideration we as humans have in the fight to make computers behave.

Software development is a hunt. A hunt for the set of desired behaviors that will be evidenced by the machine. And the machine *must* behave in certain ways. The human is tasked with modeling elusive behavior and ensuring stability. And the hunt itself is consuming. It is important to remember the nature of the human species. We are a living, breathing, imaginative construct. We strive and struggle and cry. We find an obstacle and we have to climb over it. We want to win. By design, we have two lungs, two kidneys, a pair of eyes, and the instincts to eat and to procreate. We are animals. We are proof of life. Emotion and instinct bleed into our decision making process. We have so little in common with computers, our creation.

Humans evidence animalistic tendencies in intellectual endeavors. The hunt for a solution produces bio-physical responses. Like a lion trying to feed the pride, our quest for answers causes our hearts to race, our breathing to quicken, and our senses to sharpen. For humans, intellectual inertia torrents through the human mind as fiery blood courses though veins. We can feel ourselves approaching success. But even in moments of impending success, the desired result can evade our efforts. In a single moment, a minor misstep in reasoning can cause a major setback, leaving the human bereft of energy, dissatisfied and starving for success in the face of failure. As humans, we might '*throw in the towel*.' A machine will never '*call it quits for the day*.'

In order to better secure any target, humans attempt to refine their strategy. The refinement may originate from a desire to reduce requisite effort or to pursue perfection. One such software refinement takes the form of Test Driven Development (TDD). TDD is a process by which tests

for the software are written before the source code itself. TDD is often credited to Kent Beck. Ten years ago, Beck helped the software community refine development techniques by rearranging the software process itself. His argument: if we know what the software has to do, let us build the related tests first, then when we write the code we'll know it is correct when it passes the tests.

The refinement I propose centers around a re-harnessing of the human mind. Beck attempted to improve the software process by forcing the test code to come first. The tests are always written before the source implementation. But Beck wanted to write one test at a time. And he did so using a computer. Analog Driven Development (ADD) does not write one test at a time, nor does it use a computer as a tool for algorithmic construction. ADD will resurrect old world engineering via pencil, paper and sketch books. The eureka moment occurs with frenzied hands scribbling notes attempting to keep pace with the mind. The search for the answer ends with an exhalation of relief. ADD will remind us of our human strengths and throttle the exposure of our weaknesses. And ultimately, ADD will dispose of the unfortunate thought that curses the minds of our students:

> "Listen, Timmy, you are going to have to learn to think like a computer."

This sentence is nothing short of disrespectful to the power of the human mind. This suggestion in summary: take the most creative and forceful computing device we have at our disposal and make it work like a slab of silicone manufactured by the lowest bidder. Do we need to *talk* like a computer? Yes, a necessary skill set. Understand how a computer *thinks* and how to efficiently utilize its hardware? Necessary skill sets. But to sacrifice our power, creativity and ingenuity in order to dumb ourselves down to the intelligence level of a non-conscious tool? Never. We are living creatures with inherent strengths. Our abstract thoughts, our ability to ponder in continuous space, our analog conceptualizations are how we naturally process information. We do not think in machine code. We think with symbols and representations. There is no screen resolution on the mental image of a chair. No refresh rate on our memories. No video card upgrade to make a half-thought out idea any clearer. Our minds do not work like a machine. We are, thinking animals.[12] Our process for creation should be designed with this in mind. We ought play to our strengths.

Discussion now as to the merit of this mechanism is pointless. I will have to show you. I will begin my exploration with a dive into TDD, the nature of inquiry itself, and a discourse on the connection of language and concepts. Following, I will explore how these three venues assisted in the design off what has become Analog Driven Development. I will show the evolution of my test first practice from Beck's own work. And, I will validate the practice through explorations of code repositories built using ADD. But first, definitions.

1.2 – Definitions

Before diving deeper into the substance of this document, it would be beneficial to establish meanings for the words that will be used herein. The following is not a set of meanings from industry or literature, though in most cases they closely match. The following definitions are precisely what is meant when the words are used.

Analog : involving continuous space; a 'rule'; non-digital; the nature of a concept that does not yet exist in a manifested form; *i.e. the idea of a chair, any chair, versus the mathematical height and weight bearing properties of that object; a class declaration*

Digital :	involving discrete space; an 'instance'; non-continuous; explicitly manifested version of a concept; *i.e. an instantiated object of a given class*
Inquiry :	the process of discovery, completed via novelty or ampliative gain
Production Code :	'source code'; executed code designed to fulfill requirements for a given project
Programming :	the a process by which a conceptual abstraction is translated line by line into source code
Software Process :	methodology by which software is created in an intelligent, structured and disciplined manner
Test :	a mechanism for the atomic verification of a single unit of source code
Test Code :	scaffolding by which production code will be measured and thereby verified
Test Harness :	collection of tests, generally organized to match the package structure of a source code itself
Test Scenario :	a mechanism for the environmental verification of multi-component behavior
T.D.D. :	Test Driven Development; a software development process employing a test first programming strategy
A.D.D. :	Analog Driven Development; a software development process originally fabricated from T.D.D. in which complex testing scenarios are formally solved with the use of pencil and paper

Highlighting the differences between analog and digital aspects is important for continuing conversation. Analog representations have meta-connections and conceptual implications that digital representations do not exhibit. [12] Justice, for example. A just action exemplifies what it is to execute justice; however, there is more to the idea of justice than can be fit into a single action. Justice entails a legal system, ideas as to fairness, religious connotation, basic morality, etc. This is a common set of American concepts that float to the surface of the mind when justice is thought upon. And this is the analog representation of justice. It includes thoughts of famous persons who have spoken on justice, and things we have been taught about justice. The collection of our knowledge on the topic does not exist in any one story or example. Our human understanding of justice is an amalgamation of experience, time and exposure. And our analog definition of justice is further refined by digital manifestations. Such an example might be: upholding academic integrity, or enacting fairness. The distinction between the analog and the digital is based in the segregation of *idea* versus *example*; or, of rule versus instance. Software, too, has analog and digital aspects. This is seen in the design of a class structure and the impending instantiation of a discrete object; there exists a difference between the generalized, conceptual class declaration and the specific run-time version.

Humans were designed to execute action based upon a collection of information. Computers were designed to execute an action based upon what a variable means at a particular moment. Computers view only the here and the now: one single set of instructions to be executed right now under current circumstances with little or no regard for historical knowledge or future consideration. For the computer, the action has no place in a conscious history. Humans take more into thought. For a human, every action can become a memory, or a fear, or a hobby. Novelty can be attached to growth or self-degradation. For the human, concepts and thoughts are naturally connected.

Computers must have a series of actions explicitly pre-determined as no action a machine executes promotes any cognitive inertia. This is the functional difference between the analog and the digital.

1.3 – Future Lab : The Venue of Advancement

Analog Driven Development was developed out of need in connection with the FutureLab Project at Auburn University. The project's goal was to reconstruct an educational science simulator for middle school students. The original artifact contained several experiments that students can work through; balancing a scale with weights or freefall from a platform. The benefactor, Auburn Engineering alum Walt Woltosz, '77 Aerospace Engineering, donated the original FutureLab program. [11] FutureLab, as a piece of software, would undergo a rebuild from the ground up. The program was being moved C to Java and from mid-1990's operating systems to the Android OS. FutureLab, as a project, would provide a number of challenges, the most pertinent of which required the design of a homemade physics environment.

The physics designed for FutureLab required that any object to be simulated also be mapped to a location within the designated simulation space, the container where the experiment takes place. This space is an abstract grid system layered on the pixel display of the Android screen itself. Each point within the grid system, a measurably discrete location. Points within the simulation space are combined with metadata into node structures. These nodes are connected via pointer chain creating enclosed shapes. Shapes congregate into the skeleton of simulation objects: a ball, a standard mass, a cannon, etc. Further data is combined with the shape: mass, labels, acceleration vectors. The laws of physics are recapitulated into mathematical functions and managed by event watchers. The watchers themselves are a set of reactionary algorithms that respond to physical events such as a collision. All of this taking place within an abstract grid system.

ADD evolved into a mechanism for stable software design, but it began as a resource for variable tracking. The development of tests for a system that models physics in an abstract space proved difficult. In order to keep track of the location of objects and their shapes within the simulation space, I began to sketch a blue print for each test. Engineering paper, rulers and a compass became power tools software construction.

CHAPTER TWO – BACKGROUND

2.1 – Test Driven Development : The First Baseline

Beck's desire to overhaul the development process appears to stem from the work environment of a less disciplined era of software engineering. He references a time when testing was not a part of every team's process. A time when a developer would have to wait through the night to see if the tests passed or failed. [2] Software development was not as comfortable as it is today. One major issue was the human's confidence in the software artifact. Testing and quality assurance practices were not as conversed as they are today. As such, the industry needed thought on how to improve quality.

A snapshot of the test driven development mechanism is as follows :

1) Make a test;
2) Run all tests, verify the new one fails;
3) Make a change to the source;
4) Run all tests, verify they all pass; and
5) Refactor to remove duplication.[2]

This multi-step process is cyclically repeated. To build a new piece of source code, you must first have a test that fails because the source is not written; to build that test, you must first pass all other tests. This structure mandates stability. If the last function install fails the related tests, that function and the related test must be examined for defects before anything new can be generated. Also, if the last function install has a negative impact on other pieces of the software, running the entire test battery will evidence the problem. This structure provides a controlled development environment. Throughout his exploration of TDD, Beck identifies with the human side of engineering. He acknowledged his own humanity by going so far as to say "If you're upset, take a cleansing breath."[2] He then went on to explain how to take this breath. Beck understood the strain of a negative work environment. So, he supplied us two mechanisms for confidence and stability. The first, related to squelching emotional uncertainty by reducing the unknowns in an ongoing project; the other, a respiratory mechanism to calm bio-physical tension.

The test driven process itself is not complex. However, it can be tailored and is therefore flexible. Beck suggests a developer start small. Test for a class that has yet to be created. Fix the error by installing the class. Then test the constructor of the class to see if a certain value is set. Fix the error by going back and setting the value in the source. Each step has a small test for a small piece of code. As the developer becomes more familiar with the process and how they intend to self-tailor, larger tests can be written for much larger installations. These tests can be as small as an assertion on the return of a 'getter' function, or as large as the verification of output from a multi-table database query.

The process allowed for great strides in the development of quality software; however, the mechanism has a greedy heuristic to the design. It is quite powerful, but places do exist for refinement. Most notably, TDD requires a certain amount of duplicative effort, "…speed trumps design, just for a brief moment."[2] But this brief moment happens once per cycle. Long term design decisions do not receive immediate consideration. Alterations to existing code are a necessary evil. These tedious changes are the price paid for confidence and stability. Refactoring is a must. Common code spread across same depth in class structure ought to be transplanted to higher, more

appropriate tiers. Support functionality that can be refactored often requires the generation of related and novel tests. This upkeep is necessary and often temporally random in nature. And as such, emotional and intellectual flows of development can be turbulent.

When Beck moved test based activities to the front of the process queue, he overhauled the system. Traditionally, production code was written and then tests were created to exercise the source. But this organization also acknowledges a tenant of human behavior. We will always do what we have to do; we will not always do what we should do. The production code has to be finished. The test code does not. [2] If the test code is written first, it cannot become a cut-corner. Also, pre-emptive generation of test code would not be subject to the biases of having already written the source code which in turn would have to pass the tests. Test driven development also began to answer the question, "*When is this piece of software complete?*" Well, this small piece of code is done when it passes the associated test. The artifact itself will be complete when it passes every necessary test. By re-structuring the process, Beck gave us the ability to generate small milestones over the course of a large project. Creating an entire database takes time. However, creating one table or one query at a time lessened the emotional gravity of a long term project. That allowed for better focus. These facts indicate that Beck understood how the human mind worked, both intellectually and emotionally.

2.2 – The Nature of Inquiry : The Second Baseline

James Blachowicz, PhD, author and retired professor at Loyola University Chicago provides the necessary foundation for a definition of inquiry. In *The Nature of Inquiry*,[1] Blachowicz suggested inquiry itself is a dualistic process that mandates "the partial generation from experience of ideas which come to explain experience, and the partial generation from ideas of consequences which come to match experience." Blachowicz goes on to simplify this definition into a two-sided process involving both experience and thought. One must be able to interact with the known portions of the problem while wrestling with the unknown portions. As the window of exposure to the object of inquiry is lengthened, conceptual understanding of the object is refined.

This dualistic consideration is important to the definition of inquiry as it contains the necessary pieces to solving a problem of any venue, engineering, mathematics, logic, etc. The need to solve a problem requires one to know various pieces of the problem while simultaneously not knowing the problem in some way. [1] For Blachowicz, this is the first law of inquiry. Strictly speaking the solution to the problem is unknown while other pieces of the puzzle may also be obfuscated. Examples of obfuscation are: a variable's behavior over time, or the effect of multi-variable interaction. However, a starting point is needed. The problem itself must have a definition. Without a bounding definition, no problem is resolved in an intelligent manner.

Accidental solutions may be discovered for various problems, but for the purposes herein the premise is that we have a specific software problem that must be solved. As such, there is a desired result and intelligent observation of the distance between the known position and the goal can be made. For Blachowicz, this is the second law of inquiry. This provides a means for intelligent inquiry. Spontaneous discovery and randomized creativity are outside the scope of this discourse.

Each piece of software that must be written is a unique problem requiring a unique solution. If a solution to a software problem already exists, generally the problem is not resolved again. If a program can be purchased for seventy dollars, it likely took more than seventy dollars of effort and time to produce that program. Reusability is a primary tenant of development. This focus has a twofold purpose. One, reusing existing code promotes confidence if the code is known to 'work'.

Two, reuse detracts from overall development time. Therefore, almost every software solution is a solution unique unto itself even if the uniqueness takes the form of refinement. Facebook must only be made once. The database aspect of Facebook remains the same from access medium to access medium. The rendering of that information may change from device to device, but therein lays a novel problem requiring a novel solution. The code executed by my Playstation when I load Assassin's Creed is the exact code run by every Playstation when Assassin's Creed is loaded on each gaming console. It *could not* be Assassin's Creed unless this held true. There could be a second installment of the game. Or there might be a similar game. Metaphysically speaking, these are not be the same.

As each piece of software inherently contains the resolution to a problem, each piece of software necessitates inquiry. The developer must discover the solution to what it is they wish to build. Later I will discuss the location of problem resolution, but for having a unique problem is sufficient. Above, I discussed the ability to simultaneously know and not know the solution to a given problem. Meno's paradox suggests that this type of knowledge is impossible :

> "And how will you inquire into a thing when you are wholly ignorant of what it is? Even if you happen to bump right into it, how will you know it is the thing you didn't know?"[10]

Firstly, and necessarily, it may be impossible to inquire into a thing that one is wholly ignorant of, for there would be no subject to the inquiry's very own predicate. The act of inquiry inherently requires a subject. For there to exist a predicate to the question, there must be an acknowledgement of that subject. Secondly, we are not inquiring into something we are wholly ignorant of. When solving a software problem, one knows what the desired result is. This follows suit with Blachowicz's second law of inquiry. One also defines both the functional and aesthetic portions of the desired result. This knowledge can be converted into a first order map, a mechanism that intelligently determines a specific direction to head when traversing a problem. [1] (First order maps are discussed further below. For the time being, they are synonymous with a plan, or a route from A to B.) The software developer also is well aware of several use cases or testing scenarios that must be passed before the software is completed. Behaviors are explicitly defined to their end, but not to their means. This collection of knowledge beings to paint a picture as to what the desired result of the effort is. The developer knows exactly what we want the end behaviors to be and know how they want the software to look and feel. The developer does not know how they are going to model those behaviors, their actors or their user interface. Consequentially, there exists simultaneous knowing and not-knowing.

Less amorphously, there are two points in a journey to solving a problem. The origin is the current location. The desired result is our expected location upon completion. Simply having a task necessitates that the current location and the goal are not the same. If one were where they needed to be, movement would be a divergence from the desired result. Consequentially, if we were to represent our current location in reference to our desired location in some measurable manner, we would be able to diagnose the differences between the spots. This is a first order map. This is the mechanism for defining the avenue from A and B. [1]

When Kepler began to search for the true orbit of Mars, he began by examining a large number of observations as to the orbital pattern of Mars. Kepler 'knew' these observations were incomplete as there was no correct mathematical explanation for the orbit of Mars. The incomplete observations gave Kepler a springboard. He was able to compare his findings with those of others. Ultimately, he was able to resolve the mathematical explanation for Mars' orbit by figuring out how wrong the current solution was. [1] The resulting solution bloomed from an understanding of what

already existed. Known elements helped to prescribe the behaviors of unknown elements. The solution began to betray itself through the observations of the algorithm's creator.

The definition of inquiry is: a process for intelligent generation of novelty and ampliative gain. Firstly, known elements and unknown elements are segregated. Known elements are then reviewed in light of each other. As a conceptual understanding as to their whole is formed, the current assessment of the solution is compared to the desired result. The differential is quantified and systematically dissolved.

Intelligent discovery, the orchestrated removal of unknowns.

2.3 – The Temporal Relationship of Thought and Expression : The First Premise

Any expression that has not spontaneously occurred from the human must first have been a thought. A reflex is an example of spontaneous reaction from the physical body without premeditation. Story writing is not. Even if the story was written as a stream of consciousness, it must occur in the mind before the hand can begin to craft the letters representing the symbols which represent the concept that occurred within the mind. This is a necessary tenant of language; words simply represent ideas and concepts. [12] Concepts necessitate a symbolic representation to serve as a key back to that concept. Words themselves do not beget abstraction. Without expression existing within the confines of a mandated form, communication does not occur. The story of Don Quixote is not a Spanish story. It is a story written in Spanish. Had the author decided to write in Italian, the book would be in Italian. But the essence of the story would remain the same. Perhaps linguistic differences change minor details. However, the tale of the ingenious gentleman occurred in the mind of Miguel de Cervantes Saavendra before it occurred on paper. The story was not produced by an involuntary set of muscle spasms happening to manifest into one of the world's literary classics. Spanish was the encoding language for Miguel's imagination.

Consider the following sentences.

1) "el Diablo sabe mas por viejo, que por Diablo"

2) "the devil knows more because he is old, than because he is the devil"

3) "age breeds knowledge"

Although sentences 2 and 3 are in English and contain similar meaning, numbers 1 and 2 are translations of each other. By definition, a translation is a representation of the meaning contained in one language, yet represented in another. Both 1 and 2 contain a force and vivacity that directly compares the Devil's wickedness to his age in terms of each quality's ability to correspond to garnered knowledge. Sentence 3 has no such comparison and, therefore, is most dissimilar. This example promotes the conclusion that language itself is simply an encoding of a conceptually based idea. This analogy is also observable in congruent software architectures implemented in distinct programming languages. The backend for a website can be scripted in PHP, MySQL or Django while still containing the same database structure. A student versus teacher relationship can be modeled and keyed in any of these. The language itself does not open the door for the student versus teacher relationship. The language is nothing more than an encoding. It is the medium of communication.

As a programming language can be reduced to a simple encoding scheme for a known solution; one can begin to equate the design of a software solution with a problem to be resolved by the conceptual human mind. It is in this realization that both power and flexibility are restored to the human intellect. The search for a solution is removed from the confines of computational logic and Boolean algebra. The assertive human is invigorated by the realization that the fight has been revenued to the home field of continuous space analysis and playful tinkering. A decisive advantage. And the human knows the beauty of this advantage. Unbridled and rejuvenated, the human can attack the problem at will and without reservation. Once captured, the solution is transmogrified into the digital aspect of the chosen language, Java, Python, procedural C. The lines of code themselves will differ. Library imports and custom modules varying from implementation to implementation, but the solution itself will be translatable nonetheless.

2.4 – Conceptual versus Mechanical Representation : The Second Premise

In section 1.2 of this document, there exists a list of foundational definitions. Words that will be used repeatedly, many of which have evidenced already. For communication to take place, two humans must be on the same linguistic page. The suggestion here is that the verbal and visual symbols of the language must be the same for two people to communicate.[12] If I say "dog" and the listener thinks "cat", there is a problem. One individual might define programming as: "messing around with code until it works" or "writing software". These two ideas could be seen as similar, or vastly different. "Messing with code" *could* be analogous to refactoring, reworking a database schema, or removing a bug. "Writing software", could be an entry level person working at Microsoft, or a student completing 'Hello, World!' for the first time. "Writing code" and "engineering software" should never be equated. The act of writing is simply the execution of a detailed intellectual endeavor.

Back to the machines and the way they communicate. The following explores a plurality of atomic programming instructions.

```
int x = 4 ;
```

This assigns the variable 'x' with the value four. The location in memory where 'x' exists contains an integer value of '4'.

```
long x = System.currentTimeMillis();
```

This assigns the variable 'x' with the current system time as a 'long' which is simply a digital reservation for a number.

```
for current_student in Students.objects.all( ):
      print current_student.__unicode__()
```

This grabs every student in a database and prints them out based upon a unicode encoding. These lines of code have no relation to each other. But they have something specific in common. They will each do exactly one thing. If a programmer in Spain wants to assign the integer value four to a variable named 'x' in Java, there is one way to do it. Java asks the operating system for the time in one way: `System.currentTimeMillis()`. A human can ask for the time in many ways: *what time is it?*, or *do you have the time?* Though the question, "Do you have the time?" is a yes/no question strictly

speaking. The responding human will generally give you the time, not just look at their watch and say "yes". Humans understand what is being asked based upon context. Machines do not have this ability. Therefore, a database query will always query the same data. They do exactly what you tell them to do. They answer only the questions you explicitly ask.

It is possible to design duplicative functions. It is indeed possible to have two different mechanisms for the same input and output pairing. However, there still exists a one to one relationship between the input and the output. One knows explicitly what they should receive as output. This is the very nature of an API. Having erratic behavior is considered a bug and bugs must be expunged. Proper behavior, the way computers *must* behave, has one explicitly designed input for one explicitly designed output.

A human can look at three apples and divide them among three people. A human can experience the number one-third conceptually as a fraction. One-third of the pile is given out to each person. They can perceive, through senses, one-third of that pile. A computer has no ability to experience to the same degree and no ability to accurately represent one-third. Floating point arithmetic is powerful. But breaking down those very words, 'arithmetic' and 'floating point', yields the following definitions.

Arithmetic :	the branch of mathematics dealing with the properties and manipulation of numbers.[11]
Floating point :	denoting a mode of representing numbers as two sequences of bits, one representing the digits in the number and the other an exponent that determines the position of the radix point[11]

Sequences of bits. This mathematical operation transforms a number, inherently an abstract conceptual mechanism for measurement and counting [12], into a sequence of bits. Computers have finite memory and finite bit reservation for numeric storage. Therefore, a sequence of finite bits is not able to represent one-third as point three repeating, 0.333333 ad infinitum. There are no conceptual links between 1's and 0's. This implies a fundamental difference between machine and human processing.

It is evident that machines and humans 'think' differently. It is also evident that thought and creativity exist within the human mind before expression can take place; however, translating a thought into any language is possible if the language is known. This is synonymous with finding the right set of symbols by which the thought will be represented. Software design, being a logic problem, can be resolved conceptually. ADD takes this into account. By combining the natural manner in which the human mind attacks problem solving with the disciplined engineering technique proposed by Beck, ADD enhances the development of software.

CHAPTER THREE – IMPLEMENTATION

3.1 – TDD Influences : Similarities and Differences

Analog development borrows significant knowledge from Beck's test driven process. A number of similarities are found between the two methodologies. The primary goal of the each mechanism is the same: to produce stable, reliable and clean code. The aesthetic structures of both processes look similar in their coded forms. However, the step-by-step processes of the mechanisms vary to a large degree.

Each software test created using these methods contains the same three building blocks. The first similarity is the arraignment of objects to be exercised by the test itself. This is set of objects and data structures. This group of actors is called 'the setup'. The second commonality is the behavior being tested. This can be referred to as the target behavior. This can be a script, a formal function, a database query, anything that encapsulates machine behavior into a custom call of some kind. Lastly, the assertion of the behavior is a part of every test. Ultimately, the purpose of the test is to ensure a behavior is being executed and that the resultant is appropriate. One example might be to ensure a mathematical calculation produced the proper product. Or, that a database query fetched the proper data entries.

The test suites created from TDD and ADD are also aesthetically similar. The organization of the suites themselves reflects the package structure of the source code in both instances. A database which models an academic environment will have an individual package for the human classes and tables: students, professors, administrative staff, etc; while another package exists for the modeling of courses, majors and degrees. Each of these packages will have unique test suites that internally organize and breakdown classes into atomic behaviors. The greater test harness for the entire artifact is comprised of these package specific suites.

The differences between ADD and TDD begin to evidence when the immediate purpose of each method is explored. TDD does not strive for perfection, and TDD promotes speed and simplicity over performance and accuracy. Beck himself admits such. [2] As such, TDD requires a number of ad hoc repairs to both test and source implementation over time. ADD attempts to answer every question as to every component and behavior before any code is written. As such, ADD requires very little upkeep in terms of modifying code so long as the design appropriately matches the requirements of the project.

Beck suggests that in the natural course of TDD "one cannot rely on the idea that appropriate flashes of insight will occur at the appropriate times."[2] This is true. Temporally harnessing insight is not practicable. As such, TDD ventures forth making the best decisions that can be made at the time and writing the line of code which seems most appropriate. ADD attempts to write no lines until the unknowns are resolved. As such, ADD has a significantly stronger focus on design work. ADD attempts to kick start flashes of insight through problem dissection. In turn, ADD requires and yields a deeper understanding of the greater system.

The measurement of the numerical difference between the two becomes difficult to calculate. The obvious question, which is faster? Firstly, ADD designs, tests and implements in much larger chunks of code and time than TDD. Properly dissecting the time needed for each phase within the larger pieces that ADD tackles, is possible over several experiments, but both tedious and delicate. However, the benefits of in depth design and test documentation are difficult to quantify, as are the benefits of dividing a complex problem into two more distinct problems. In the case of FutureLab, ADD was developed because TDD was insufficient in terms of the ability to track

variables. Building an environment that calculated collisions of organized pixels with individually representative mass values on a synthetic grid system required a test driven process that relied on design work. Too much to keep straight in the mind at one time. So, the system was drawn. For now, that acknowledgement will suffice as the strongest indicator of ADD's value. A tool that successfully allowed an engineer to escape a cognitive limitation: simply keeping all the variables straight.

3.2 – Influence of Intelligent Discovery : First Order Mapping

Section 2.2 introduced the idea that the analog solution to the software problem would be a map, a first order map. The first order map, as defined by Blachowicz, is a mechanism that intelligently determines a specific direction to head when traversing a problem.[1] This map is built from the human's conceptual understanding of the problem's variables. In inquiry, this map is rather dynamic in nature. Information is collected over time. A growing knowledge base of the problem's input variables will change the landscape of the known problem. Second and potentially third order maps are needed for dynamic problems. In this instance, there exists a very well defined first order problem for a static problem: a given software product needs to be manufactured and someone knows what it should do. The problem is, "*How do I get that guy's idea out of his head… and into that phone?"* Unless the desired behavior of software changes, the first order map can be created just once.

One elicited, the requirements of the project are transformed into test cases. This process is further detailed below. The source code must ultimately pass each test case, though the form of the code is currently unknown. This ties back to the first law of inquiry: *knowing while not knowing*. A sketch of the resolved test cases for a sub-set of the code provides the first order map. This sketch is a conceptual encoding of the problem space and gives an arguably *digital* resolution of a singular instance of the greater system behavior. This ties back to the second law of inquiry: *determining proximity to the target*. If one were to create an instance of a database that contains known data, then that individual could:

1) Design a query;
2) Resolve the query against the testdata by hand;
3) Encode the test into the test suite;
4) Write the source; and,
5) Compare the return of the implemented query to the 'by-hand' solution in the test.

The map's integrity is verified by implementing the source code itself to a passing state. If the test code is translated from a sketch of the solution space, which is in turn reflective of the desired behavior of the end game software, then one can be confident that the source acts as intended if it passes those tests. Each time a new test is passed, ampliative knowledge of the software solution has been garnered. The avenue to achieving a particular behavior is now known because the tests created to ensure the behavior have been passed. The developer can intelligently discover the solution. The definition of inquiry has been preserved.

Figure 3.1 – 'Analog' Aspect of test_collision_31_01_00_check

```
// Collision.collision_check()
//  --> Heterogeneous Test
@Test
public void test_collision_31_01_00_collision_check() {
        // The Setup
        Circle  Alpha    = new Circle( -5, 15, 0),
                Beta     = new Circle(  5, 15, 0),
                Gamma    = new Circle( 15,  0, 0);

        Square Delta    = new Square( -5, (float)8.7, 0, 3, 3),
               Iota     = new Square( -7, (float)6.6, 0, 3, 3),
               Eta      = new Square(-15,         -5, 0, 3, 3);

        // Alpha Checks
        assertEquals(Collision.collision_check( Alpha, Alpha ),  false);
        assertEquals(Collision.collision_check( Alpha, Beta  ),  true);
        assertEquals(Collision.collision_check( Alpha, Gamma ),  false);
        assertEquals(Collision.collision_check( Alpha, Delta ),  true);
        assertEquals(Collision.collision_check( Alpha, Iota  ),  false);
        assertEquals(Collision.collision_check( Alpha, Eta   ),  false);

        // Beta Checks
        assertEquals(Collision.collision_check( Beta,  Alpha ),  true);
        assertEquals(Collision.collision_check( Beta,  Beta  ),  false);
        assertEquals(Collision.collision_check( Beta,  Gamma ),  false);
        assertEquals(Collision.collision_check( Beta,  Delta ),  false);
        assertEquals(Collision.collision_check( Beta,  Iota  ),  false);
        assertEquals(Collision.collision_check( Beta,  Eta   ),  false);

        // Gamma Checks
        assertEquals(Collision.collision_check( Gamma, Alpha ),  false);
        assertEquals(Collision.collision_check( Gamma, Beta  ),  false);
        assertEquals(Collision.collision_check( Gamma, Gamma ),  false);
        assertEquals(Collision.collision_check( Gamma, Delta ),  false);
        assertEquals(Collision.collision_check( Gamma, Iota  ),  false);
        assertEquals(Collision.collision_check( Gamma, Eta   ),  false);

        // Delta Checks
        assertEquals(Collision.collision_check( Delta, Alpha ),  true);
        assertEquals(Collision.collision_check( Delta, Beta  ),  false);
        assertEquals(Collision.collision_check( Delta, Gamma ),  false);
        assertEquals(Collision.collision_check( Delta, Delta ),  false);
        assertEquals(Collision.collision_check( Delta, Iota  ),  true);
        assertEquals(Collision.collision_check( Delta, Eta   ),  false);

        // Iota Checks
        assertEquals(Collision.collision_check( Iota,  Alpha ),  false);
        assertEquals(Collision.collision_check( Iota,  Beta  ),  false);
        assertEquals(Collision.collision_check( Iota,  Gamma ),  false);
        assertEquals(Collision.collision_check( Iota,  Delta ),  true);
        assertEquals(Collision.collision_check( Iota,  Iota  ),  false);
        assertEquals(Collision.collision_check( Iota,  Eta   ),  false);

        // Eta Checks
        assertEquals(Collision.collision_check( Eta,   Alpha ),  false);
        assertEquals(Collision.collision_check( Eta,   Beta  ),  false);
        assertEquals(Collision.collision_check( Eta,   Gamma ),  false);
        assertEquals(Collision.collision_check( Eta,   Delta ),  false);
        assertEquals(Collision.collision_check( Eta,   Iota  ),  false);
        assertEquals(Collision.collision_check( Eta,   Eta   ),  false);
}
```

Figure 3.2 – 'Digital' Aspect of test_collision_31_01_00_collision_check

3.3 – The Analog Process : A First Pass

Software development requires an understanding as to how the individual pieces of the project will interface. Having a collection of code segments that work independently, but do not work together is unacceptable. The analog process conceptually unites individual modules and components into a global picture; the forest through the trees. This is accomplished by creating a visual solution. This section will explore the creation of such a solution.

Analog development entails the following steps:

1) Escape technology;
2) Intellectually prepare;
3) Sketch the problem and a potential solution;
4) Repair the solution; and
5) Pseudo-Code the solution.

In order to illustrate these steps, an example from FutureLab is explored. The visualization was drafted to depict the algorithm created to check for collisions of shapes within the simulation grid. In FutureLab, each object within the simulation space has a shape. That shape is used to determine the boundary of the object. Collisions are detected by determining whether or not one shape has touched another. The sketch above, in Figure. 3.1, shows a number of individual use cases:

1) Homogenous collisions (*i.e. Circle vs Circle, Square vs Square*);
   (seen in the Alpha and Beta circle interaction and the Delta and Iota square interaction)
2) Heterogeneous collisions (*i.e. Circle vs Square*); and,
   (see in the Alpha and Delta circle-square interaction)
3) Non-collisions.
   (see in Eta and Gamma which sit off to the sides not interacting with other shapes)

Figure 3.1 has a significant amount of information. First off, the top right corner of the document contains the test scenario's date of creation and name, test_collision_31_01_00_collision_check. The top left of the page contains collision types by shape: those involving circles and those involving squares. The central portion of the page depicts a *potential* state of the physics simulator itself. Each shape has a name and a location. And each can be seen to touch, or collide, with various other shapes within the sketch. The FutureLab software must be able to resolve this state should it exist within the simulation space. If three circular and three square objects existed within a simulation, the software would have to be able to resolve any collisions. The algorithm used to check for collisions *must* be able to resolve the instance of state depicted in Figure 3.1. The formal test created from this visualization can be found above this section in Figure 3.2.

Stage One – Escape Technology

Stage one immediately addresses the nature of software's author, a human, a thinking animal. Humans are habitual creatures and software developers spend significant time in front of a keyboard. It is easy for a developer to jump to a computer to '*check something*' during a design meeting. A natural tendency exists to spontaneously seek verification through a tool humans are familiar using. This stems from an emotional trust in the machine. In order to remove this crutch, it is easiest to move away from the computer altogether. Let there be no digital temptation.

Stage Two – Intellectually Prepare

The second stage can be ritualistic. Psychology has proven that working in a single environment improves recollection. A student taking an exam in the room where lectures were given has a greater capacity to recall pieces of information that are difficult to recollect. Unifying environment with intellectual work or practice has beneficial side effects. This stage can be executed as part of a weekly or daily schedule. The purpose here is to begin churning cognitive inertia in a controlled manner. This can be accomplished through several means, or a combination thereof: review of pre-existing design documents, review of meeting notes and sketches, or mentally walking through the requirements for the given package. Even a simple phone call to a fellow developer to ask for clarification on a feature can begin to build intellectual steam. This preparation is synonymous with an athlete stretching before a game.

Proper preparation requires the developer ask two questions. One, "*What am I building?*" In this instance, an algorithm that will check for collisions within a simulated physical environment. Two, "*Why am I building this?*" This particular algorithm was needed in order to collect information regarding which objects were colliding. That information will be turned over to another algorithm that executes the necessary calculations of impulse acting on objects found to collide with one another. The collision_check function has a specific purpose: to ascertain which objects are colliding with which other objects. Nothing more. Nothing less.

Stage Three – Sketch the Problem and the Potential Solution

Stage three requires that the developer sketches the problem into a solution. In this stage, the developer will take up pencil and paper and draw the answer to the problem. Returning now to Figure 3.1, this test scenario attacks the use casing associated with checking for collisions. The use casing requires: 1) collisions between shapes of the same class; 2) collisions between shapes of differing classes; and 3) non-collisions.

As givens, there exists a class representing a Circle, a Square and an abstract-class representing a generic event within a physical environment. This abstract-class is the Event_Interaction class. The Collision Event has been scheduled to derive off of Event_Interaction, and as such will inherit a method to check the simulation space for the particular event. In this case, the collision_check method will look for any collision. The Circle class is an aggregation of data: a central point where the object is fixed on a grid system, a shape with a radius, and some miscellaneous fields for user interface display and other administrative purposes. The Square class is quite similar, both being derivatives of a higher level Shape class.

Before a resolution of collision state can be crafted, an instance of colliding objects must be depicted. First, the grid system is marked off on engineering or graph paper. Arbitrary values may be applied to the grid. However, having the origin near the center of the paper promotes simpler math by hand. Circles can be drawn on the paper in such a way that they collide (*Alpha vs Beta*). Their positions are determined by their locations on the grid. Other shapes are drawn to collide (*Delta vs Iota*). *Eta* and *Gamma* are not colliding with any other objects but represent non-collisions. The collision_check algorithm must properly flag *Alpha* and *Beta* as colliding, but not *Alpha* and *Eta*. When crafting the sketch, it is beneficial to depict as many use cases as practicable for the size of the canvas.

Stage Four – Repair the Solution

Stage four mandates a review of the initial sketch in light of the project requirements through the use cases. Various sketches may be required to depict all use cases. However, each use case must be accounted for within the set of visualizations. If a use case has not been translated into

visual form (*i.e. a collision between a circular object and a square shaped object*) then this interaction must be drawn.

There are two purposes to stage four. The first is to ensure requirement coverage. The second is perform a moment of self-reconnaissance. Stage three requires the depiction of the problem space as it is currently understood by the developer. Stage four requires that the initial depiction be repaired for any missing considerations. The developer is able to gauge their level of comfort with the problem. The transition from phase three to four allows one to determine any discrepancy from their current knowledge base to the one they ought have.

In the instance of collision_check, heterogeneous collisions are important. Had the collision between *Alpha* and *Delta* been missing from Figure 3.1, such a collision would need to be created within the sketch. A review of use cases will determine the completeness of the set of visualizations.

Stage Five – Pseudo-Code the Solution

Stage five begins the transition from human thought to machine code. The algorithm crafted to check for collisions within FutureLab must be able to pass every collision instance drafted as a test. The conceptual logic for the algorithm can be deduced directly from the sketches. A collision will not occur between *Eta* and *Gamma* because they do not touch. However, a collision will occur between *Alpha* and *Beta* because they do touch. The properties of the shapes themselves begin to betray the solution into light. In the case of two Circles, if the distance between their central points is less than the combined length of their radii, then a collision has occurred. If a Square is involved in a potential collision, one of its vertices may be inside of another shape (*i.e. the bottom-left corner of Delta is currently inside of the area contained by Iota*).

An initial draft of the algorithm might look like:

```
0)  F(x) collision_check( Shape shape_one, Shape shape_two )
1)    bool result = false;
2)    if shape_one == shape_two:
3)          // do nothing, identities are not collisions
4)    else if shape_one && shape_two are Circles :
5)          distance = calculate_distance( shape_one.location, shape_two.location )
6)          if distance < ( shape_one.radius + shape_two.radius ) :
7)                result = true
8)    else :
9)          for each vertex of shape_one :
10)               if the vertex is inside shape_two :
11)                     result = true
12)   return result
```

Figure 3.3 – Pseudo-Code for collision_check

This first pass of pseudo-code will often be incomplete. However, it can be amended in time. The purpose of drafting this algorithm is to peek at what support pieces are needed. It is non-consequential to have a Java or Python version of this algorithm. For the time being, only the flow of logic and data is important. Understanding what support functionality will be required opens a semi-recursive dive into the nature of the greater system. As will be discussed later, this particular dissection can lead to pre-emptive refactoring.

Before the first draft of the collision_check algorithm, the developer may or may not have known that determining the distance between two points was a necessary sub-routine of (*line 5 of the*

above). The developer may not have realized the need to have a sub-routine check for the presence of a single point within another shape (*line 10 of the above*). These support functions can be visualized as well. Figure 3.3 shows the depiction of the algorithm which checks whether or not a given point exists within a shape. Figure 3.4 is the digital aspect of 3.3.

Within Stage Five, the ampliative nature of analog development can be witnessed. As one problem is solved, others come to light. The generalized function designed to check for collisions needs support that the developer was unaware of before exploring the problem. The knowledge gain associated with the functionality of the software itself can take a on a life of its own. As the pseudo-code for a given scenario is written, the human can begin to sketch the support functionality. Or, whatever greater function will use the currently drafted algorithm. Conceptual granularity can take either course.

The Aftermath

Aftermath includes the activity of translating the sketches into encoded test scenarios. Nothing of consequence will be added to the *intent* of the sketch, which is to resolve a given instance of a collision. The test will carry the same *intent*, to resolve an encoded version of that very instance. The *digital* aspect of figure 3.1 can be found in figure 3.2.

Secondly, this involves the creation of production code to pass the newly drafted test scenarios. The purpose of analog development is to create a robust test harness that sufficiently exercises project uses cases. The custom test scenario exists as a digital environment to be resolved by source code. Assuming proper encoding of the test sketches themselves, code that properly resolves the digital scenario confidently meets the requirements of the project. This is because requirements have been transformed into explicit use cases, while each use case has been transformed into a piece of a test. Passing the tests passes the requirements.

Within this final phase, it is possible that defects in the sketches will evidence. Missing or incorrect considerations require the sketches themselves to be amended along with the encoded test scenarios. This is often due to an error related to project requirements; not having them all, not understanding them correctly, etc.

3.4 – The Analog Process : Secondary Discovery

Section 3.3 details the breakdown and design of the collision_check algorithm. Stage five yielded a pseudo-code necessitating a function that would determine if a given point was within a given shape. Singular points within FutureLab are represented as Nodes. The Nodes are a container class that aggregate x, y, and z location coordinates and also have a pointer to the next Node along the outside of a Shape. As such, Shapes are comprised of Nodes. Each polygon contains a chain of Nodes enclosing a given area of space between the locations of each point stored in the Node. If an area is encompassed by more than one Shape, a collision is present. For polygons, an iterative check of each Node's location will determine if there is overlap. If any point of a Shape exists within another Shape, there exists a collision. The acknowledgement as to the need for this support function is secondary discovery.

The algorithm designed to determine if a single point is within a Shape is called point_inside_shape. This support function was designed to yield a Boolean return reflecting whether or not a given point existed within another Shape, and in turn if a collision had taken place. The function required resolution to the following use cases:

1) Does a point exist within a Circle;
2) Does a point exist within a polygon; and,
3) Does a point exist within an aggregate of Shape, a combination of Circles and polygons.

As such, a test scenario was designed with the following:

1) Two distinct Circle objects;
2) Two distinct Square objects;
3) Two distinct Rectangle objects;
4) A complex object made of a Circle, a Square and a Rectangle; and
5) Five distinct points.

The point_inside_shape function would have to determine for each point if it existed within each Shape. A review of Figure 3.3 indicates that each point is within a given Shape, but no point is within all shapes. The resulting test in Figure 3.4 shows how each point was checked against each Shape.

The pseudo-coding stage for this algorithm did not indicate the need for additional support functionality. As such, this phase of secondary discovery came to a close. And as the design of collision_check required no additional support, that process also came to an end. However, should either have required further logic, secondary discovery would continue until the atomic pieces of logic were defined.

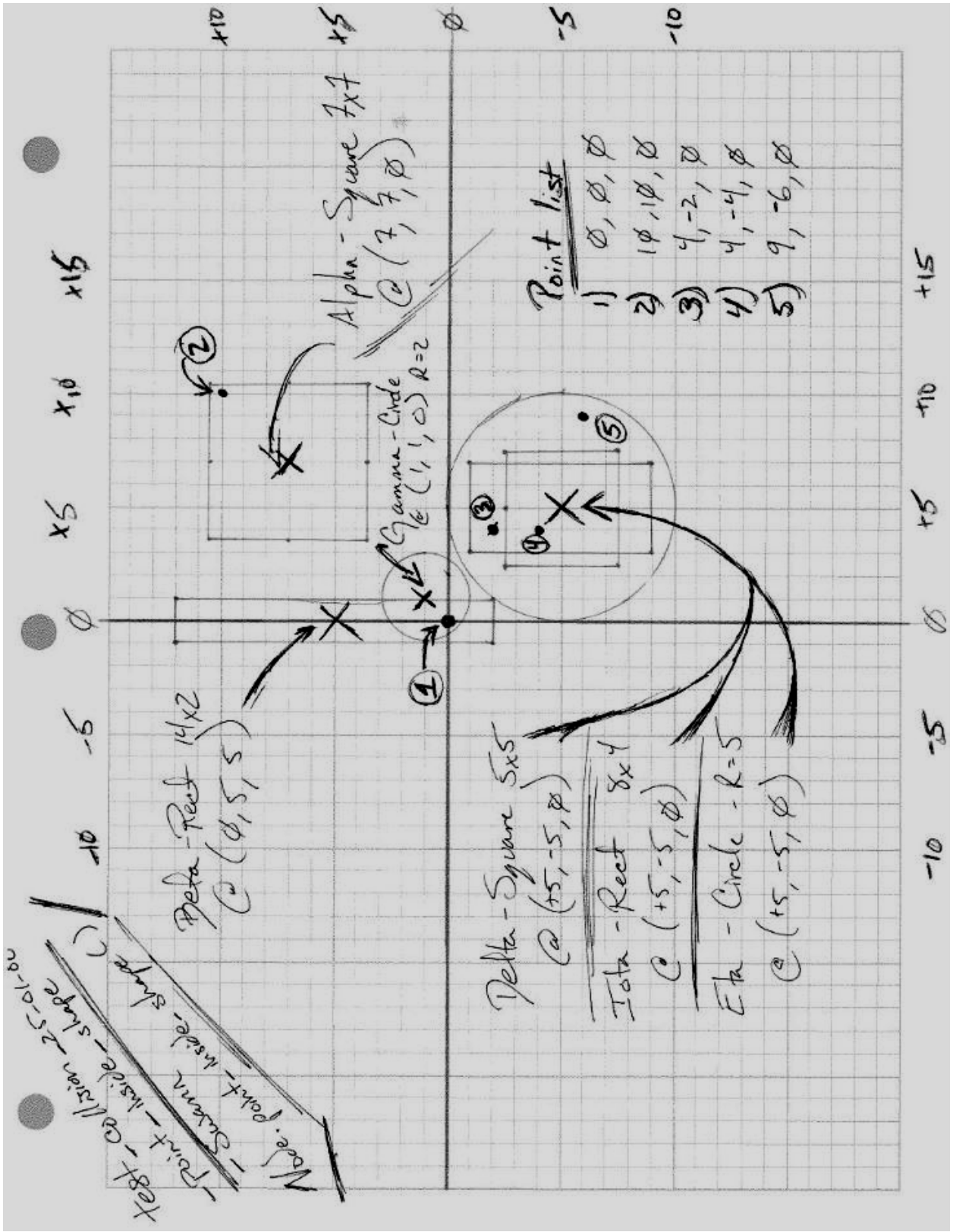


Figure 3.4 – 'Analog' Aspect of test_collision_25_01_00_point_inside_shape

```
// Collision.point_inside_shape()
//  --> Heterogeneous Test
@Test
public void test_collision_25_01_00_point_inside_shape() {
        // The setup
        Node    one  = new Node(0,   0, 0),
                two  = new Node(10, 10, 0),
                tre  = new Node(4,  -2, 0),
                four = new Node(4,  -4, 0),
                five = new Node(9,  -6, 0);
        // Simple Shapes
        Square alpha   = new Square(    7,  7,  7,  7,  7);
        Square delta   = new Square(    5, -5,  0,  5,  5);
        Rectangle beta = new Rectangle( 0,  5,  0, 14,  2);
        Rectangle iota = new Rectangle( 5, -5,  0,  8,  4);
        Circle gamma   = new Circle(    1,  1,  0,  2);
        Circle eta     = new Circle(    5, -5,  0,  5);
        // Complex Shape
        Shape omega    = new Shape(     5, -5,  0);
        omega.add_shape(delta);
        omega.add_shape(iota);
        omega.add_shape(eta);
        // Alpha Shape
        assertEquals(Collision.point_inside_shape(one,  alpha),  false);
        assertEquals(Collision.point_inside_shape(two,  alpha),  true);
        assertEquals(Collision.point_inside_shape(tre,  alpha),  false);
        assertEquals(Collision.point_inside_shape(four, alpha),  false);
        assertEquals(Collision.point_inside_shape(five, alpha),  false);
        // Beta Shape
        assertEquals(Collision.point_inside_shape(one,  beta),  true);
        assertEquals(Collision.point_inside_shape(two,  beta),  false);
        assertEquals(Collision.point_inside_shape(tre,  beta),  false);
        assertEquals(Collision.point_inside_shape(four, beta),  false);
        assertEquals(Collision.point_inside_shape(five, beta),  false);
        // Gamma Shape
        assertEquals(Collision.point_inside_shape(one,  gamma),  true);
        assertEquals(Collision.point_inside_shape(two,  gamma),  false);
        assertEquals(Collision.point_inside_shape(tre,  gamma),  false);
        assertEquals(Collision.point_inside_shape(four, gamma),  false);
        assertEquals(Collision.point_inside_shape(five, gamma),  false);
        // Delta Shape
        assertEquals(Collision.point_inside_shape(one,  delta),  false);
        assertEquals(Collision.point_inside_shape(two,  delta),  false);
        assertEquals(Collision.point_inside_shape(tre,  delta),  false);
        assertEquals(Collision.point_inside_shape(four, delta),  true);
        assertEquals(Collision.point_inside_shape(five, delta),  false);
        // Iota Shape
        assertEquals(Collision.point_inside_shape(one,  iota),  false);
        assertEquals(Collision.point_inside_shape(two,  iota),  false);
        assertEquals(Collision.point_inside_shape(tre,  iota),  true);
        assertEquals(Collision.point_inside_shape(four, iota),  true);
        assertEquals(Collision.point_inside_shape(five, iota),  false);
        // Eta Shape
        assertEquals(Collision.point_inside_shape(one,  eta),  false);
        assertEquals(Collision.point_inside_shape(two,  eta),  false);
        assertEquals(Collision.point_inside_shape(tre,  eta),  true);
        assertEquals(Collision.point_inside_shape(four, eta),  true);
        assertEquals(Collision.point_inside_shape(five, eta),  true);
        // Omega Shape
        assertEquals(Collision.point_inside_shape(one,  omega),  false);
        assertEquals(Collision.point_inside_shape(two,  omega),  false);
        assertEquals(Collision.point_inside_shape(tre,  omega),  true);
        assertEquals(Collision.point_inside_shape(four, omega),  true);
        assertEquals(Collision.point_inside_shape(five, omega),  true);
}
```

Figure 3.5 – 'Digital' aspect of test_collision_25_01_00_point_inside_shape

CHAPTER FOUR – VALIDATION

4.1 – Class Normalization & Multi-Layered Design

FutureLab required a plurality of wall-like structures that served as barriers within the simulator. Three barrier types were designed, each with differing functionality. Figure 4.1 depicts the visual and functional requirements for each Barrier type. Figure 4.2 is a listing of the subsequent class organization. This section will detail the design process for the Barrier_Event class and its descendants.

The project requirements mandated three specific Barrier behaviors. Each class was sketched and given a temporary name for the design phase. These names were later amended for clarity and meaning. The specific behaviors of each are listed in the table below.

Name in Figure 4.1	*Implemented Class Name*	*Functionality*
α Barrier	Bounce_Barrier_Event	Objects colliding with this Barrier should bounce backwards. (*i.e. A ball hitting the ground should bounce back into the air*)
β Barrier	Pass_Through_Barrier_Event	When an object's center point hits this Barrier, it should be reflected across the simulation space. (*i.e. A ball hitting this wall would wrap around the environment to the other side.*)
δ Barrier	Non_Render_Barrier_Event	When an object hits this Barrier, it should become invisible and no longer be rendered by the Android device. (*i.e. A ball escaping the current view port of the simulation space would disappear from visual processing, but continue being evaluated for collisions, etc.*)

Table 4.1 – Barrier_Event Class Breakdown

Visual depiction of the requirements evidenced a number of similarities between each of the Barrier classes. Each would rely upon an enumeration of planes: to which axis the Barrier itself was aligned. Each Barrier also required localization upon an axis. Additionally, enumeration was required to determine the direction the Barrier faces. For instance, a Non_Render_Barrier should turn off visibility for an object that exits the simulation space that the Barrier encloses; however, it should return that object to visibility should it pass back inside.

Each Barrier required a specific algorithm to check for an interaction and subsequently engage behavior. Each Barrier was derived from a generalized Barrier_Event class that contained the above common functionality. The Barrier_Event class itself was a derivation of the Event_Interaction class, which was also the parent class for Collision. Being an abstract class, Event_Interaction required decedents to implement functions for *check* and *execute*. As the Barrier_Event class was not designed for instantiation, it was also made abstract. As a result, each Barrier type would be required to implement the *check* and *execute* functions. By design, these were the only two requirements for the specific classes. They contained no other significant differences. Analog design assisted in pulling all duplicative fields and behaviors into an umbrella class. This normalization was resultant of forethought.

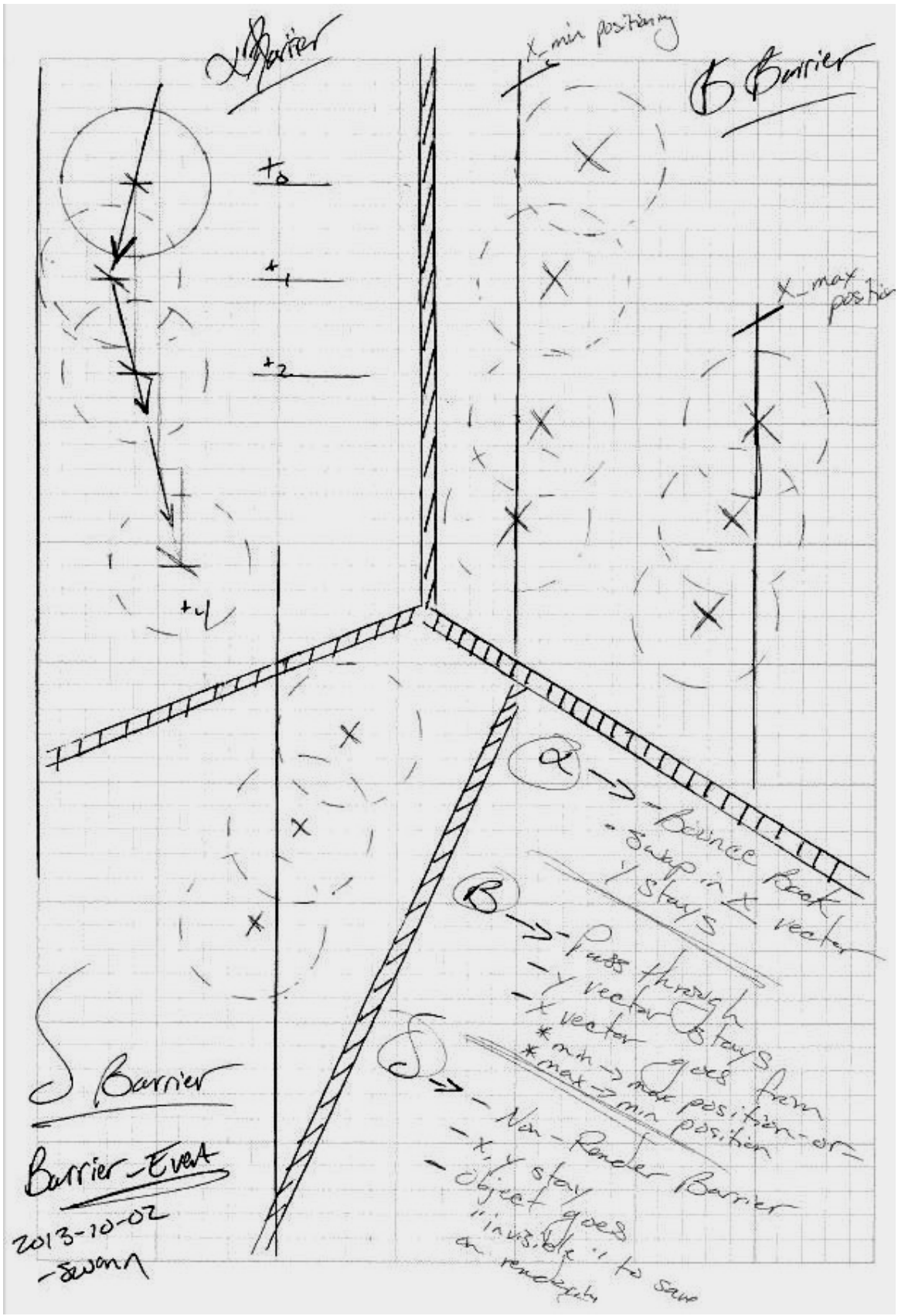


Figure 4.1 – Barrier_Event Behavior Mapping

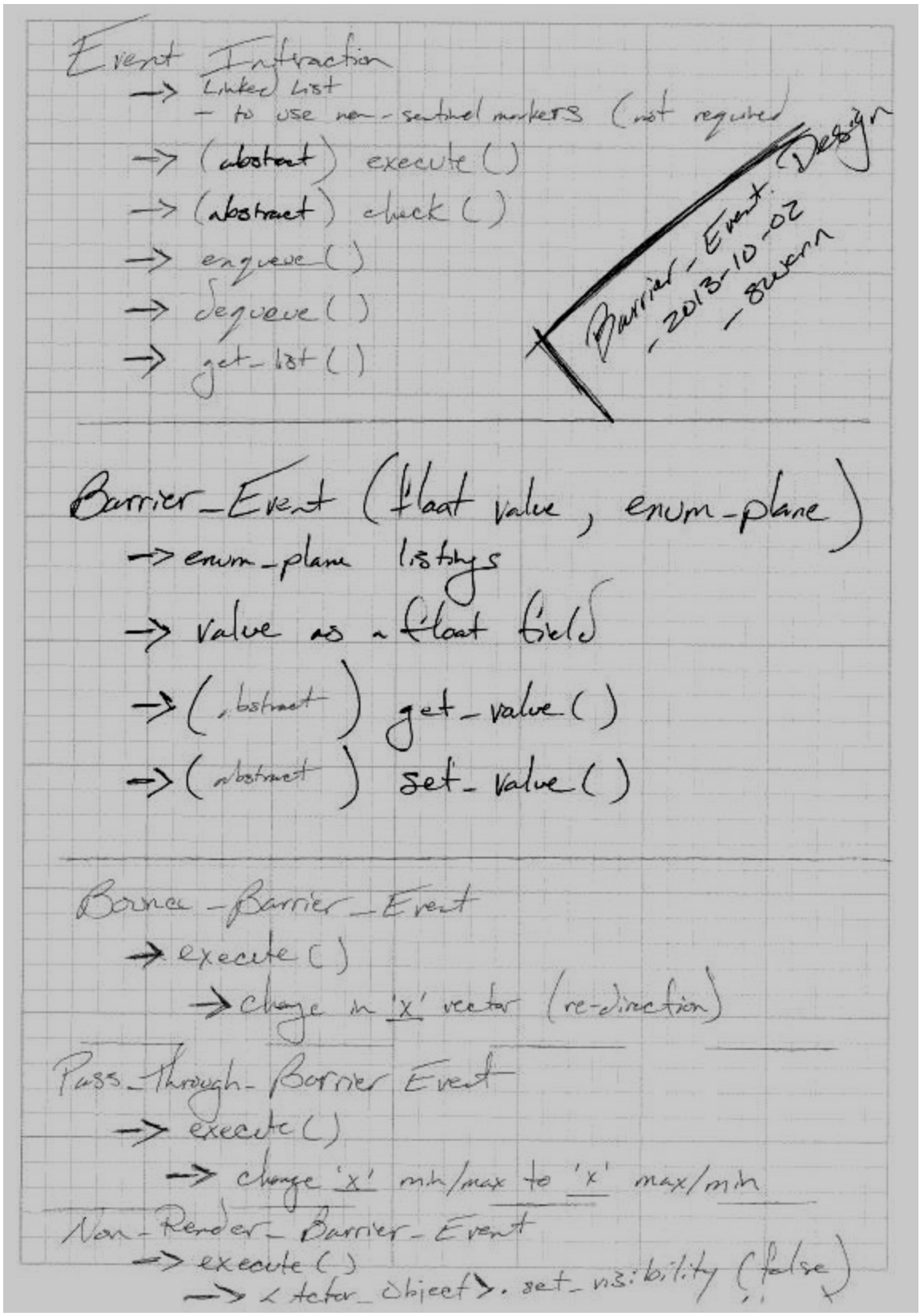


Figure 4.2 – Barrier_Event Class Notes and Sub-Class Notes

4.2– Relative Math & Test Scenario Flexibility

A particular point of discomfort in software development is the process of adjusting tests when requirements change. This often results in a need to either restructure tests or recalculate expected outcomes. The effort needed to make these adjustments would not have been necessary had the change not occurred. Understanding the proportional mathematics behind a calculation, if such a relationship exists, may ameliorate the situation.

Figure 4.3 depicts the design of a Drop_Tower and an associated Swing_Arm. A Drop_Tower is a simple structure with an attached platform, a Swing_Arm, which is designed to allow objects to rest upon it. Given a trigger event, the Swing_Arm will drop allowing gravity to enact upon any objects once atop the tower. The Drop_Tower and Swing_Arm classes were designed to co-exist. As such, analog design was used to explore the proximal relationship between the two objects.

As can be seen in Figure 4.3, the Drop_Tower itself has a central location at a given x, y coordinate pair. The related Swing_Arm is situated off to the side of the tower with a central location of its own. Any function called at runtime to create a Swing_Arm off of a given Drop_Tower would require a dynamic look at the Drop_Tower's location in order to determine the proper placement for the Swing_Arm. Any change to the sizing of either the tower or the arm would require revisiting the math which calculates the center point of the Swing_Arm.

Resolving the problem began by designing static variables to represent the height and width of each structure. Static variables were appropriate as FutureLab did not require various sized towers.

Component	*Variable Name*	*Variable Value*
Drop_Tower	Tower_Height	20
Drop_Tower	Tower_Width	5
Swing_Arm	Arm_Height	3
Swing_Arm	Arm_Width	5

Table 4.2 – Static Values for Drop_Tower & Swing_Arm Classes

The explicit math on this scenario is embedded within the below figure. A simple triangular relationship is seen. Given values from Table 4.2 and an (x_0, y_0) coordinate pair of (10, 15) for the center of the Drop_Tower, a Swing_Arm should be created at (x_1, y_1) coordinate pair (15, 23.5). This offset location is found in two steps: 1) the *x* differential is a sum of half the tower width and half the arm width; and 2) the *y* differential is the difference between the half the tower height and half the arm height. As a formula, the (x_1, y_1) for the arm's location:

$$x_1 = x_0 + \frac{Tower\_Width}{2} + \frac{Arm\_Width}{2}$$

$$y_1 = y_0 + \frac{Tower\_Height}{2} - \frac{Arm\_Height}{2}$$

This formula was implemented within the function which created a Swing_Arm adjacent to a Drop_Tower. It directly pulls the static values for the sizing of each object. The related tests also calculated their outcomes by accessing these static values. As such, regardless of how many changes were made to the sizing of either object, the Swing_Arm would be created flush with the top of the tower and off to the right due to the implementation of these formulae. Also, due to the use of this

relative math, test scenarios can be run and immediately passed as they call the same accessor methods. A change in requirements regarding the size of either structure would only require the update of a few values. The flexibility of logic handled the rest.

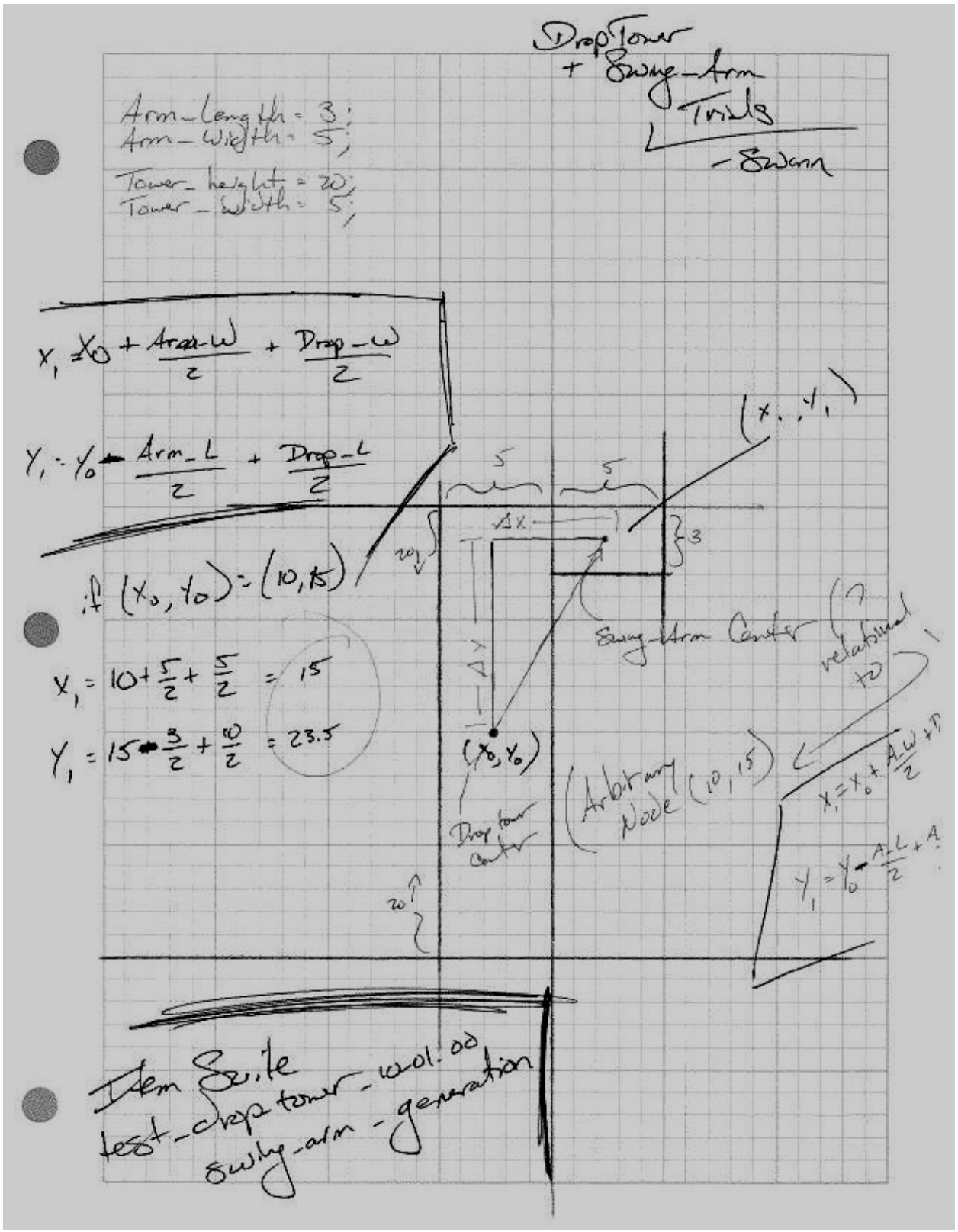


Figure 4.3 – Relational Math Exploration

4.3 – Self-Reconnaissance & Won't Fix Designations

It is not practicable to design software in such a way that no bugs exist within the artifact. Algorithms may indeed fail for requirements outside of the project scope. There exist too many logic paths and too many scenarios to perfect each algorithm outside of intended use. The goal of software development is to create a code base that passes the project requirements, not a code base the handles every imaginable scenario. Though these two may coincide, often they do not. And though the developer may not be responsible for the creation of code that passes use cases outside of the project requirements, knowing the limitations of the system has significant advantage.

In order to explore the limits of the collision_check algorithm explored in section 3.3, a test was created that contained aggregations of complex shapes that were not designed for FutureLab. Figure 4.4 depicts the related test scenario. The depiction has numerous simple shapes, those with just one instantiated shape. These are all named after letters of the Greek alphabet. The complex shapes, coagulations of simple shapes, were outside of project scope and are as follows:

Complex Shape Name	*Location (x, y)*	*Aggregation Of <Shape> – <Type> at (x,y) – Dimensions*
Ares	(7, 3)	Delta – Rectangle (8, 3) – 2 x 14 Iota – Circle (5, 3) – Radius 3
Durga	(-4, 5)	Omega – Rectangle (-5, 5) – 2 x 20 Omicron – Square (-3, 4) – 8 x 8
Hades	(0, -5)	Lambda – Circle (0, -7) – Radius 4 Mu – Circle (-3, -5) – Radius 2 Tau – Circle (0, -3) – Radius 4 Theta – Circle (3, -5) – Radius 2
Kali	(2, 7)	Alpha – Circle (0, 10) – Radius 4 Gamma – Square (7, 6) – 2 x 2

Table 4.3 – Complex Shape Aggregation for test_collision_30_02_00_collision_check

Though this *potential* state for FutureLab is outside of the requirements, a perfect collision algorithm would be able to handle it. The encoded version of the test does not pass to completion. It will fail. However, the resolution of each collision between simple shapes and the complex shapes designed for implementation within FutureLab pass. Those assertions which fail have been commented out of the test code and documented.

Dissection of the failures within this test scenario revealed that a logical error exists within the calculation of the boundary detection algorithm used as a part of the collision_check algorithm. Specifically, if a complex shape is evaluated for collision it may return a false negative for a collision if the shape has a plurality of Circles. The external boundary of the shape is miscalculated to a small degree allowing for a collision to go unresolved. The margin of error is a proportion of the last Circle's physical radius. However, FutureLab was not designed to contain objects with a plurality of circular components. This logic error is depicted in Figure 4.5 and has been designated as *won't fix*. Should there be a change to the project requirements the bug is documented in the version control software used for the project, the design documents, and the code itself. A developer stepping into my place on the project would know exactly where and why the code fails sections of this test. This allows for expedited repairs on a known bug.

The data pulled from this test was primarily positive. The collision_check function was able to handle portions of an impossible *potential* arraignment of shapes within project scope. Complex shapes with central points far removed from their internal components were found to be evaluated properly in regards to collisions. Proximity of shapes had no ill effect. This boded well for future developments involving angular rotation. Time to test-completion for a large arraignment of shapes

was also found to be positive. No difference in execution time was noted between tests with a single object or a plurality thereof. This suggested the algorithm was acceptably efficient.

The self-reconnaissance preformed through this test greatly enhanced knowledge of the software's capabilities, where it stands in regards to future developments, and where it will not succeed as currently implemented. This information was, and still is, quite valuable.

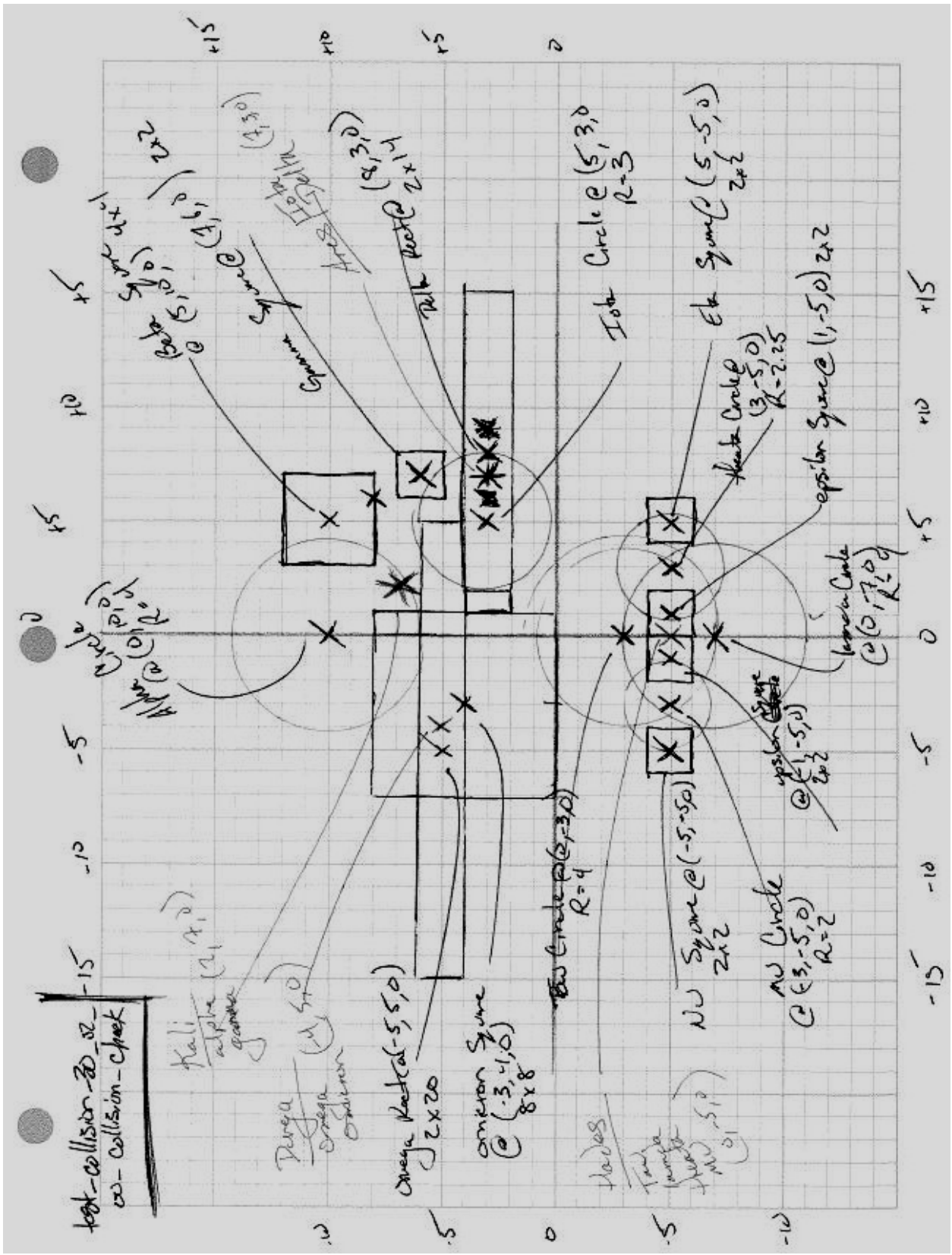


Figure 4.4 – 'Analog' Aspect of test_collision_30_02_00_collision_check

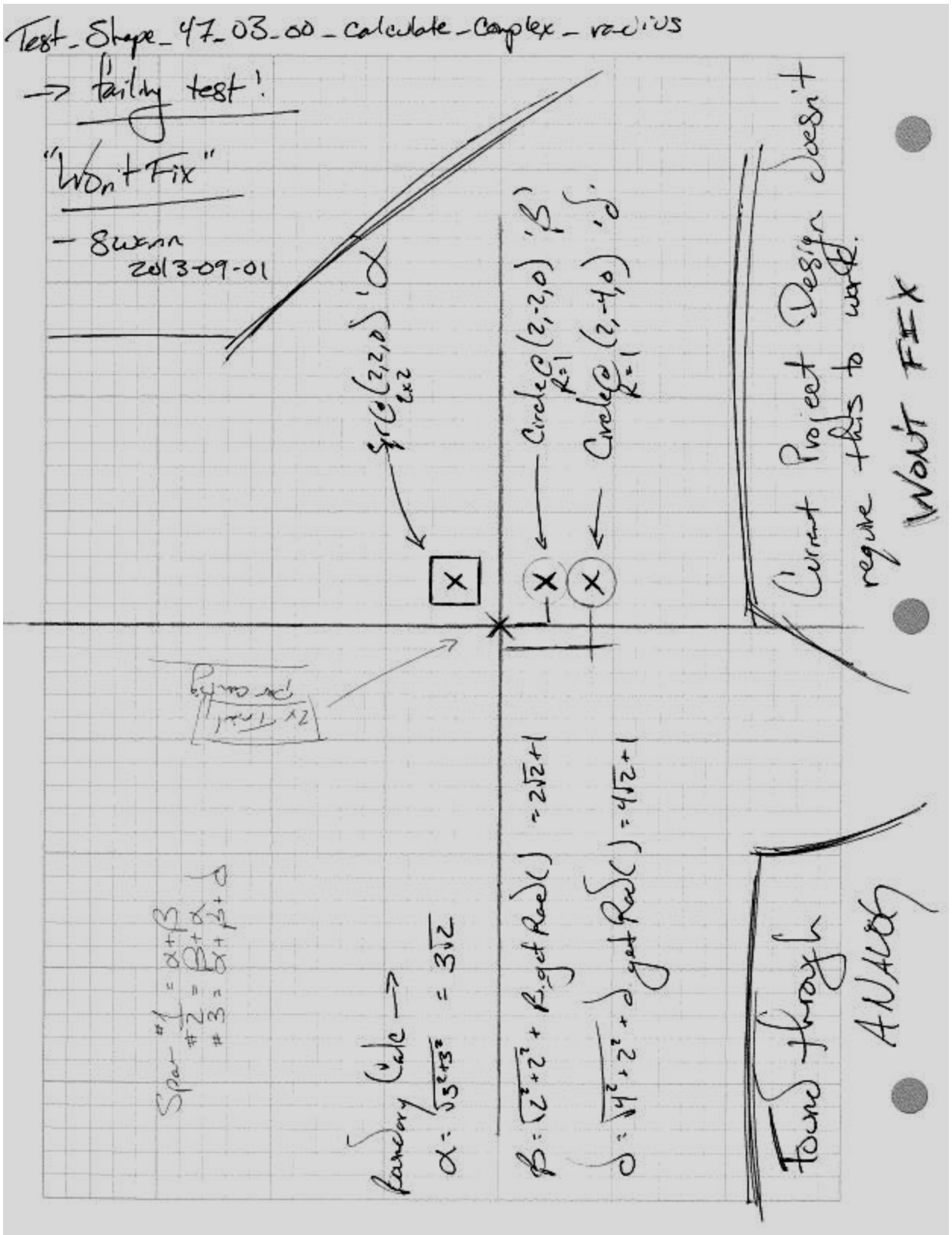


Figure 4.5 Won't Fix Documentation for Requirements Outside Project Scope

CHAPTER FIVE – CONCLUSIONS

Analog development is a mechanism that was engineered for the purpose of assisting the software developer. The process acknowledges the human nature of the developer and accordingly attempts to harness a natural human strength by reflecting upon the manner in which the conceptual mind works. As a result, the mechanism allows for a form of intelligent discovery. By measuring the discrepancy between the current status and the desired behavior, the developer is able to map a course to the endgame.

5.1 – In Summary

Analog Driven Development was born out of need. Locating the boundaries and vertices of a shape without a map proved difficult. Evaluating impulse from collisions using velocity vectors would have been impractical without some form of pre-emptive test design. I chose to draw the scenarios. I wanted to see them. I wanted to see all the points of interaction. I wanted something I could trust.

Initially, ADD existed only for a single test case. I needed to know where a couple things were in the simulation space. It was immediately apparent how simple the transition from the sketch to the test suite was. The sketch was comprised of the pieces I already had, but as a whole it represented what I was building next. I had found a design tool. This became my underlying structure. A structure every form of writing requires. [3]

The analog process as it currently stands is a result of the benefits I found inherent to sketching my designs: isolation of support logic from a greater function, coagulation of similar class features allowing for normalization and hierarchy design, creation flexible test scenarios using relative mathematics, and the value of self-reconnaissance.

These benefits come from the different ways I have molded a use for the process. Because ADD requires only an initial visual solution, it is easily adaptable to various conceptual problems. Not shown in the examples herein are analog designs other adaptations of this process, including: a customized linked-list for queuing members of a collision and the design of algorithms for reversing an object's trajectory.

Aside from the direct benefits of ADD, there are also positive side effects to the process. Firstly, familiarizing another developer with the backend code for FutureLab has proven to be a simpler process if I can show what is happening. Reading through an algorithm in Java is not as easy as looking at a picture of how the code resolves a collision event. Secondly, I have found a significant increase in my confidence regarding written code. The analog process forces a deep understanding of the artifact itself. The test scenarios provide a robust exercise of the code. This combination allows me to be confident in my product. Thirdly, when asked in a design meeting how a proposed feature might impact the backend, I can simply open my sketchbook and see exactly how that feature is going to impact what FutureLab already has.

Analog development is a test-first development practice by definition. The test code is written before the source. But before a test is written, the entire scenario is resolved. This process is not for every design decision as there is associated overhead. For difficult problems, I have found benefit in the disciplined nature of this process. When solving any engineering problem, discipline is important. "As you sow, so too shall you reap." [7]

5.2 – Considerations for the Future

The known advantages of ADD are listed above. However, there may be a plurality of other benefits to this process that will require more exploration to derive. I doubt I've found the very best way to sketch the physics of FutureLab. I continue to find new applications. Also, there may be venue specific benefits to the process. Further use of this process is required in order to understand what true potential it has.

The full design of a database will likely take a different visual form that FutureLab did. Instead of depicting a grid system for collisions, one could map table relationships. A visual representation of a database's keying structure might facilitate the logic behind query designs or optimization. If an engineer could see the key structure, mapping a query might take less effort. Or perhaps larger queries could be built as aggregations of sub-queries. Analog design found the ability to isolate support logic within a simulated physical environment. Perhaps in an object relationally mapped database with the same would be applicable in the creation of modular sub-queries.

It is also plausible that ADD may be beneficial in academic scenarios. Perhaps it has uses in the classroom. Might an inexperienced student benefit from being able to 'see' the code about to be scripted? Might an advanced student benefit from an additional design tool? Might we all benefit from further harnessing our greatest human tool, our conceptual minds?

REFERENCES

[1] J. Blachowicz, *Of Two Minds: The Nature of Inquiry*, State University of New York Press, Albany, NY 1998

[2] K. Beck, *Test-Driven Development by Example*, Pearson Education, Inc., Boston, MA, 2003

[3] W. Strunk, E.B. White, *The Elements of Style*, 15th Edition, Pearson Education, Boston, MA, 2009

[4] F. Keenan, *Agile Process Tailoring and probLem analYsis (APTLY)*, Proceedings of the 26th International Conference on Software Engineering, 2004

[5] I. Yoon, S. Min, D. Bae, *Tailoring and Verifying Software Process*, Software Engineering Conference, 2001, ASPEC 2001 Eighth Asia-Pacific

[6] V. Basili, H. Rombach, *Tailoring the Software Process to Project Goals and Environments*, Proceedings of the 9th International Conference on Software Engineering, ICSE 1987, Review by B. Boehm

[7] T. Ashley-Farrand, *Shakti Mantras*, Random House, New York, NY, 2003

[8] R.S. Bluck, *Plato's Meno*, Cambridge Press, Cambridge, MA, 1964

[9] Oxford University Press, *The Oxford English Dictionary*, Oxford University Press, 2013 15 Jan 2014 < http://www.oed.com/ >

[10] F.M. Cornford, *Plato's Theory of Knowledge: The Theaetetus and the Sophist,* Dover Publications, Mineola, NY, 2003

[11] Auburn University, *Into the Lab: Computer Science and Software* , 6 June 2013 <http://ecm.eng.auburn.edu/wp/emag/?p=2115>

[12] G.L. Murphy, *The Big Book of Concepts*, MIT Press, Cambridge, MA, 2004

APPENDIX ALPHA

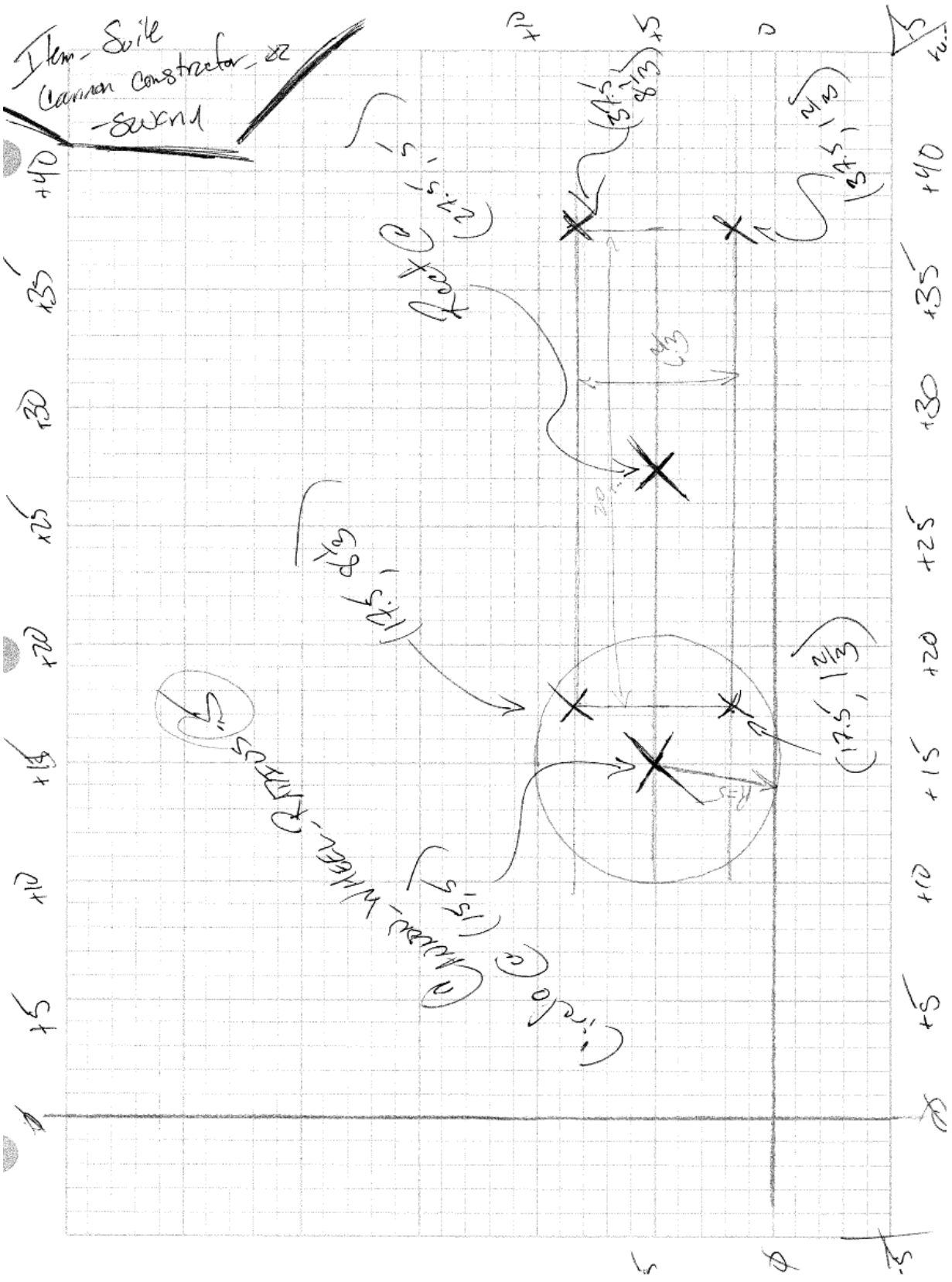
Legend ::

module	associated java module being tested
test/design	specific test and design document name
description	brief overview of the purpose of the test
test notes	target behaviors being explored
function notes	implementation of target behaviors (where applicable)

Nota Bene ::

The appendix includes only test and source code that is immediately applicable to the resolution of use cases explored through Analog Driven Development. Several thousand lines of FutureLab's test code and source code are absent from this section.

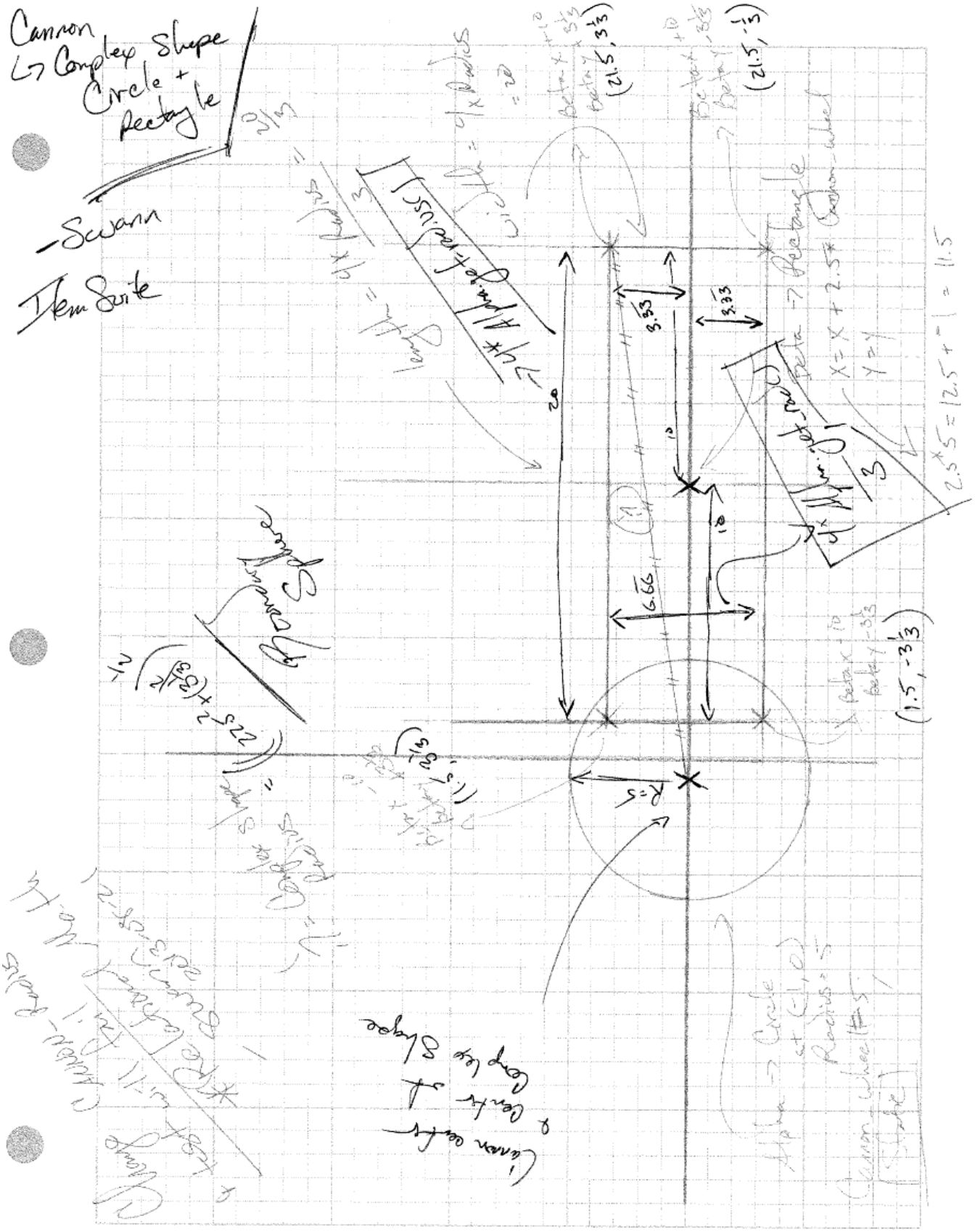
module :: Item/Cannon.java
test/design :: test_cannon_10_02_00_constructor_equivalence
description :: cannon class design and constructor verification



test notes :: cannon size values changed from initial sketch; sketch not re-drawn to reflect amendments to test

```
// Cannon constructor equivalence { part 2 }
@Test
public void test_cannon_10_02_00_constructor_equivalence() {
        // Cannon object
        Cannon the_new_cannon     = new Cannon(15, FIVE, ZERO);
        // Composite Shape
        Shape  the_shape          = (Shape) the_new_cannon.get_shape();
        // Composite List
        ArrayList<Shape> the_list = the_shape.get_composite_list();
        // Admin arrays
        float[] tracking_one, tracking_two;
        // Internal shape iterator
        Shape  inner_shape        = the_list.get(ZERO);
        // Non-assert testing --> same effect different angle of attack
        if ( ! (inner_shape instanceof Circle) ) {
                fail(" test_cannon_10_02_00_constructor_equivalence --> First shape should be a circle");
        }
        tracking_one = inner_shape.get_location();
        if ( ! ( tracking_one[ZERO] == 15 ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> Circle X-coord");
        }
        if ( ! ( tracking_one[ONE] == 5 ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> Circle Y-coord");
        }
        if ( ! ( tracking_one[TWO] == ZERO ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> Circle Z-coord");
        }
        inner_shape = the_list.get(ONE);
        if ( ! (inner_shape instanceof Rectangle) ) {
                fail(" test_cannon_10_02_00_constructor_equivalence --> Second shape should be a rectangle");
        }
        Node head = inner_shape.get_head_point();
        tracking_two = head.get_location();
        assertEquals(tracking_two[ZERO],       127.5, A_THOUSANDTH);
        assertEquals(tracking_two[ONE],       21.667, A_THOUSANDTH);
        assertEquals(tracking_two[TWO],         ZERO, A_THOUSANDTH);

        head = head.get_next();
        tracking_two = head.get_location();
        assertEquals(tracking_two[ZERO],       127.5, A_THOUSANDTH);
        assertEquals(tracking_two[ONE],      -11.667, A_THOUSANDTH);
        assertEquals(tracking_two[TWO],         ZERO, A_THOUSANDTH);

        head = head.get_next();
        tracking_two = head.get_location();
        assertEquals(tracking_two[ZERO],       27.5, A_THOUSANDTH);
        assertEquals(tracking_two[ONE],     -11.667, A_THOUSANDTH);
        assertEquals(tracking_two[TWO],        ZERO, A_THOUSANDTH);

        head = head.get_next();
        tracking_two = head.get_location();
        assertEquals(tracking_two[ZERO],       27.5, A_THOUSANDTH);
        assertEquals(tracking_two[ONE],      21.667, A_THOUSANDTH);
        assertEquals(tracking_two[TWO],        ZERO, A_THOUSANDTH);
}
```

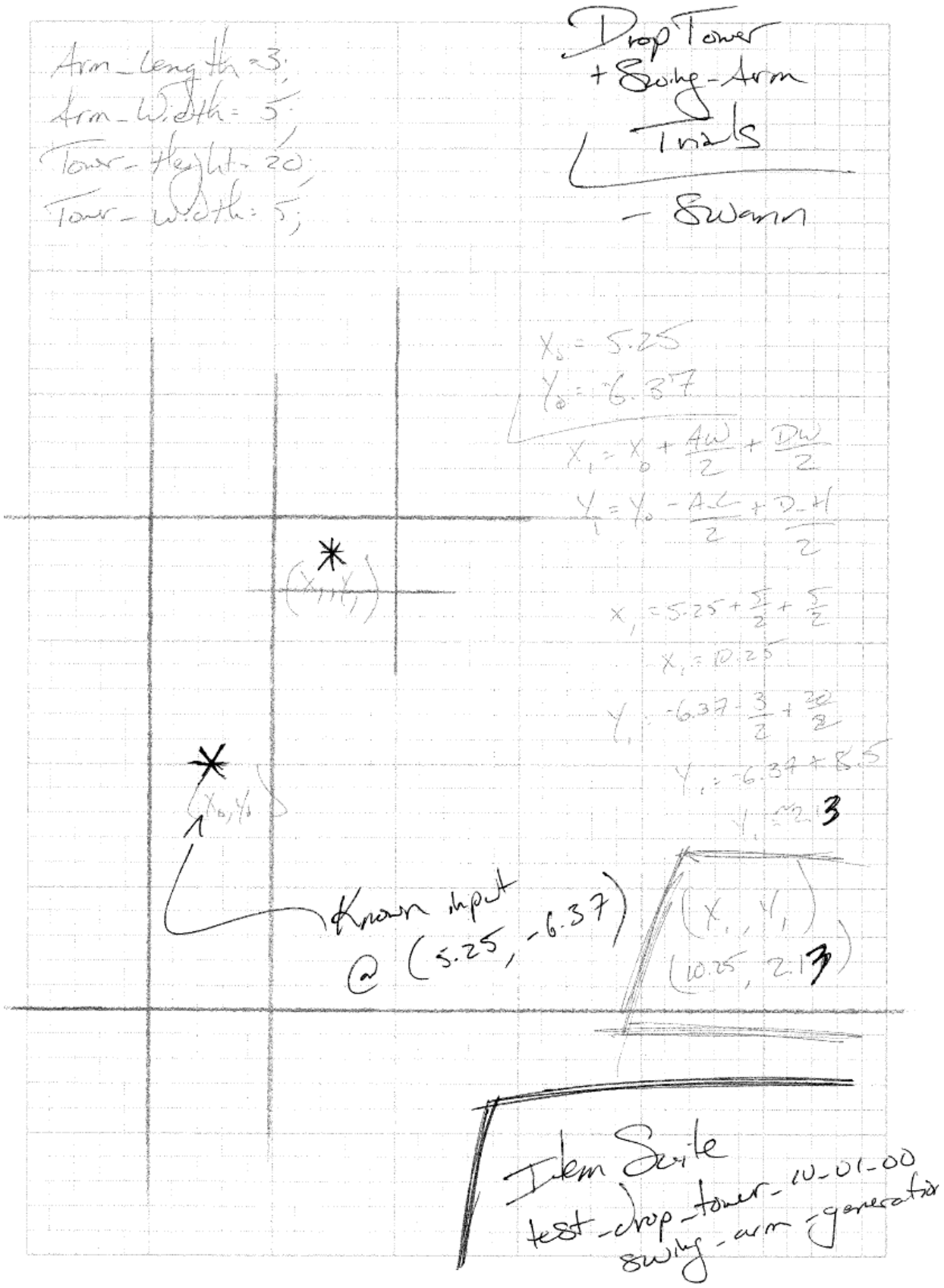
module :: Item/Cannon.java
test/design :: test_cannon_10_01_00_constructor_equivalence
description :: cannon class design and relational math equations; text flexibility installation



test notes :: verification of relative mathematics on cannon aspect proportions

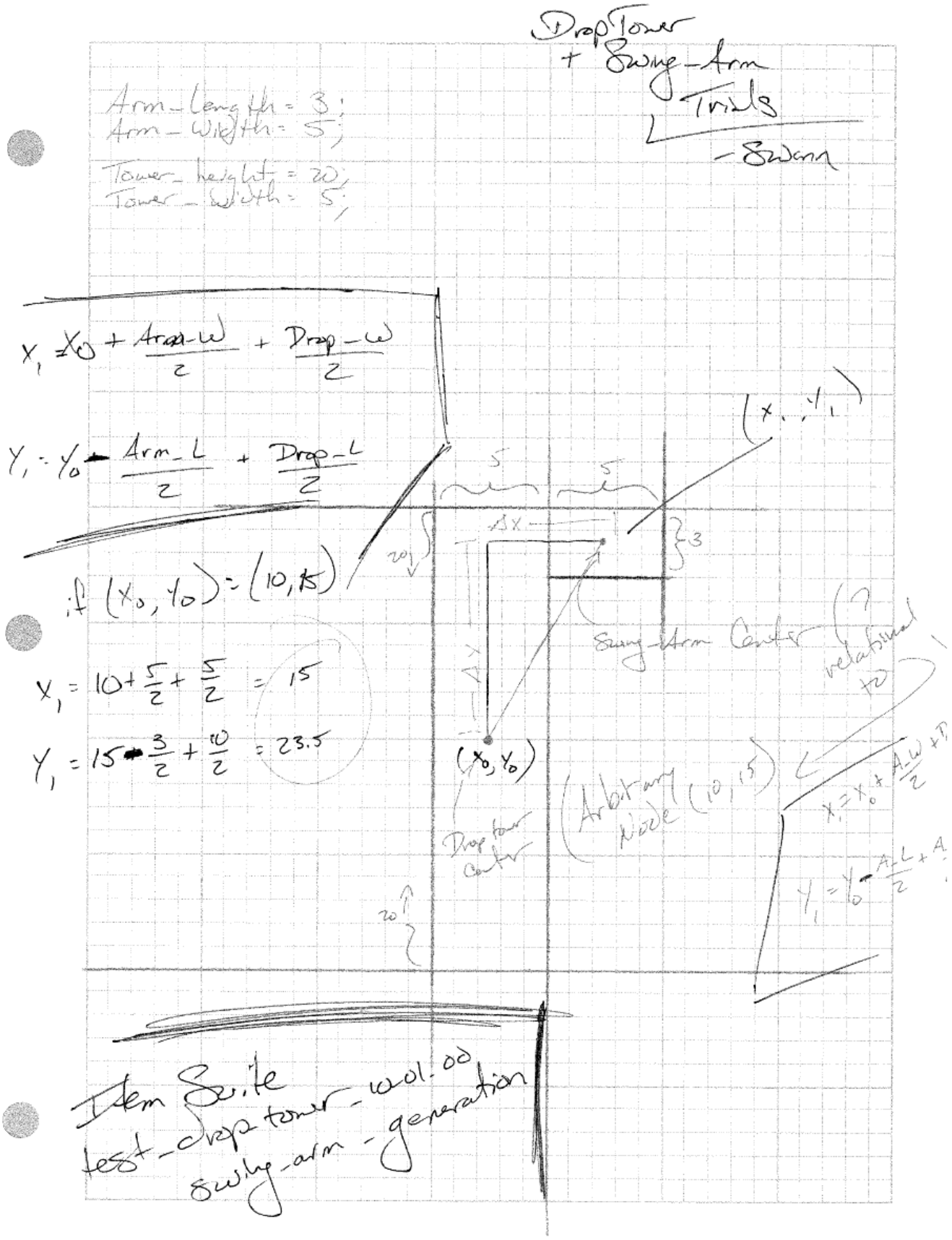
```
// Cannon constructor equivalence { part 1 }
@Test
public void test_cannon_10_01_00_constructor_equivalence() {
        // Cannon object
        Cannon the_new_cannon     = new Cannon(NEGATIVE_ONE, ZERO, ZERO);
        // Composite Shape
        Shape  the_shape          = (Shape) the_new_cannon.get_shape();
        // Composite List
        ArrayList<Shape> the_list = the_shape.get_composite_list();
        // Admin arrays
        float[] tracking_one, tracking_two;
        // Internal shape iterator
        Shape  inner_shape        = the_list.get(ZERO);
        // Non-assert testing --> same effect different angle of attack
        if ( ! (inner_shape instanceof Circle) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> First shape should be a circle");
        }
        tracking_one = inner_shape.get_location();
        if ( ! ( tracking_one[ZERO] == NEGATIVE_ONE ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> Circle X-coord");
        }
        if ( ! ( tracking_one[ONE] == ZERO ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> Circle Y-coord");
        }
        if ( ! ( tracking_one[TWO] == ZERO ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> Circle Z-coord");
        }
        float radius = inner_shape.get_radius();
        inner_shape = the_list.get(ONE);
        if ( ! (inner_shape instanceof Rectangle) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> Second shape should be a rectangle");
        }
        Node head = inner_shape.get_head_point();
        tracking_two = head.get_location();
        if ( ! ( tracking_two[ZERO] == tracking_one[ZERO]+4.5*radius ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point one X-coord");
        }
        if ( Math.abs(tracking_two[ONE] - tracking_one[ONE]+2/3*radius) < A_HUNDREDTH ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point one Y-coord");
        }
        if ( ! ( tracking_two[TWO] == ZERO ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point one Z-coord");
        }
        head = head.get_next();
        tracking_two = head.get_location();
        if ( ! ( tracking_two[ZERO] == tracking_one[ZERO]+4.5*radius ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point two X-coord");
        }
        if ( Math.abs(tracking_two[ONE] - tracking_one[ONE]-2/3*radius) < A_HUNDREDTH ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point two Y-coord");
        }
        if ( ! ( tracking_two[TWO] == ZERO ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point two Z-coord");
        }
        head = head.get_next();
        tracking_two = head.get_location();
        if ( ! ( tracking_two[ZERO] == tracking_one[ZERO]+.5*radius ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point three X-coord");
        }
        if ( Math.abs(tracking_two[ONE] - tracking_one[ONE]-2/3*radius) < A_HUNDREDTH ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point three Y-coord");
        }
        if ( ! ( tracking_two[TWO] == ZERO ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point three Z-coord");
        }
        head = head.get_next();
        tracking_two = head.get_location();
        if ( ! ( tracking_two[ZERO] == tracking_one[ZERO]+.5*radius ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point four X-coord");
        }
        if ( Math.abs(tracking_two[ONE] - tracking_one[ONE]+2/3*radius) < A_HUNDREDTH ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point four Y-coord");
        }
        if ( ! ( tracking_two[TWO] == ZERO ) ) {
                fail(" test_cannon_10_01_00_constructor_equivalence --> point four Z-coord");
        }
}
```

module :: Item/Drop_Tower.java
test/design :: test_drop_tower_10_01_00_swing_arm_generation
description :: drop tower class design and constructor verification with generation of attached swing arm



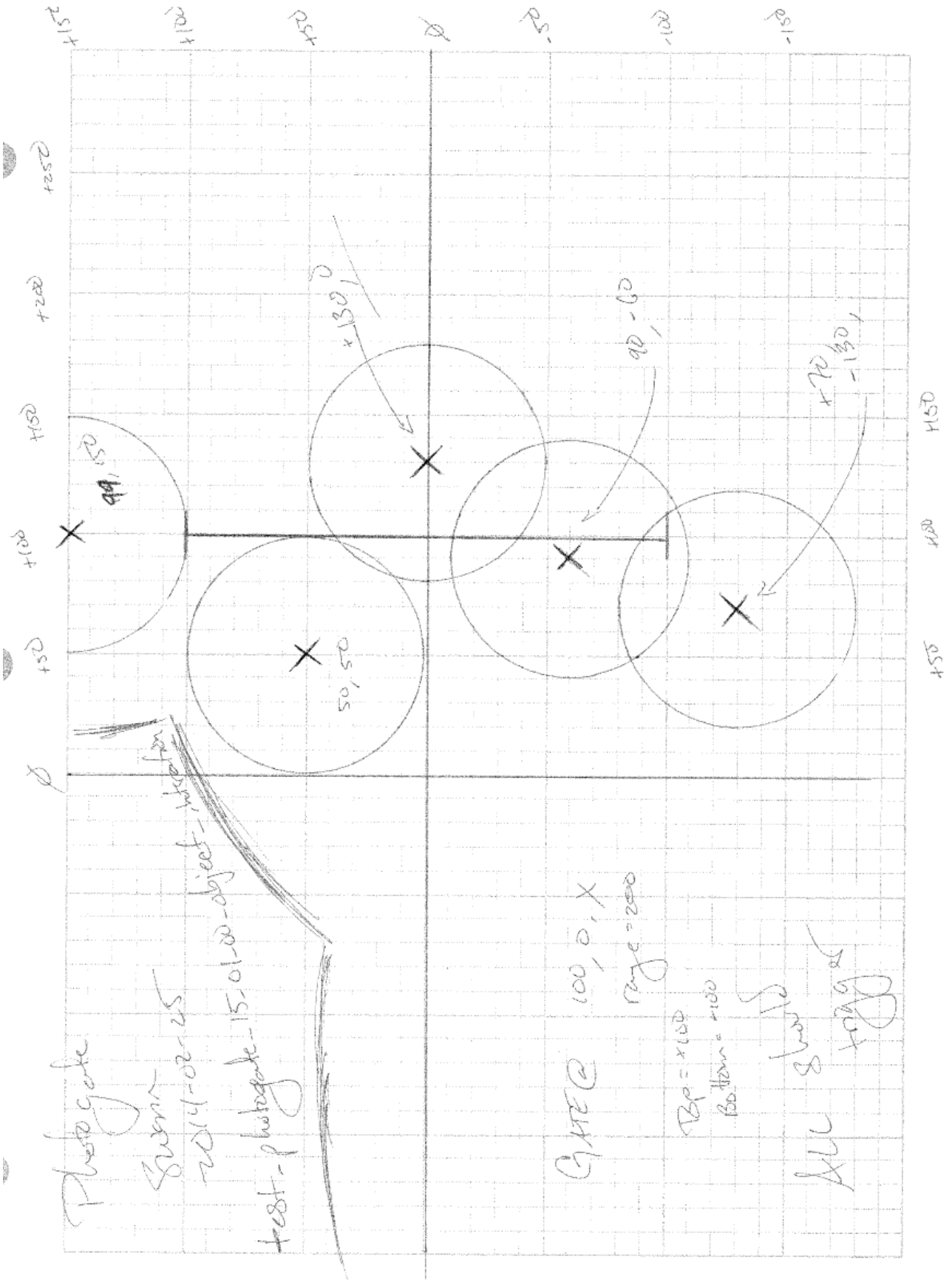
```
// DropTower.swing_arm_generation()
@Test
public void test_drop_tower_10_01_00_swing_arm_generation() {
        // Battery One
        DropTower tower = new DropTower(TEN, 15, ZERO);
        SwingArm swing_arm = tower.swing_arm_generation();
        float[] location = swing_arm.get_location();
        assertEquals(location[ZERO], (float) 15,   A_THOUSANDTH);
        assertEquals(location[ONE],  (float) 23.5, A_THOUSANDTH);
        assertEquals(location[TWO],  (float) ZERO, A_THOUSANDTH);
        // Battery Two
        tower = new DropTower((float) 5.25, (float) -6.37, ZERO);
        swing_arm = tower.swing_arm_generation();
        location = swing_arm.get_location();
        assertEquals(location[ZERO], (float) 10.25, A_THOUSANDTH);
        assertEquals(location[ONE],  (float) 2.13,  A_THOUSANDTH);
        assertEquals(location[TWO],  (float) ZERO,  A_THOUSANDTH);
}
```

module :: Item/Drop_Tower.java
test/design :: test_drop_tower_10_01_00_swing_arm_generation
function :: Drop_Tower(x_coord, y, coord, z_coord) && Drop_Tower.swing_arm_generation()
description :: relational math diagram of generated swing arm



```
/**
 * Basic constructor for the DropTower Class taking parameters for the x, y, and z
 * coordinates.
 *
 * Current 'z' parameter currently unused.
 *    ~swann 2013-11-06
 *
 * @param x_coordinate : Position on 'x' axis
 * @param y_coordinate : Position on 'y' axis
 * @param z_coordinate : Position on 'z' axis
 */
public DropTower( float x_coordinate, float y_coordinate, float z_coordinate ) {

        this.set_interactive( false );
        this.shape = new Rectangle( x_coordinate, y_coordinate, z_coordinate,
                                    TOWER_HEIGHT, TOWER_WIDTH);

} // end DropTower()


/**
 * Generates and returns a SwingArm object at a relative location to the current
 * DropTower.
 *
 * @return { SwingArm } : Object generated in relation to the space occupied by the
 *                        DropTower itself.
 */
public SwingArm swing_arm_generation( ) {

        float[] location = this.get_location();

        float x_prime = (float)  ( location[ZERO] +
                                   ( SwingArm.ARM_WIDTH/(float)TWO) +
                                   ( DropTower.TOWER_WIDTH/(float)TWO));

        float y_prime = (float)  ( location[ONE] -
                                    ( SwingArm.ARM_LENGTH/(float)TWO) +
                                   ( DropTower.TOWER_HEIGHT/(float)TWO));

        float z_prime = ZERO;

        return new SwingArm( x_prime, y_prime, z_prime );
} // end DropTower.swing_arm_generation()
```

module :: Item/Photogate.java
test/design :: test_photogate_15_01_00_object_interaction
description :: battery of checks on photogate vs circular-objects; each should trip the gate



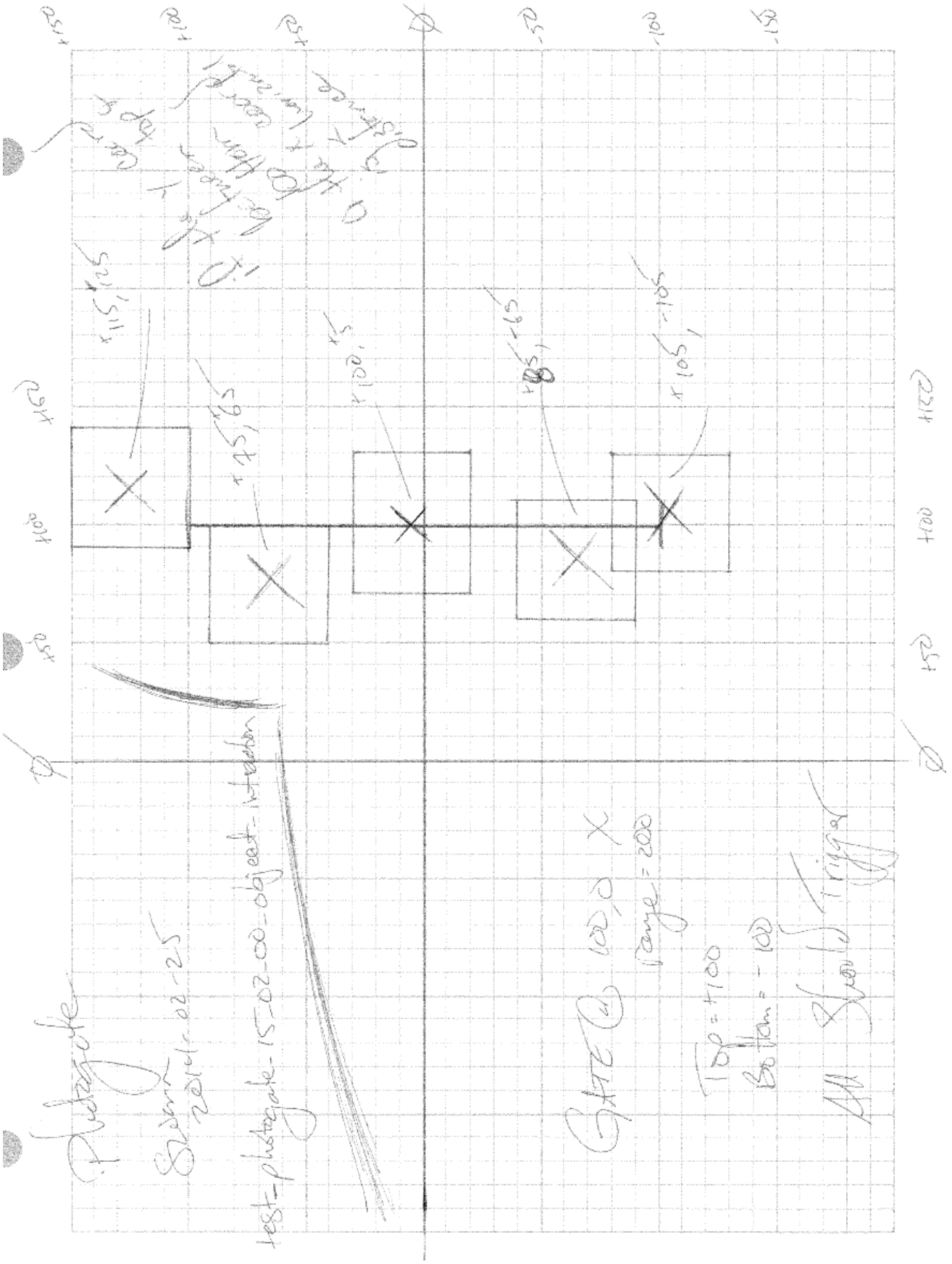
test notes :: design of interaction of circular objects with the photogate class

```
// Photogate object interaction tests
@Test
public void test_photogate_15_01_00_object_interaction() {
        // The Setup
        Ball alpha = Ball.generate_Baseball(99,  150, ZERO);
        Ball beta  = Ball.generate_Baseball(50,   50, ZERO);
        Ball delta = Ball.generate_Baseball(130,   0, ZERO);
        Ball gamma = Ball.generate_Baseball(90,  -60, ZERO);
        Ball iota  = Ball.generate_Baseball(70, -130, ZERO);

        Photogate gate_one  = new Photogate( 100,           0,              ZERO,
                                            100, Photogate.axis_enumeration.X, 200);

        // Each circle should trip the gate
        assertEquals(gate_one.is_tripped_by( alpha ), true);
        assertEquals(gate_one.is_tripped_by( beta  ), true);
        assertEquals(gate_one.is_tripped_by( delta ), true);
        assertEquals(gate_one.is_tripped_by( gamma ), true);
        assertEquals(gate_one.is_tripped_by( iota  ), true);
}
```

function notes :: implementation of related `is_tripped_by( )`

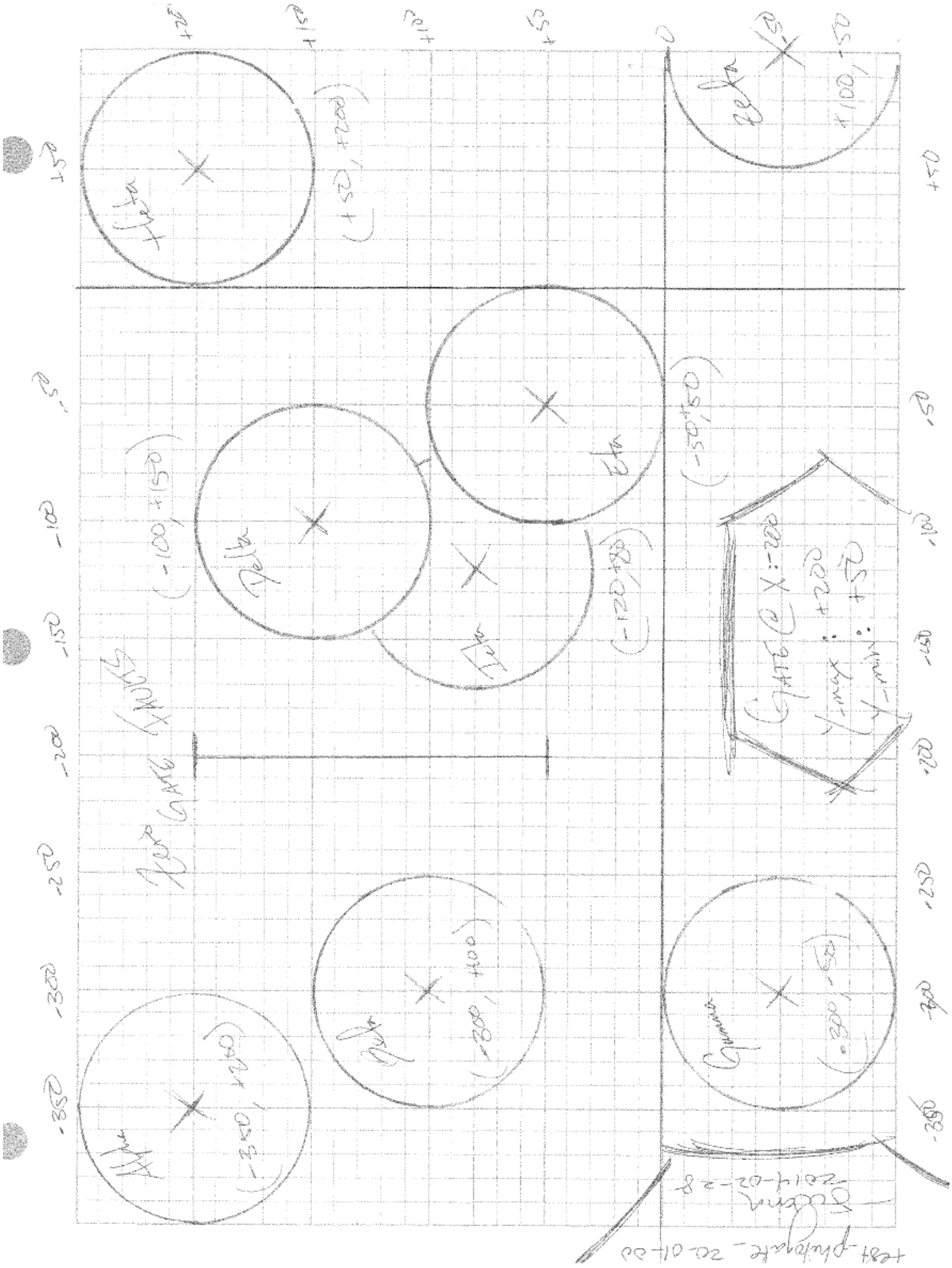
```
/**
 * Returns true or false depending on whether or not the object tripped the gate by
 * entering the area of influence.
 *
 * @param { Actor_Object } : Any Actor_Object with a Shape
 *
 * @return { boolean } : True if the current placement of the Actor_Object trips the gate.
 */
public boolean is_tripped_by( Actor_Object the_object ) {

        boolean output = false;

        switch ( this.axis ) {

                case X:
                        if ( the_object.get_y_position() <= this.ranged_axis_top &&
                             the_object.get_y_position() >= this.ranged_axis_bottom &&
                            ( the_object.shape.get_high_bound_x_projection() >= this.fixed_axis_value &&
                              the_object.shape.get_low_bound_x_projection()  <= this.fixed_axis_value )) {

                                output = true;
                        }
                        else {

                                Node top_node = new Node(this.fixed_axis_value, this.ranged_axis_top,    ZERO);
                                Node bot_node = new Node(this.fixed_axis_value, this.ranged_axis_bottom, ZERO);

                                if ( Collision.point_inside_shape(top_node, the_object.get_shape()) ) {
                                        output = true;
                                }
                                if ( Collision.point_inside_shape(bot_node, the_object.get_shape()) ) {
                                        output = true;
                                }
                        }
                        break;

                case Y:
                        if (  the_object.get_x_position() <= this.ranged_axis_top &&
                              the_object.get_x_position() >= this.ranged_axis_bottom &&
                             ( the_object.shape.get_high_bound_y_projection() >= this.fixed_axis_value &&
                               the_object.shape.get_low_bound_y_projection()  <= this.fixed_axis_value )) {

                             output = true;
                        }
                        else {

                                Node top_node = new Node(this.ranged_axis_top,    this.fixed_axis_value, ZERO);
                                Node bot_node = new Node(this.ranged_axis_bottom, this.fixed_axis_value, ZERO);

                                if ( Collision.point_inside_shape(top_node, the_object.shape) ) {
                                        output = true;
                                }
                                if ( Collision.point_inside_shape(bot_node, the_object.shape) ) {
                                        output = true;
                                }
                        }
                        break;
        } // end switch

        return output;
} // end Photogate.is_tripped_by()
```

module :: Item/Photogate.java
test/design :: test_photogate_15_02_00_object_interaction
description :: battery of checks on photogate vs polygon-objects; each should trip the gate



```
// Photogate object interaction tests
@Test
public void test_photogate_15_02_00_object_interaction() {
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(115, 125, ZERO);
        Standard_Mass beta  = Standard_Mass.generate_fifty_g_mass(75,   65, ZERO);
        Standard_Mass delta = Standard_Mass.generate_fifty_g_mass(100,   5, ZERO);
        Standard_Mass gamma = Standard_Mass.generate_fifty_g_mass(85,  -65, ZERO);
        Standard_Mass iota  = Standard_Mass.generate_fifty_g_mass(105,-105, ZERO);

        Photogate gate_one  = new Photogate( 100,           0,              ZERO,
                                  100, Photogate.axis_enumeration.X, 200);

        // Each circle should trip the gate
        assertEquals(gate_one.is_tripped_by( alpha ), true);
        assertEquals(gate_one.is_tripped_by( beta  ), true);
        assertEquals(gate_one.is_tripped_by( delta ), true);
        assertEquals(gate_one.is_tripped_by( gamma ), true);
        assertEquals(gate_one.is_tripped_by( iota  ), true);
}
```

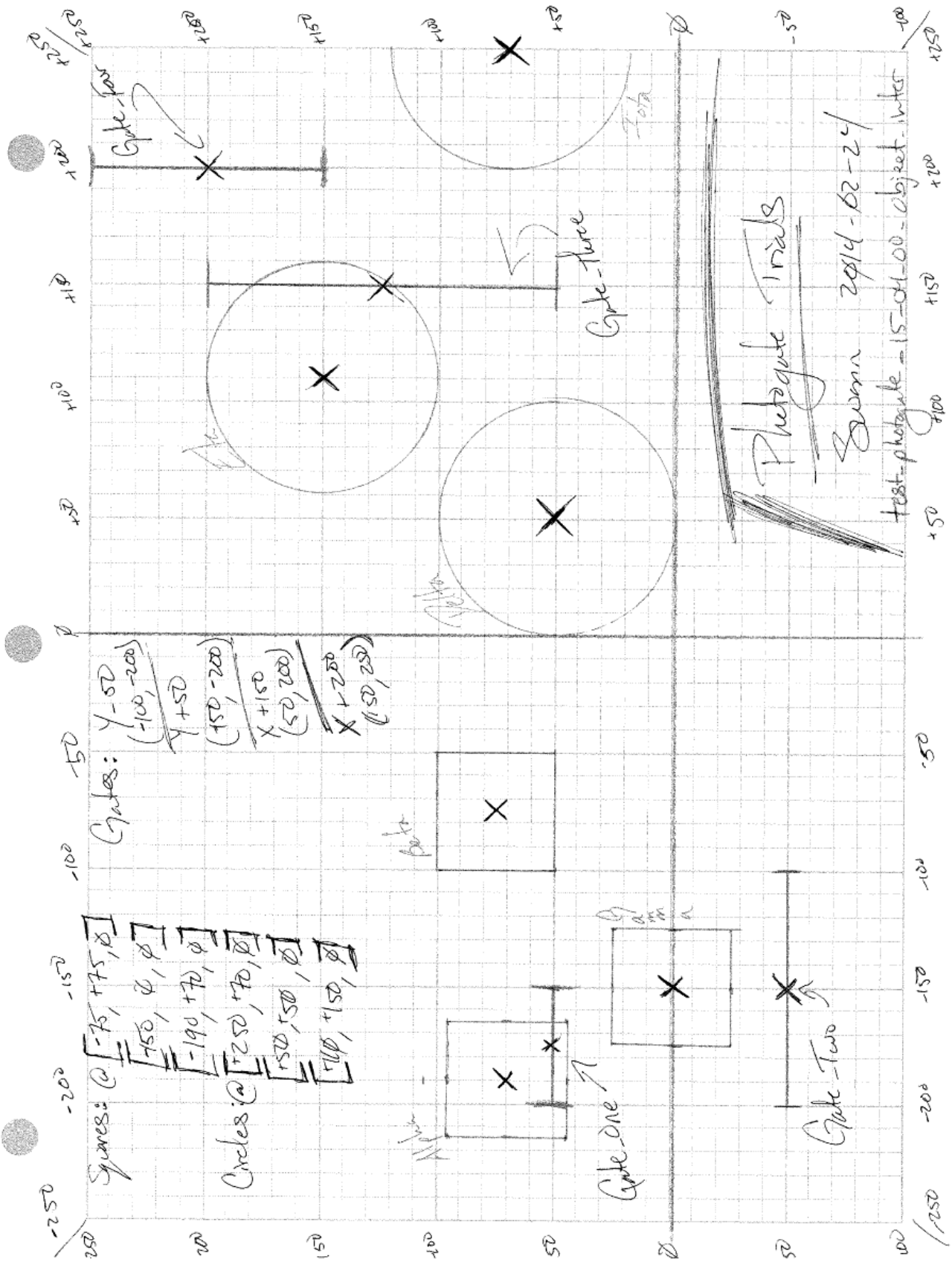
module :: Item/Photogate.java
test/design :: test_photogate_15_03_00_object_interaction
description :: battery of checks on photogate objects; none should trip the gate



test notes :: designed for above_list && below_list tracking; doubled as a set of non-tripping objects

```
// Photogate object interaction tests
@Test
public void test_photogate_15_03_00_object_interaction() {
        // The Setup
        Ball alpha = Ball.generate_Baseball( -350,  200, ZERO );
        Ball beta  = Ball.generate_Baseball( -300,  100, ZERO );
        Ball gamma = Ball.generate_Baseball( -300,  -50, ZERO );
        Ball delta = Ball.generate_Baseball( -100,  150, ZERO );
        Ball iota  = Ball.generate_Baseball( -120,   80, ZERO );
        Ball eta   = Ball.generate_Baseball(  -50,   50, ZERO );
        Ball theta = Ball.generate_Baseball(   50,  200, ZERO );
        Ball zeta  = Ball.generate_Baseball(  100,  -50, ZERO );

        Photogate the_gate = new Photogate(  -200,  125, ZERO,
                                               -200, Photogate.axis_enumeration.X, 150);

        // Each circle should NOT trip the gate
        assertEquals(the_gate.is_tripped_by( alpha ), false);
        assertEquals(the_gate.is_tripped_by( beta  ), false);
        assertEquals(the_gate.is_tripped_by( gamma ), false);
        assertEquals(the_gate.is_tripped_by( delta ), false);
        assertEquals(the_gate.is_tripped_by( iota  ), false);
        assertEquals(the_gate.is_tripped_by( eta   ), false);
        assertEquals(the_gate.is_tripped_by( theta ), false);
        assertEquals(the_gate.is_tripped_by( zeta  ), false);
}
```

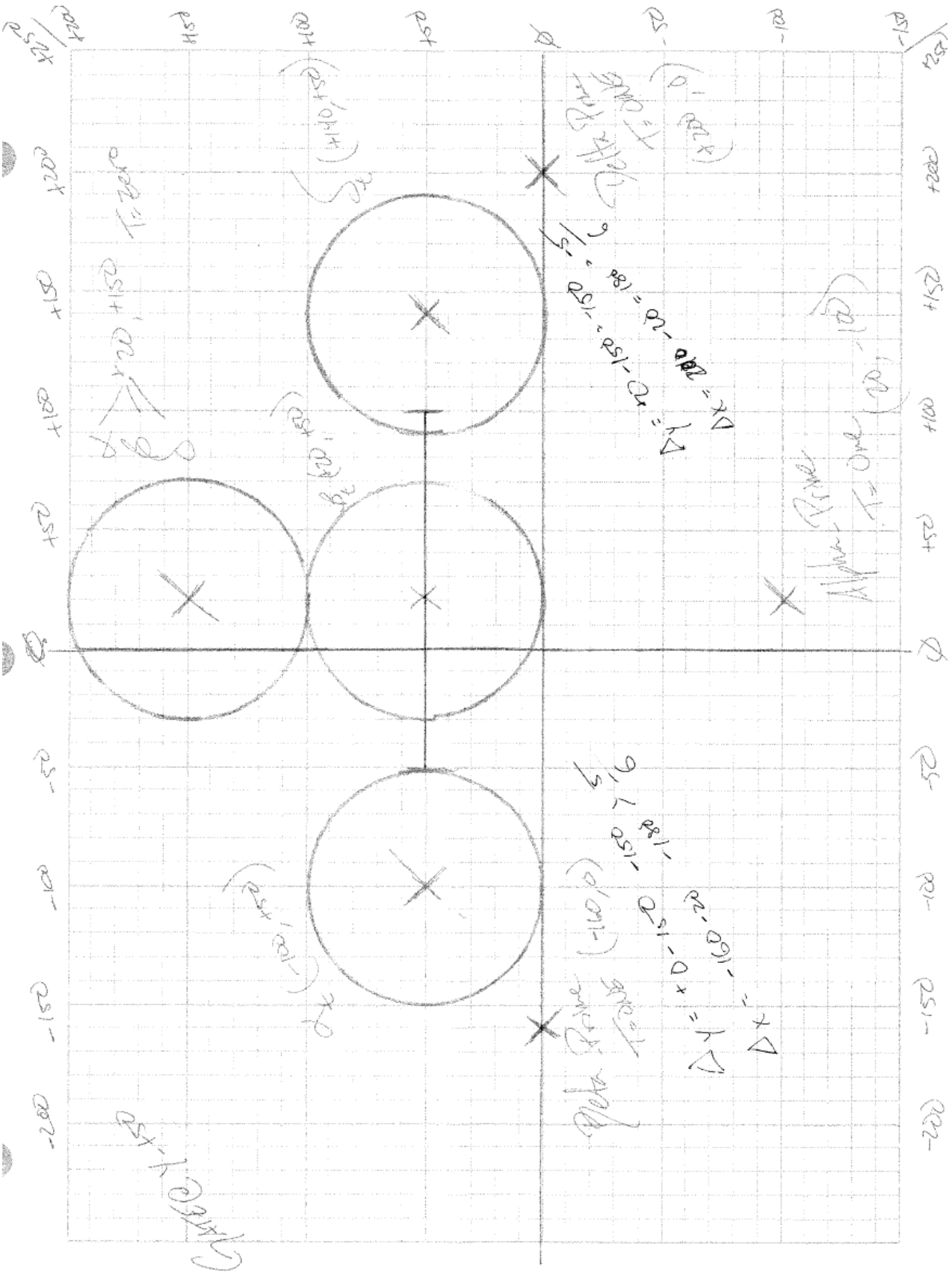
module :: Item/Photogate.java
test/design :: test_photogate_15_04_00_object_interaction
description :: battery of checks on photogate objects; none should trip the gate



test notes :: design of heterogeneous interaction with photogates; some gates tripped in static state, some not; tracking of tripped/locked status along with the object responsible for the locked state

```
// Photogate object interaction tests
@Test
public void test_photogate_15_04_00_object_interaction() {
        // The Setup
        //   Objects with simple objects
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(-190, 70,   ZERO),
                      beta  = Standard_Mass.generate_fifty_g_mass(-75,  75,   ZERO),
                       gamma = Standard_Mass.generate_fifty_g_mass(-150, ZERO, ZERO);

        Ball          delta = Ball.generate_Baseball(50,  50,  ZERO),
                     eta   = Ball.generate_Baseball(110, 150, ZERO),
                     iota  = Ball.generate_Baseball(250, 70,  ZERO);

        alpha.set_label("alpha");
        beta.set_label("beta");
        gamma.set_label("gamma");
        delta.set_label("delta");
        eta.set_label("eta");
        iota.set_label("iota");

        ArrayList<Actor_Object> interaction_list = new ArrayList<Actor_Object>();
        interaction_list.add(alpha);
        interaction_list.add(beta);
        interaction_list.add(gamma);
        interaction_list.add(delta);
        interaction_list.add(eta);
        interaction_list.add(iota);

        //   Gates
        Photogate gate_one  = new Photogate( -175,           50,              ZERO,
                                              50, Photogate.axis_enumeration.Y, 50),

                  gate_two  = new Photogate( -150,          -50,              ZERO,
                                             -50,  Photogate.axis_enumeration.Y, 100),

                  gate_tre  = new Photogate(  125,          125,              ZERO,
                                             150, Photogate.axis_enumeration.X, 150),

                  gate_for  = new Photogate(  200,          200,              ZERO,
                                             200, Photogate.axis_enumeration.X, 100);

        gate_one.update_information(interaction_list, ZERO);
        assertEquals(gate_one.is_locked(), true);
        assertEquals(gate_one.get_object_which_tripped(), alpha);

        gate_two.update_information(interaction_list, ZERO);
        assertEquals(gate_two.is_locked(), false);
        assertEquals(gate_two.get_object_which_tripped(), null);

        gate_tre.update_information(interaction_list, ZERO);
        assertEquals(gate_tre.is_locked(), true);
        assertEquals(gate_tre.get_object_which_tripped(), eta);

        gate_for.update_information(interaction_list, ZERO);
        assertEquals(gate_for.is_locked(), false);
        assertEquals(gate_for.get_object_which_tripped(), null);
}
```

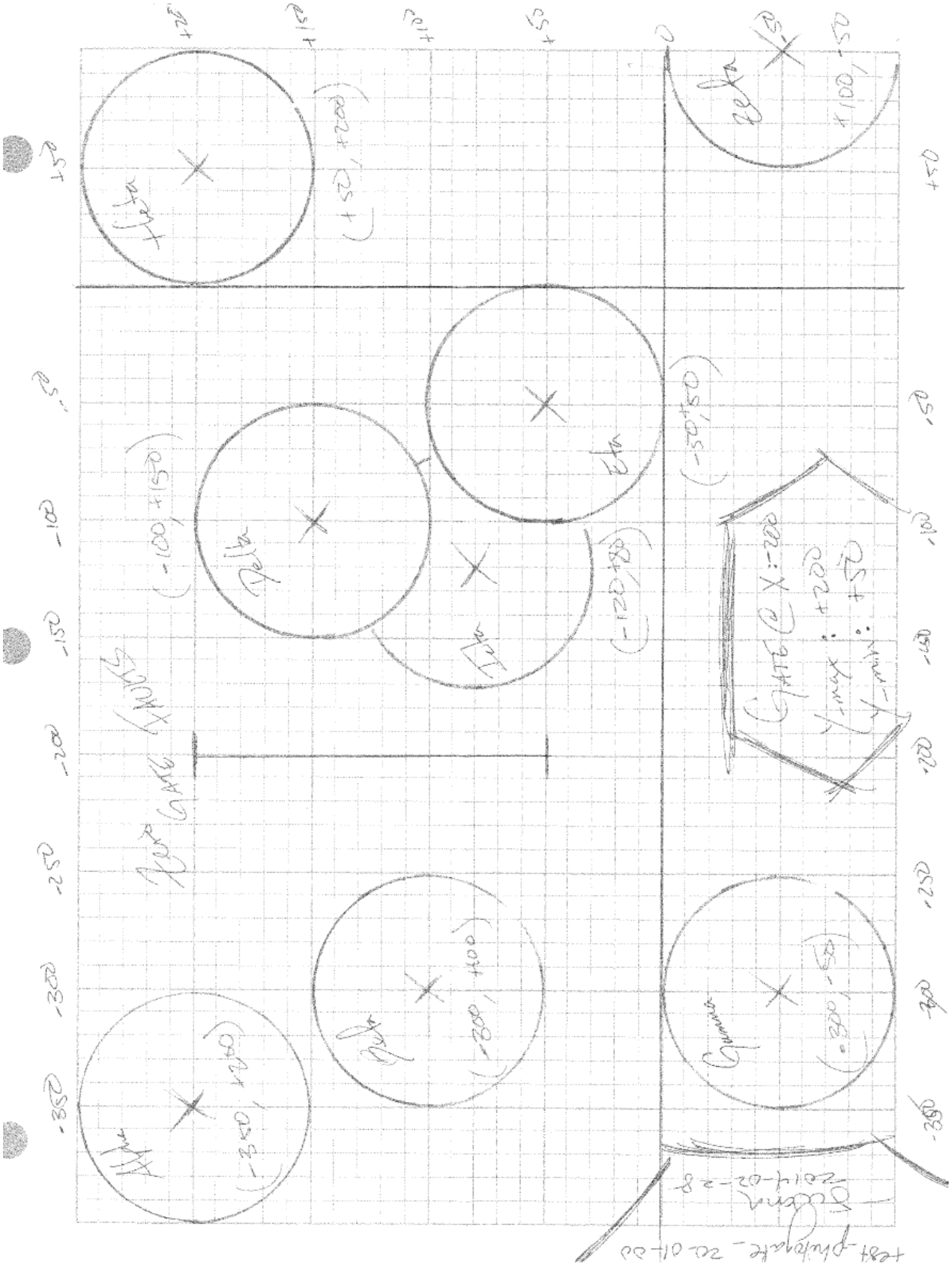
module :: Item/Photogate.java
test/design :: test_photogate_15_05_00_object_interaction
description :: battery of checks on photogates with static state; beginning work on the 'clipping algorithm'



test notes :: design of heterogeneous interaction with photogates; some gates tripped in static state, some not; tracking of tripped/locked status along with the object responsible for the locked state

```
// Photogate object interaction tests
@Test
public void test_photogate_15_05_00_object_interaction() {
        // The Setup
        Ball alpha_knot  = Ball.generate_Baseball(   20,  150, ZERO );
        Ball beta_knot   = Ball.generate_Baseball(   20,  150, ZERO );
        Ball delta_knot  = Ball.generate_Baseball(   20,  150, ZERO );

        Ball alpha_intra = Ball.generate_Baseball((float)99.99999,   50, ZERO );
        Ball beta_intra  = Ball.generate_Baseball(   20,   50, ZERO );
        Ball delta_intra = Ball.generate_Baseball(  140,   50, ZERO );

        Ball alpha_prime = Ball.generate_Baseball( -160,    0, ZERO );
        Ball beta_prime  = Ball.generate_Baseball(   20, -100, ZERO );
        Ball delta_prime = Ball.generate_Baseball(  200,    0, ZERO );

        Photogate gate_one = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_two = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_tre = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_for = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_fiv = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_six = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_svn = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_ate = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);
        Photogate gate_nin = new Photogate(    25,   50, ZERO,
                                               50, Photogate.axis_enumeration.Y, 150);

        // Each gate has a specific object that COULD trip it
        //   see designs for test_photogate_.....................
        //        ~swann 2014-03-01
        assertEquals(gate_one.is_tripped_by( alpha_knot ), false);
        assertEquals(gate_two.is_tripped_by( beta_knot  ), false);
        assertEquals(gate_tre.is_tripped_by( delta_knot ), false);

        assertEquals(gate_for.is_tripped_by( alpha_intra ), true);
        assertEquals(gate_fiv.is_tripped_by( beta_intra  ), true);
        assertEquals(gate_six.is_tripped_by( delta_intra ), true);

        assertEquals(gate_svn.is_tripped_by( alpha_prime ), false);
        assertEquals(gate_ate.is_tripped_by( beta_prime  ), false);
        assertEquals(gate_nin.is_tripped_by( delta_prime ), false);
}
```

module	::	Item/Photogate.java
test/design	::	test_photogate_20_01_00_populate_new_lists
functions	::	Photogate.populate_new_above_list() && Photogate.populate_new_below_list() && Photogate.populate_new_swapped_list()
description	::	used to determine which objects are above or below the gate; to be used within the 'clipping algorithm'



test notes :: algorithms used to determine which objects have switched sides in relation to the photogate; to be used as support functionality in connection to the 'clipping algorithm' which determines whether an object passed over a gate tripping it between time-steps and if multiple objects did so, which was first to trip the gate

```
// Photogate.populate_new_lists()
// --> Photogate.populate_new_above_list()
// --> Photogate.populate_new_below_list()
// --> Photogate.produce_swapped_list()
@Test
public void test_photogate_20_01_00_populate_new_lists() {
        // The Setup
        Ball alpha = Ball.generate_Baseball( -350,  200, ZERO );
        Ball beta  = Ball.generate_Baseball( -300,  100, ZERO );
        Ball gamma = Ball.generate_Baseball( -300,  -50, ZERO );
        Ball delta = Ball.generate_Baseball( -100,  150, ZERO );
        Ball iota  = Ball.generate_Baseball( -120,   80, ZERO );
        Ball eta   = Ball.generate_Baseball(  -50,   50, ZERO );
        Ball theta = Ball.generate_Baseball(   50,  200, ZERO );
        Ball zeta  = Ball.generate_Baseball(  100,  -50, ZERO );

        ArrayList<Actor_Object> swapped_list     = new ArrayList<Actor_Object>();
        ArrayList<Actor_Object> above_list_one   = new ArrayList<Actor_Object>();
        ArrayList<Actor_Object> below_list_one   = new ArrayList<Actor_Object>();
        ArrayList<Actor_Object> above_list_two   = new ArrayList<Actor_Object>();
        ArrayList<Actor_Object> below_list_two   = new ArrayList<Actor_Object>();
        ArrayList<Actor_Object> interaction_list = new ArrayList<Actor_Object>();

        Photogate the_gate = new Photogate(  -200,  125, ZERO,
                                            -200, Photogate.axis_enumeration.X, 150);

        alpha.set_label("alpha");
        beta.set_label("beta");
        gamma.set_label("gamma");
        delta.set_label("delta");
        eta.set_label("eta");
        iota.set_label("iota");
        theta.set_label("theta");
        zeta.set_label("zeta");

        interaction_list.add( alpha );
        interaction_list.add( beta  );
        interaction_list.add( gamma );
        interaction_list.add( delta );
        interaction_list.add( iota  );
        interaction_list.add( eta   );
        interaction_list.add( theta );
        interaction_list.add( zeta  );
        assertEquals(interaction_list.size(), EIGHT, ZERO);
        assertEquals(below_list_one.size(), ZERO, ZERO);
        assertEquals(above_list_one.size(), ZERO, ZERO);

        // Initial State Assertions
        below_list_one = the_gate.populate_new_below_list(interaction_list);
        assertEquals(below_list_one.size(), THREE,  ZERO);
        above_list_one = the_gate.populate_new_above_list(interaction_list);
        assertEquals(above_list_one.size(), FIVE,   ZERO);

        // Secondary State Assertions
        alpha.update_location(350, 200, ZERO);
        below_list_two = the_gate.populate_new_below_list(interaction_list);
        assertEquals(below_list_two.size(), TWO,  ZERO);
        above_list_two = the_gate.populate_new_above_list(interaction_list);
        assertEquals(above_list_two.size(), SIX,  ZERO);
        swapped_list = the_gate.produce_swapped_list( above_list_one, below_list_one,
                                                      above_list_two, below_list_two);
        assertEquals(swapped_list.size(), ONE, ZERO);
        if ( !swapped_list.contains( alpha )) {
                fail("Secondary State Assertions");
        }

        // Tertiary State Assertions
        theta.update_location(-400, 200, ZERO);
        zeta.update_location( -500, -50, ZERO);
        below_list_one = the_gate.populate_new_below_list(interaction_list);
        assertEquals(below_list_one.size(), FOUR,  ZERO);
        above_list_one = the_gate.populate_new_above_list(interaction_list);
        assertEquals(above_list_one.size(), FOUR,   ZERO);
        swapped_list = the_gate.produce_swapped_list( above_list_two, below_list_two,
                                                      above_list_one, below_list_one);
        assertEquals(swapped_list.size(), TWO, ZERO);
        if ( !swapped_list.contains( theta ) && !swapped_list.contains( zeta )) {
                fail("Tertiary State Assertions");
        }

        // Return to Initial State and Re-Assert
        alpha.update_location(-350, 200, ZERO);
        theta.update_location(  50, 200, ZERO);
```

```
                zeta.update_location(  100,  50, ZERO);
                below_list_two = the_gate.populate_new_below_list(interaction_list);
                assertEquals(below_list_two.size(), THREE,  ZERO);
                above_list_two = the_gate.populate_new_above_list(interaction_list);
                assertEquals(above_list_two.size(), FIVE,   ZERO);
                swapped_list = the_gate.produce_swapped_list( above_list_one, below_list_one,
                                                              above_list_two, below_list_two);
                assertEquals(swapped_list.size(), THREE, ZERO);
                if ( !swapped_list.contains( theta ) && !swapped_list.contains( zeta ) &&
                                !swapped_list.contains( alpha )) {
                        fail("Return to Initial State and Re-Assert");
                }
        }
```

function notes :: implementation of the `populate_new_below_list( )`

```
        /**
         * Returns an ArrayList with the objects below the fixed point axis of the current
         * photogate.
         *
         * @param { ArrayList<Actor_Object> } : List of Actor Objects from the working set.
         *
         * @return { ArrayList<Actor_Object> } : List of Actor Objects below the fixed point axis of the
         *                                       photogate.
         */
        public ArrayList<Actor_Object> populate_new_below_list( ArrayList<Actor_Object> interaction_list ){

                ArrayList<Actor_Object> below_list = new ArrayList<Actor_Object>();

                for ( int i = ZERO; i < interaction_list.size() ; i ++ ) {

                        Actor_Object the_object = interaction_list.get(i);

                        switch ( this.axis ) {

                                case X:

                                        // if the x-coord is below the fixed axis value add to below list,
                                        //   otherwise put it on the above list
                                        if ( the_object.get_x_position() < this.fixed_axis_value ) {

                                                below_list.add( the_object );
                                        }
                                        break;

                                case Y:

                                        // if the y-coord is below the fixed axis value add to below list,
                                        //   otherwise put it on the above list
                                        if ( the_object.get_y_position() < this.fixed_axis_value ) {

                                                below_list.add( the_object );
                                        }
                                        break;

                        } // end switch

                } // end iteration

                return below_list;
        }// end Photogate.populate_new_below_list()
```

function notes :: implementation of the `populate_new_above_list( )`

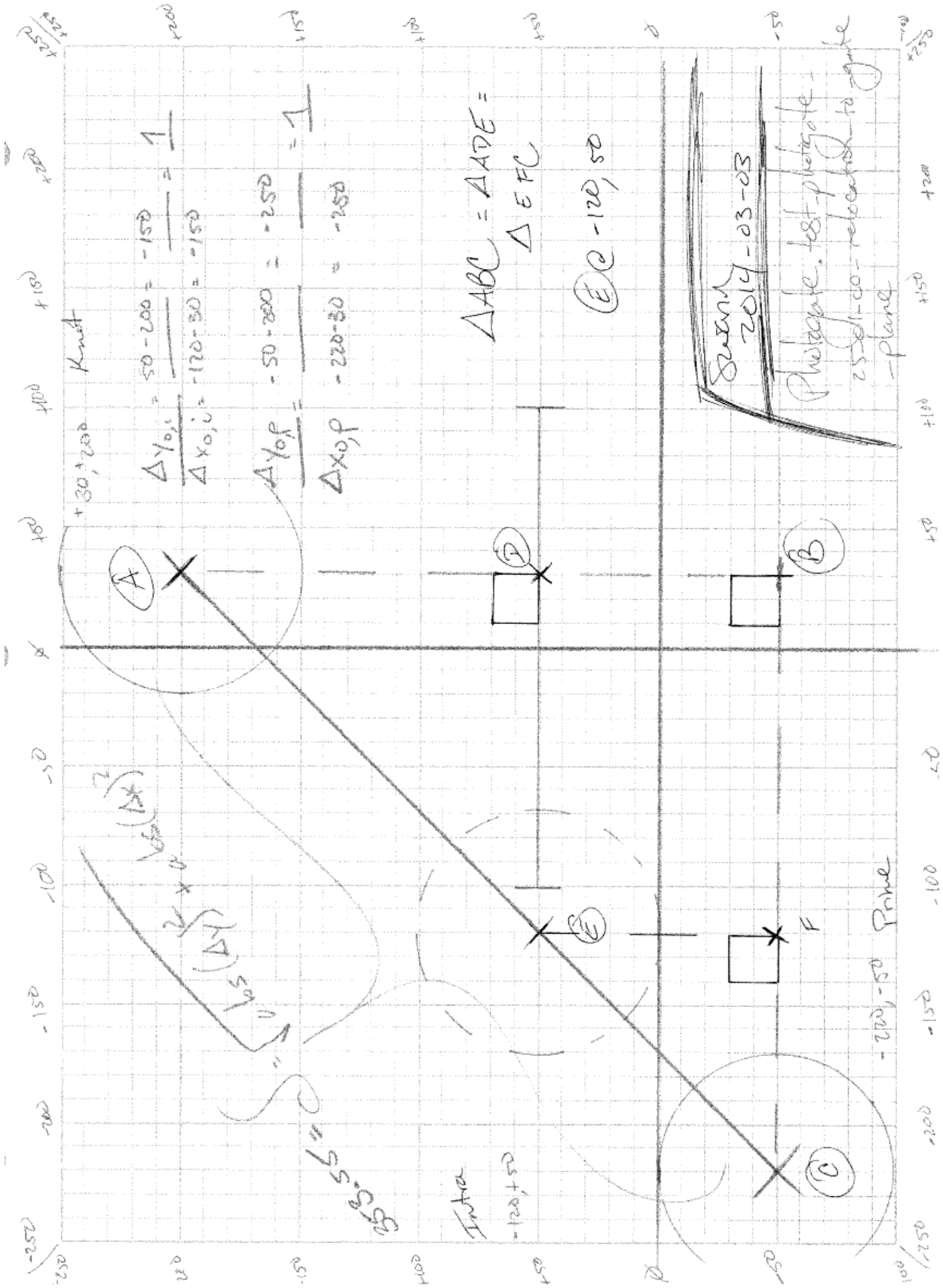
```
        /**
         * Returns an ArrayList with the objects above or equal to the fixed point axis of the current
         * photogate.
         *
         * @param { ArrayList<Actor_Object> } : List of Actor Objects from the working set.
         *
         * @return { ArrayList<Actor_Object> } : List of Actor Objects above or equal to the fixed point
         *                                       axis of the photogate.
         */
        public ArrayList<Actor_Object> populate_new_above_list( ArrayList<Actor_Object> interaction_list ){

                ArrayList<Actor_Object> above_list = new ArrayList<Actor_Object>();

                for ( int i = ZERO; i < interaction_list.size() ; i ++ ) {

                        Actor_Object the_object = interaction_list.get(i);

                        switch ( this.axis ) {

                                case X:

                                        // if the x-coord is below the fixed axis value add to below list,
                                        //   otherwise put it on the above list
                                        if ( the_object.get_x_position() >= this.fixed_axis_value ) {
```

```
                                        above_list.add( the_object );
                                }
                                break;

                        case Y:

                                // if the y-coord is below the fixed axis value add to below list,
                                //   otherwise put it on the above list
                                if ( the_object.get_y_position() >= this.fixed_axis_value ) {

                                        above_list.add( the_object );
                                }
                                break;

                } // end switch

        } // end iteration

        return above_list;
}// end Photogate.populate_new_above_list()
```

function notes :: implementation of the `populate_swapped_list( )`

```
/**
 * Returns an array list of Actor Object that have swapped from a relative high or low position
 * in regards to the photogate to the other designation. For instance, if an object was initially
 * below the fixed axis point and a time step moved it to a position where it is now above that
 * fixed point axis, then the object will appear in the swapped list.
 *
 * @param { old_above_list } : List of actor objects above the fixed point axis before the time step.
 * @param { old_below_list } : List of actor objects below the fixed point axis before the time step.
 * @param { new_above_list } : List of actor objects above the fixed point axis after the time step.
 * @param { new_below_list } : List of actor objects below the fixed point axis after the time step.
 *
 * @return { ArrayList<Actor_Object> } : List of objects which have crossed the fixed point axis plane.
 */
public ArrayList<Actor_Object> produce_swapped_list( ArrayList<Actor_Object> old_above_list,
                                                     ArrayList<Actor_Object> old_below_list,
                                                     ArrayList<Actor_Object> new_above_list,
                                                     ArrayList<Actor_Object> new_below_list) {

        ArrayList<Actor_Object> swapped_list = new ArrayList<Actor_Object>();

        // Check for objects going from above to below
        for ( int i = ZERO ; i < old_above_list.size(); i ++) {

                if ( new_below_list.contains( old_above_list.get(i) )) {

                        swapped_list.add( old_above_list.get(i) );
                }
        } // end new_below_list iteration

        // Check for objects going from below to above
        for ( int i = ZERO ; i < old_below_list.size(); i ++) {

                if ( new_above_list.contains( old_below_list.get(i) )) {

                        swapped_list.add( old_below_list.get(i) );
                }
        } // end new_below_list iteration

        return swapped_list;
} // end Photogate.produce_swapped_list()
```

module :: Item/Photogate.java
test/design :: test_photogate_25_01_00_relocation_to_gate_plane
functions :: Photogate.relocation_to_gate_plane()
description :: design of functionality scripted to return an object's state to the point when it passed the gate's plane; then call of static state check on interaction with the gate itself



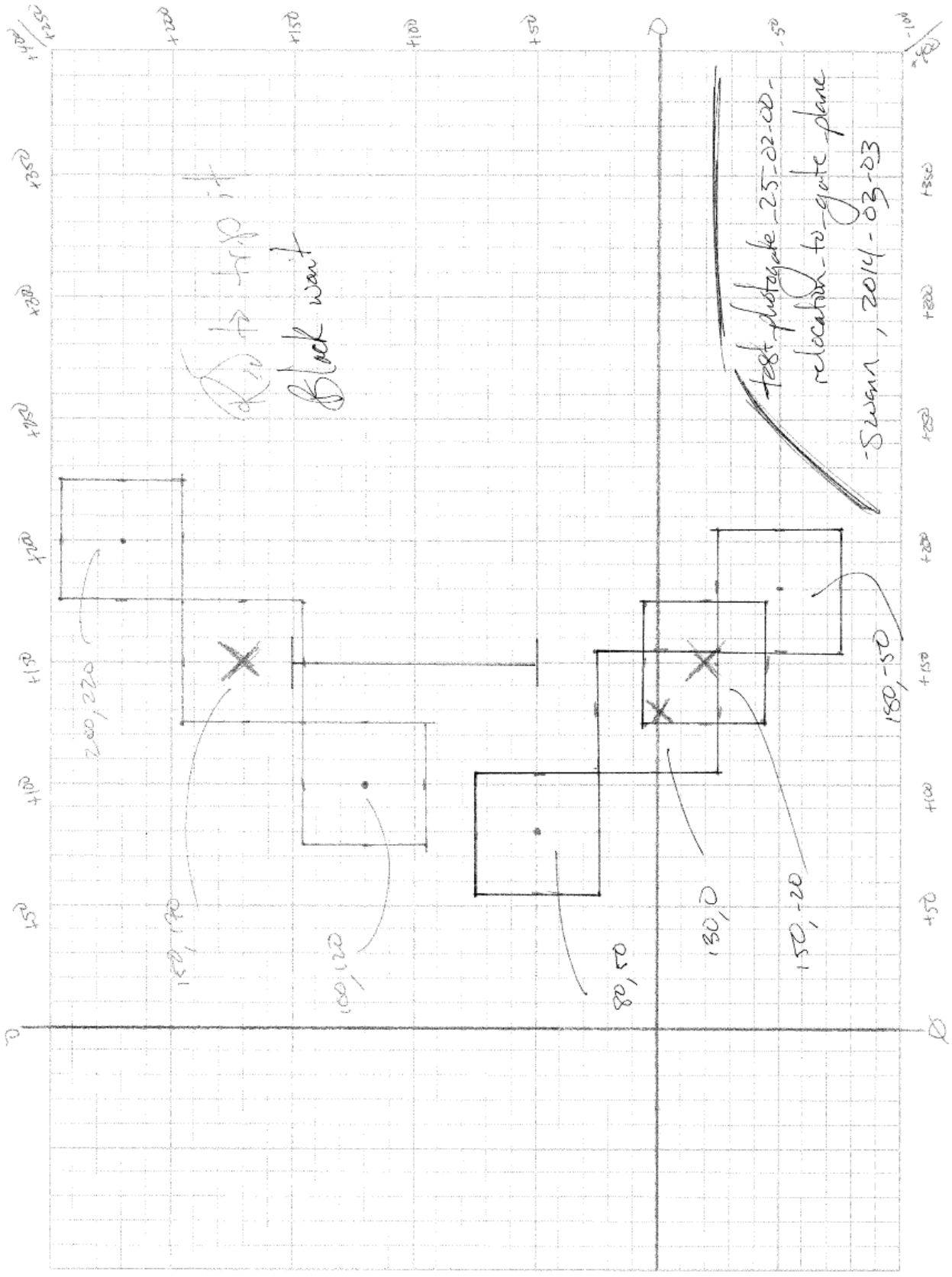
test notes :: object travels from point A to C in single time-step; should trip the gate as path includes location E

```
// Photogate.relocation_to_gate_plane()
@Test
public void test_photogate_25_01_00_relocation_to_gate_plane() {
        // The Setup
        Ball alpha = Ball.generate_Baseball(-220, -50, ZERO);

        ArrayList<Actor_Object> interaction_list = new ArrayList<Actor_Object>();
        interaction_list.add( alpha );

        Photogate the_gate = new Photogate( ZERO, 50, ZERO,
                                            50,   Photogate.axis_enumeration.Y, 200);

        // Pack velocity to full second
        alpha.update_velocity(-250*TIME_STEPS, -250*TIME_STEPS, ZERO);

        // relocation
        the_gate.relocation_to_gate_plane( alpha );
        assertEquals(the_gate.is_tripped_by( alpha ), true);

        // intra-execute test peek
        the_gate.update_information(interaction_list, ZERO);
        assertEquals(the_gate.get_object_which_tripped(), alpha);
}
```

function notes :: implementation of `relocation_to_gate_plane()`

```
/**
 * Repositions the passed actor object to the axis plan on which the gate itself exists.
 *
 * Nota Bene ::
 *   This is only to be used with objects having been flagged and added to the swapped item list.
 *      ~swann 2014-03-03
 *
 * @param { Actor_Object } : The object being re-positioned.
 */
public void relocation_to_gate_plane( Actor_Object the_object ) {

        // Establish velocity vector for intra-step calculations
        Vector object_velocity = new Vector( the_object.get_velocity() );

        Vector time_step_velocity = Vector.scalar_multiply(object_velocity, TIME_STEP);

        // tracking variables
        float x_differential, y_differential, proportion,
              x_position,     y_position;

        // axis dependent relative math
        switch( this.axis ){

        case X:

                x_differential = Math.abs( the_object.get_x_position() - this.fixed_axis_value );

                proportion     = x_differential/Math.abs(time_step_velocity.get_x_comp());

                y_differential = proportion*time_step_velocity.get_y_comp();

                y_position     = the_object.get_y_position() - y_differential;

                the_object.update_location(this.fixed_axis_value, y_position, ZERO);

                break;

        case Y:

                y_differential = Math.abs( the_object.get_y_position() - this.fixed_axis_value );

                proportion     = y_differential/Math.abs(time_step_velocity.get_y_comp());

                x_differential = proportion*time_step_velocity.get_x_comp();

                x_position     = the_object.get_x_position() - x_differential;

                the_object.update_location(x_position, this.fixed_axis_value, ZERO);

                break;
        }
} // end Photogate.relocation_to_gate_plane()
```

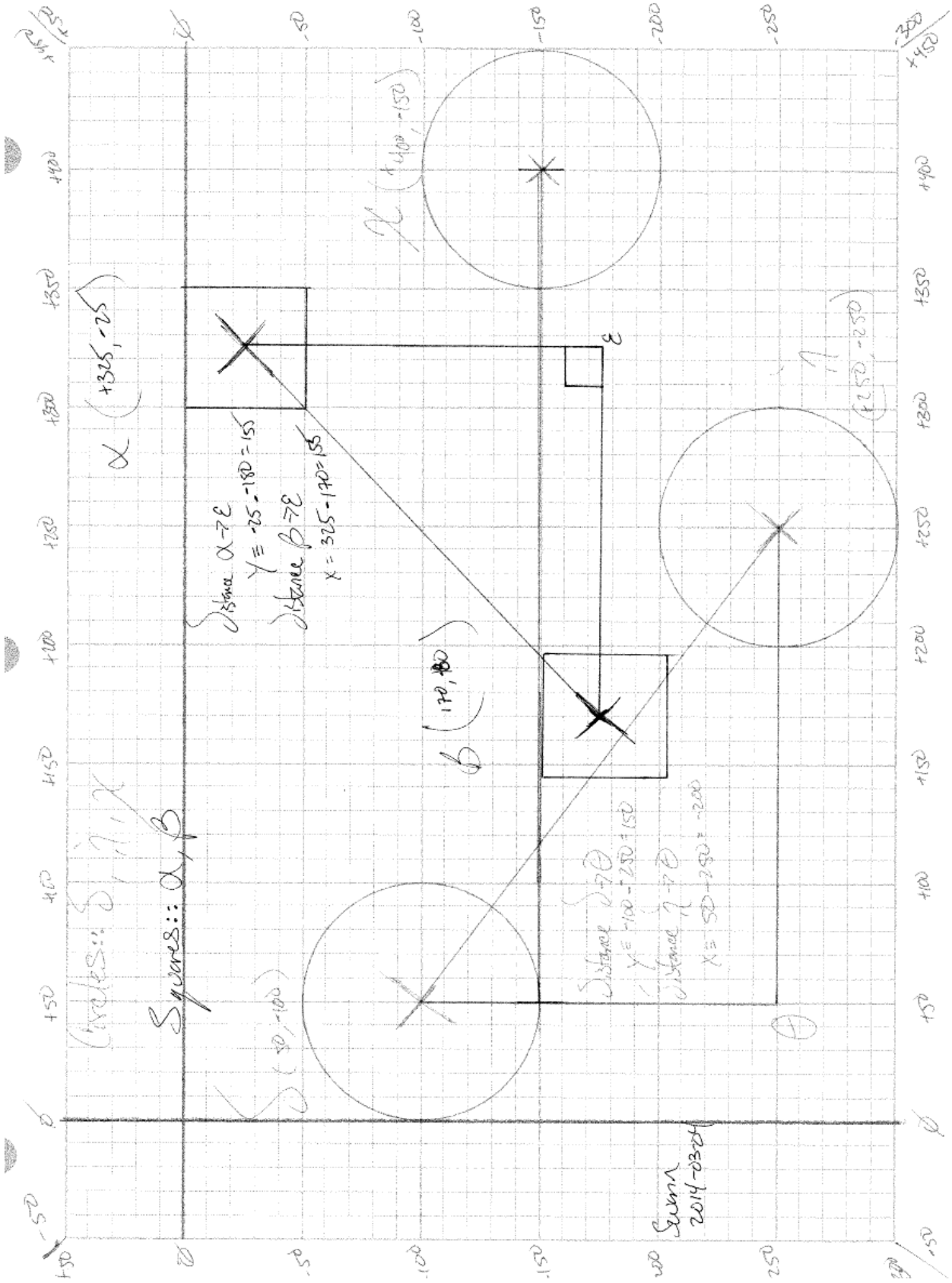
module :: Item/Photogate.java
test/design :: test_photogate_25_02_00_relocation_to_gate_plane
description :: design of functionality scripted to return an object's state to the point when it passed the gate's plane; then call of static state check on interaction with the gate itself



test notes :: explores an object just barely tripping the gate and one passing by without tripping it

```
	// Photogate.relocation_to_gate_plane()
	@Test
	public void test_photogate_25_02_00_relocation_to_gate_plane() {
		// The Setup
		Standard_Mass alpha = Standard_Mass.generate_one_g_mass( 180, -50, ZERO);
		Standard_Mass beta  = Standard_Mass.generate_five_g_mass(200, 220, ZERO);

		ArrayList<Actor_Object> interaction_list = new ArrayList<Actor_Object>();
		interaction_list.add( alpha );
		interaction_list.add( beta  );

		Photogate the_gate = new Photogate( 150, 100, ZERO,
		                                    150, Photogate.axis_enumeration.X, 100);

		// Pack velocity to full second
		alpha.update_velocity(100*TIME_STEPS, -100*TIME_STEPS, ZERO);
		beta.update_velocity( 100*TIME_STEPS,  100*TIME_STEPS, ZERO);

		// relocation
		the_gate.relocation_to_gate_plane( alpha );
		assertEquals(the_gate.is_tripped_by( alpha ), false);
		assertEquals(alpha.get_x_position(), 150, ZERO);
		assertEquals(alpha.get_y_position(), -20, A_THOUSANDTH);

		the_gate.relocation_to_gate_plane( beta  );
		assertEquals(the_gate.is_tripped_by( beta  ),  true);
		assertEquals(beta.get_x_position(),  150, ZERO);
		assertEquals(beta.get_y_position(),  170, ZERO);

		// intra-execute test peek
		the_gate.update_information(interaction_list, ZERO);
		assertEquals(the_gate.get_object_which_tripped(), beta);

	}
```

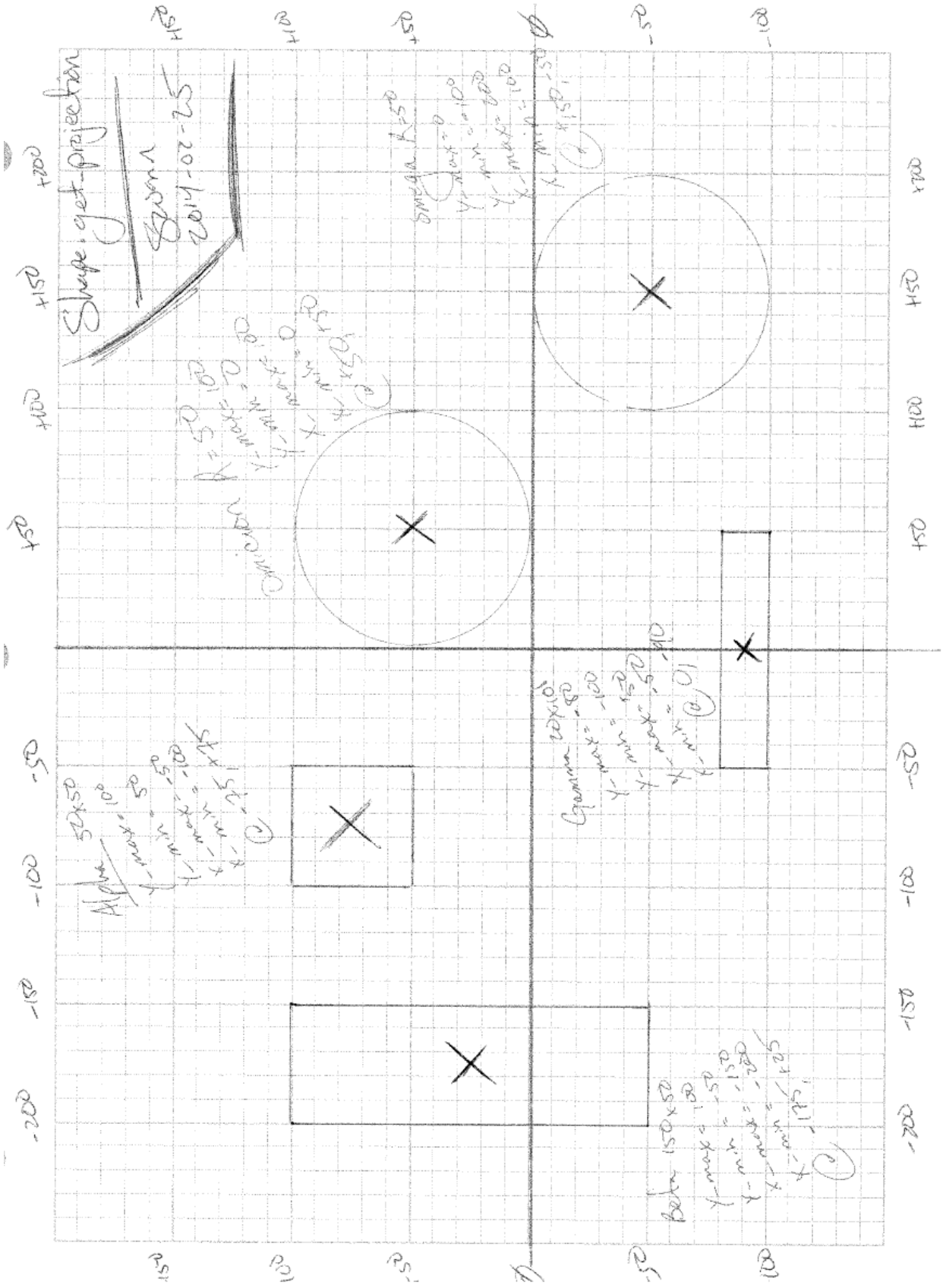
module :: Item/Photogate.java
test/design :: test_photogate_30_01_00_correct_trigger_event && test_photogate_30_02_00_correct_trigger_event && test_photogate_30_03_00_correct_trigger_event
description :: design of the functionality to determine which object tripped the gate first; includes clipping and static state objects



test notes :: explores full battery of use cases for photogate; clipping and static state objects with recognition as to which object tripped it first

```
// Photogate test --> multiple objects pass through the gate, which one is first
@Test
public void test_photogate_30_01_00_correct_trigger_event() {
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(325, -25, ZERO);
        Ball          delta = Ball.generate_Baseball( 50,   99, ZERO);

        Photogate the_gate = new Photogate( 225, -150, ZERO,
                                                -150, Photogate.axis_enumeration.Y, 350);

        ArrayList<Actor_Object> interaction_list = new ArrayList<Actor_Object>();
        interaction_list.add( delta );
        interaction_list.add( alpha );

        // Pack velocity to full second
        alpha.update_velocity( 155*TIME_STEPS,  155*TIME_STEPS, ZERO);
        delta.update_velocity(-200*TIME_STEPS,  150*TIME_STEPS, ZERO);

        the_gate.relocation_to_gate_plane( alpha );
        assertEquals(the_gate.is_tripped_by( alpha ), true);
        the_gate.relocation_to_gate_plane( delta );
        assertEquals(the_gate.is_tripped_by( delta ), true);

        // intra-execute test peek
        the_gate.update_information(interaction_list, ZERO);
        assertEquals(the_gate.get_object_which_tripped(), delta);
}


// Photogate test --> multiple objects pass through the gate, which one is first
@Test
public void test_photogate_30_02_00_correct_trigger_event() {
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(325, -25, ZERO);
        Ball          delta = Ball.generate_Baseball( 50,   99, ZERO);

        Photogate the_gate = new Photogate( 225, -150, ZERO,
                                                -150, Photogate.axis_enumeration.Y, 350);

        ArrayList<Actor_Object> interaction_list = new ArrayList<Actor_Object>();
        interaction_list.add( alpha );
        interaction_list.add( delta );

        // Pack velocity to full second
        alpha.update_velocity( 155*TIME_STEPS,  155*TIME_STEPS, ZERO);
        delta.update_velocity(-200*TIME_STEPS,  150*TIME_STEPS, ZERO);

        the_gate.relocation_to_gate_plane( alpha );
        assertEquals(the_gate.is_tripped_by( alpha ), true);
        the_gate.relocation_to_gate_plane( delta );
        assertEquals(the_gate.is_tripped_by( delta ), true);

        // intra-execute test peek
        the_gate.update_information(interaction_list, ZERO);
        assertEquals(the_gate.get_object_which_tripped(), alpha);
}


// Photogate test --> multiple objects pass through the gate, which one is first
@Test
public void test_photogate_30_03_00_correct_trigger_event() {
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(325, -25, ZERO);
        Ball          delta = Ball.generate_Baseball( 50,   99, ZERO);
        Ball          chi   = Ball.generate_Baseball(400, -150, ZERO);

        Photogate the_gate = new Photogate( 225, -150, ZERO,
                                                -150, Photogate.axis_enumeration.Y, 350);

        ArrayList<Actor_Object> interaction_list = new ArrayList<Actor_Object>();
        interaction_list.add( alpha );
        interaction_list.add( delta );
        interaction_list.add(  chi  );

        // Pack velocity to full second
        alpha.update_velocity( 155*TIME_STEPS,  155*TIME_STEPS, ZERO);
        delta.update_velocity(-200*TIME_STEPS,  150*TIME_STEPS, ZERO);

        // intra-execute test peek
        the_gate.update_information(interaction_list, ZERO);
        assertEquals(the_gate.get_object_which_tripped(), chi);
}
```

module :: Item/Shape.java
test/design :: test_circle_15_01_00_projection_returns && test_square_15_01_00_projection_returns && test_rectangle_15_01_00_projection_returns
description :: design of the functionality to determine the x and y axis projections of a given shape

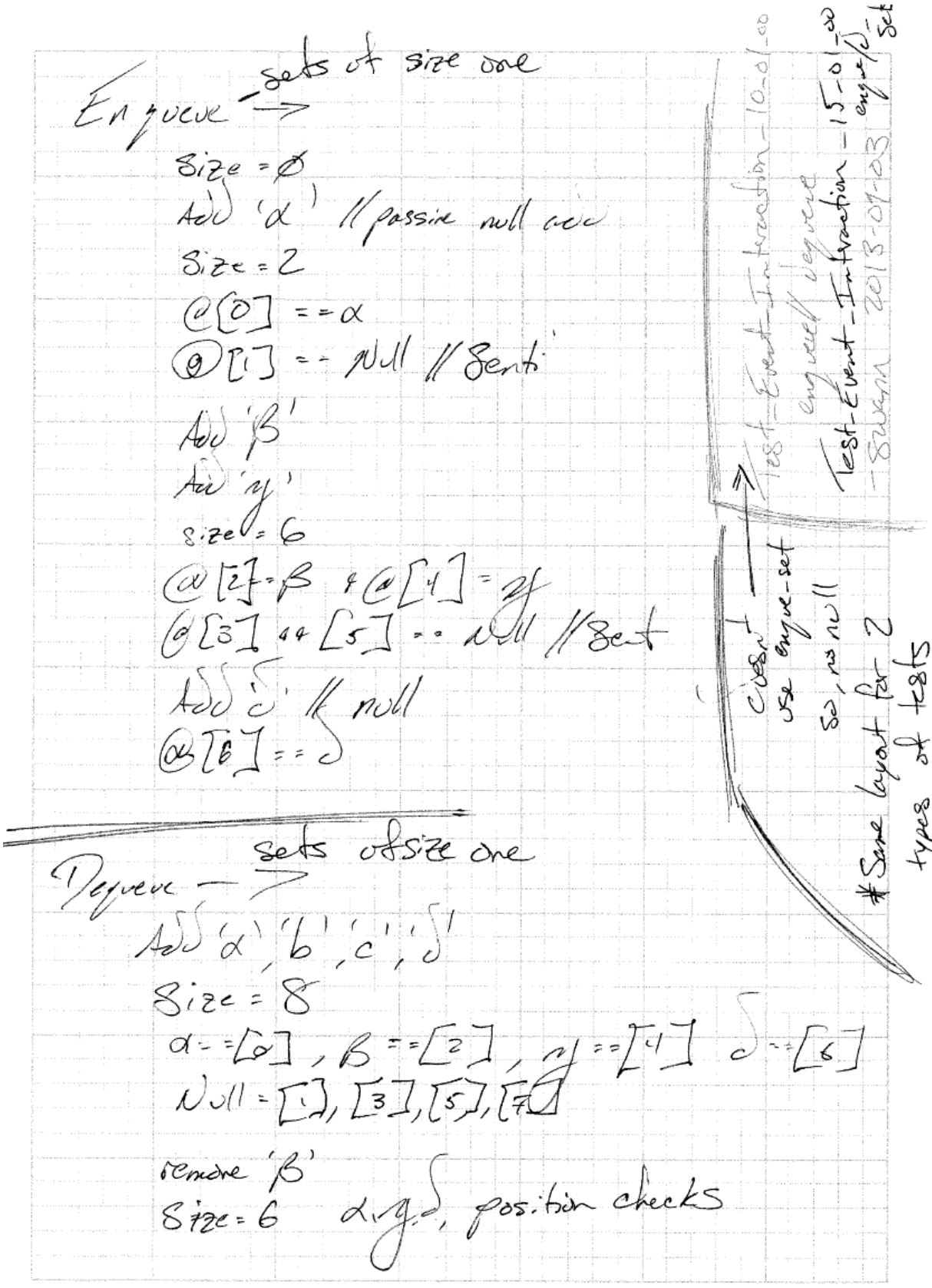


test notes :: explores full battery of shapes and their related projections on the x and y axis

```
// Circle Projection F(x)'s Suite
//   --> Circle.get_x_projection()
//   --> Cricle.get_low_bound_x_projection()
//   --> Cricle.get_high_bound_x_projection()
//
//       --> Circle.get_y_projection()
//   --> Cricle.get_low_bound_y_projection()
//   --> Cricle.get_low_bound_x_projection()
@Test
public void test_circle_15_01_00_projection_returns() {
        // The Setup
        Circle omicron = new Circle(50,   50, ZERO, 50);
        Circle omega   = new Circle(150, -50, ZERO, 50);
        // Omicron Battery
        assertEquals( omicron.get_high_bound_x_projection(), 100, ZERO );
        assertEquals( omicron.get_low_bound_x_projection(),    0, ZERO );
        assertEquals( omicron.get_high_bound_y_projection(), 100, ZERO );
        assertEquals( omicron.get_low_bound_y_projection(),    0, ZERO );
        assertEquals( omicron.get_high_bound_x_projection(), omicron.get_x_projection()[ONE],  ZERO );
        assertEquals( omicron.get_low_bound_x_projection(),  omicron.get_x_projection()[ZERO], ZERO );
        assertEquals( omicron.get_high_bound_y_projection(), omicron.get_y_projection()[ONE],  ZERO );
        assertEquals( omicron.get_low_bound_y_projection(),  omicron.get_y_projection()[ZERO], ZERO );
        // Omega Battery
        assertEquals( omega.get_high_bound_x_projection(), 200, ZERO );
        assertEquals( omega.get_low_bound_x_projection(),  100, ZERO );
        assertEquals( omega.get_high_bound_y_projection(), 0,   ZERO );
        assertEquals( omega.get_low_bound_y_projection(), -100, ZERO );
        assertEquals( omega.get_high_bound_x_projection(), omega.get_x_projection()[ONE],  ZERO );
        assertEquals( omega.get_low_bound_x_projection(),  omega.get_x_projection()[ZERO], ZERO );
        assertEquals( omega.get_high_bound_y_projection(), omega.get_y_projection()[ONE],  ZERO );
        assertEquals( omega.get_low_bound_y_projection(),  omega.get_y_projection()[ZERO], ZERO );
}



// Square Projection F(x)'s Suite
//   --> Square.get_x_projection()
//   --> Square.get_low_bound_x_projection()
//   --> Square.get_high_bound_x_projection()
//
//       --> Square.get_y_projection()
//   --> Square.get_low_bound_y_projection()
//   --> Square.get_low_bound_x_projection()
@Test
public void test_square_15_00_01_projection_returns() {
        // The Setup
        Square alpha = new Square(-75, 75, ZERO, 50, 50);
        // Omicron Battery
        assertEquals( alpha.get_high_bound_x_projection(), -50, ZERO );
        assertEquals( alpha.get_low_bound_x_projection(), -100, ZERO );
        assertEquals( alpha.get_high_bound_y_projection(), 100, ZERO );
        assertEquals( alpha.get_low_bound_y_projection(),   50, ZERO );
        assertEquals( alpha.get_high_bound_x_projection(), alpha.get_x_projection()[ONE],  ZERO );
        assertEquals( alpha.get_low_bound_x_projection(),  alpha.get_x_projection()[ZERO], ZERO );
        assertEquals( alpha.get_high_bound_y_projection(), alpha.get_y_projection()[ONE],  ZERO );
        assertEquals( alpha.get_low_bound_y_projection(),  alpha.get_y_projection()[ZERO], ZERO );
}



// Rectangle Projection F(x)'s Suite
//   --> Rectangle.get_x_projection()
//   --> Rectangle.get_low_bound_x_projection()
//   --> Rectangle.get_high_bound_x_projection()
//
//       --> Rectangle.get_y_projection()
//   --> Rectangle.get_low_bound_y_projection()
//   --> Rectangle.get_low_bound_x_projection()
@Test
public void test_rectangle_15_00_01_projection_returns() {
        // The Setup
        Rectangle beta  = new Rectangle(-175, 25, ZERO, 150, 50);
        Rectangle gamma = new Rectangle(  0, -90, ZERO, 20, 100);
        // Omicron Battery
        assertEquals( beta.get_high_bound_x_projection(), -150, ZERO );
        assertEquals( beta.get_low_bound_x_projection(),  -200, ZERO );
        assertEquals( beta.get_high_bound_y_projection(),  100, ZERO );
        assertEquals( beta.get_low_bound_y_projection(),   -50, ZERO );
        assertEquals( beta.get_high_bound_x_projection(), beta.get_x_projection()[ONE],  ZERO );
        assertEquals( beta.get_low_bound_x_projection(),  beta.get_x_projection()[ZERO], ZERO );
        assertEquals( beta.get_high_bound_y_projection(), beta.get_y_projection()[ONE],  ZERO );
        assertEquals( beta.get_low_bound_y_projection(),  beta.get_y_projection()[ZERO], ZERO );
        // Omega Battery
        assertEquals( gamma.get_high_bound_x_projection(),  50, ZERO );
```

```
        assertEquals( gamma.get_low_bound_x_projection(),  -50, ZERO );
        assertEquals( gamma.get_high_bound_y_projection(), -80, ZERO );
        assertEquals( gamma.get_low_bound_y_projection(), -100, ZERO );
        assertEquals( gamma.get_high_bound_x_projection(), gamma.get_x_projection()[ONE],  ZERO );
        assertEquals( gamma.get_low_bound_x_projection(),  gamma.get_x_projection()[ZERO], ZERO );
        assertEquals( gamma.get_high_bound_y_projection(), gamma.get_y_projection()[ONE],  ZERO );
        assertEquals( gamma.get_low_bound_y_projection(),  gamma.get_y_projection()[ZERO], ZERO );
}
```

module :: Item/Event_Interaction.java
test/design :: test_event_interaction_10_01/02_00_enqueue && test_event_interaction_10_01/02_00_dequeue && test_event_interaction_15_01/02_00_enqueue_dequeue_set
description :: design of the functionality to determine, queue and dequeue groups of actors involved in an event



Enqueue_Set ->
alaph already in -> Do Nothing

Enqueue ->
alpha-already in -> Complex

Dequeue_Set -> - Index OOB - Exception
empty

Deque_ -> - No Such Element - Exception
empty

test_event_interaction - 10-02-00
enqueue/deque - Swann

---

test_event interaction enque_set 10-02-00

add_alaph
then add alpha && beta
Should replace alph with alpha_beta

$\alpha \rightarrow$ Null $\Rightarrow$ $\alpha \rightarrow \beta \rightarrow$ null

track to index if found
store index

Bug found Issue #3 on GitHub
- Swann 2013-09-05

---

add gamma
then gamma delta
the alpha beta pi

Not A-TPD
Post Analysis Testing

test notes :: explores full battery of enqueue, enqueue_set, dequeue, and dequeue_set functions of customized event interaction grouping logic

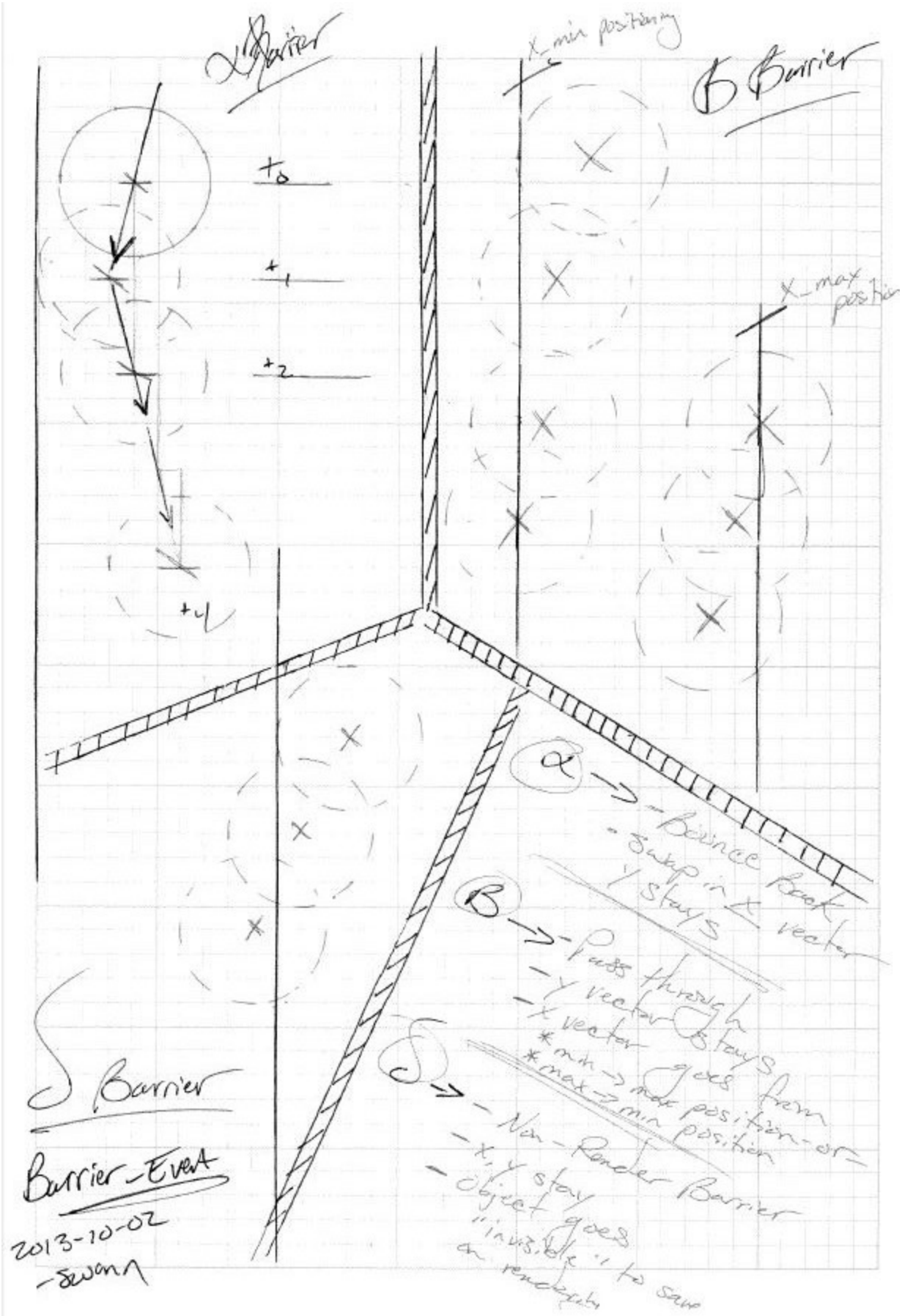
```
// Event_Interaction.enqueue()
@Test
public void test_event_interaction_10_01_00_enqueue() {
        // corresponding test draft in notebook
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, FIVE, ZERO);
        Cannon        beta  = new Cannon(TEN, NEGATIVE_ONE, ZERO);
        DropTower     gamma = new DropTower(TWO, THREE, ZERO);
        Ball          delta = Ball.generate_Baseball(NEGATIVE_ONE, SEVEN, ZERO);
        Collision collision = new Collision();
        LinkedList<Actor_Object> the_list = collision.get_list();
        // alpha add
        assertEquals(ZERO, the_list.size(), ZERO);
        collision.enqueue(alpha);
        the_list = collision.get_list();
        assertEquals(ONE, the_list.size(), ZERO);
        assertEquals(alpha, the_list.get(ZERO));
        // beta add
        collision.enqueue(beta);
        the_list = collision.get_list();
        assertEquals(TWO, the_list.size(), ZERO);
        assertEquals(alpha, the_list.get(ZERO));
        assertEquals(beta, the_list.get(ONE));
        // gamma add
        collision.enqueue(gamma);
        the_list = collision.get_list();
        assertEquals(THREE, the_list.size(), ZERO);
        assertEquals(alpha, the_list.get(ZERO));
        assertEquals(beta,  the_list.get(ONE));
        assertEquals(gamma, the_list.get(TWO));
        // delta add
        collision.enqueue(delta);
        the_list = collision.get_list();
        assertEquals(FOUR, the_list.size(), ZERO);
        assertEquals(alpha, the_list.get(ZERO));
        assertEquals(beta,  the_list.get(ONE));
        assertEquals(gamma, the_list.get(TWO));
        assertEquals(delta, the_list.get(THREE));
}


//Event_Interaction.enqueue()
@Test
public void test_event_interaction_10_02_00_enqueue() {
        // Re-adding already added
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, FIVE, ZERO);
        Collision collision = new Collision();
        LinkedList<Actor_Object> the_list = collision.get_list();
        // alpha add
        assertEquals(ZERO, the_list.size(), ZERO);
        collision.enqueue(alpha);
        the_list = collision.get_list();
        assertEquals(ONE, the_list.size(), ZERO);
        collision.enqueue(alpha);
        the_list = collision.get_list();
        assertEquals(ONE, the_list.size(), ZERO);
}


// Event_Interaction.dequeue()
@Test
public void test_event_interaction_10_01_00_dequeue() {
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, FIVE, ZERO);
        Cannon        beta  = new Cannon(TEN, NEGATIVE_ONE, ZERO);
        DropTower     gamma = new DropTower(TWO, THREE, ZERO);
        Ball          delta = Ball.generate_Baseball(NEGATIVE_ONE, SEVEN, ZERO);
        Collision collision = new Collision();
        LinkedList<Actor_Object> the_list = collision.get_list();
        // all add
        collision.enqueue(alpha);
        collision.enqueue(beta);
        collision.enqueue(gamma);
        collision.enqueue(delta);
        the_list = collision.get_list();
        assertEquals(FOUR, the_list.size(), ZERO);
        // alpha remove
        collision.dequeue();
        the_list = collision.get_list();
        assertEquals(THREE, the_list.size(), ZERO);
        assertEquals(beta,  the_list.get(ZERO));
        assertEquals(gamma, the_list.get(ONE));
        assertEquals(delta, the_list.get(TWO));
        // beta remove
        collision.dequeue();
```

```
        the_list = collision.get_list();
        assertEquals(TWO, the_list.size(), ZERO);
        assertEquals(gamma, the_list.get(ZERO));
        assertEquals(delta, the_list.get(ONE));
        // gamma remove
        collision.dequeue();
        the_list = collision.get_list();
        assertEquals(ONE, the_list.size(), ZERO);
        assertEquals(delta, the_list.get(ZERO));
        // gamma remove
        collision.dequeue();
        the_list = collision.get_list();
        assertEquals(ZERO, the_list.size(), ZERO);
}


// Event_Interaction.dequeue()
@Test
public void test_event_interaction_10_02_00_dequeue() {
        // The Setup
        Collision collision = new Collision();
        //LinkedList<Actor_Object> the_list = collision.get_list();
        try {
                collision.dequeue();
        }
        catch (NoSuchElementException e){
                // do nothing just pass
        }
}


// Event_Interaction.enqueue_set()
@Test
public void test_event_interaction_15_01_00_enqueue_set() {
        // corresponding test draft in notebook
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, FIVE, ZERO);
        Cannon        beta  = new Cannon(TEN, NEGATIVE_ONE, ZERO);
        DropTower     gamma = new DropTower(TWO, THREE, ZERO);
        Ball          delta = Ball.generate_Baseball(NEGATIVE_ONE, SEVEN, ZERO);
        ArrayList<Actor_Object> alpha_list = new ArrayList<Actor_Object>();
        alpha_list.add((Actor_Object)alpha);
        ArrayList<Actor_Object> beta_list  = new ArrayList<Actor_Object>();
        beta_list.add((Actor_Object)beta);
        ArrayList<Actor_Object> gamma_list = new ArrayList<Actor_Object>();
        gamma_list.add((Actor_Object)gamma);
        ArrayList<Actor_Object> delta_list = new ArrayList<Actor_Object>();
        delta_list.add((Actor_Object)delta);
        Collision collision = new Collision();
        LinkedList<Actor_Object> the_list = collision.get_list();
        // alpha add
        assertEquals(ZERO, the_list.size(), ZERO);
        collision.enqueue_set(alpha_list);
        the_list = collision.get_list();
        assertEquals(ONE*TWO, the_list.size(), ZERO);
        assertEquals(alpha, the_list.get(ZERO));
        // beta add
        collision.enqueue_set(beta_list);
        the_list = collision.get_list();
        assertEquals(TWO*TWO, the_list.size(), ZERO);
        assertEquals(alpha, the_list.get(ZERO));
        assertEquals(beta, the_list.get(ONE*TWO));
        // gamma add
        collision.enqueue_set(gamma_list);
        the_list = collision.get_list();
        assertEquals(THREE*TWO, the_list.size(), ZERO);
        assertEquals(alpha,       the_list.get(ZERO));
        assertEquals(beta,        the_list.get(ONE*TWO));
        assertEquals(gamma,       the_list.get(TWO*TWO));
        // delta add
        collision.enqueue_set(delta_list);
        the_list = collision.get_list();
        assertEquals(FOUR*TWO, the_list.size(), ZERO);
        assertEquals(alpha,    the_list.get(ZERO));
        assertEquals(beta,     the_list.get(ONE*TWO));
        assertEquals(gamma,    the_list.get(TWO*TWO));
        assertEquals(delta,    the_list.get(THREE*TWO));
        // null sentinel checks
        Ball SENTINEL = null;
        assertEquals(SENTINEL,    the_list.get(ONE));
        assertEquals(SENTINEL,    the_list.get(THREE));
        assertEquals(SENTINEL,    the_list.get(FIVE));
        assertEquals(SENTINEL,    the_list.get(SEVEN));
}


// Event_Interaction.enqueue_set()
@Test
public void test_event_interaction_15_02_00_enqueue_set() {
        // corresponding test draft in notebook
```

```
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, FIVE, ZERO);
        Cannon        beta  = new Cannon(TEN, NEGATIVE_ONE, ZERO);
        DropTower     gamma = new DropTower(TWO, THREE, ZERO);
        Ball          delta = Ball.generate_Baseball(NEGATIVE_ONE, SEVEN, ZERO);
        Ball              eta   = Ball.generate_Baseball(NEGATIVE_ONE, SEVEN, ZERO);
        // primary lists
        ArrayList<Actor_Object> alpha_list = new ArrayList<Actor_Object>();
        alpha_list.add((Actor_Object)alpha);
        ArrayList<Actor_Object> beta_list  = new ArrayList<Actor_Object>();
        beta_list.add((Actor_Object)beta);
        ArrayList<Actor_Object> gamma_list = new ArrayList<Actor_Object>();
        gamma_list.add((Actor_Object)gamma);
        ArrayList<Actor_Object> delta_list = new ArrayList<Actor_Object>();
        delta_list.add((Actor_Object)delta);
        // Misc. Overhead
        Collision collision = new Collision();
        LinkedList<Actor_Object> the_list = collision.get_list();
        Ball SENTINEL = null;
        // add alpha
        collision.enqueue_set(alpha_list);
        the_list = collision.get_list();
        assertEquals(ONE*TWO,     the_list.size(), ZERO);
        assertEquals(alpha,       the_list.get(ZERO));
        assertEquals(SENTINEL,    the_list.get(ONE));
        // Transmogrification of alpha_list and re-test
        alpha_list.add(beta);
        alpha_list.add(alpha);
        collision.enqueue_set(alpha_list);
        the_list = collision.get_list();
        //
        // ANALOG
        // Bug found here from ANALOG test design
        //   improper coagulation of set data for a given event
        //   issue #5 on github.
        // ~swann 2013-11-14
        assertEquals(THREE,       the_list.size(), ZERO);
        assertEquals(alpha,       the_list.get(ZERO));
        assertEquals(beta,        the_list.get(ONE));
        assertEquals(SENTINEL,    the_list.get(TWO));
        // add gamma, then gamma-delta
        collision.enqueue_set(gamma_list);
        assertEquals(FIVE,        the_list.size(), ZERO);
        assertEquals(alpha,       the_list.get(ZERO));
        assertEquals(beta,        the_list.get(ONE));
        assertEquals(SENTINEL,    the_list.get(TWO));
        assertEquals(gamma,       the_list.get(THREE));
        assertEquals(SENTINEL,    the_list.get(FOUR));
        // double add
        gamma_list.add(gamma);
        gamma_list.add(delta);
        collision.enqueue_set(gamma_list);
        assertEquals(SIX,         the_list.size(), ZERO);
        assertEquals(alpha,       the_list.get(ZERO));
        assertEquals(beta,        the_list.get(ONE));
        assertEquals(SENTINEL,    the_list.get(TWO));
        assertEquals(gamma,       the_list.get(THREE));
        assertEquals(delta,       the_list.get(FOUR));
        assertEquals(SENTINEL,    the_list.get(FIVE));
        // Triple add to alpha list
        alpha_list.add(beta);
        alpha_list.add(alpha);
        alpha_list.add(eta);
        collision.enqueue_set(alpha_list);
        the_list = collision.get_list();
        assertEquals(SEVEN,       the_list.size(), ZERO);
        assertEquals(gamma,       the_list.get(ZERO));
        assertEquals(delta,       the_list.get(ONE));
        assertEquals(SENTINEL,    the_list.get(TWO));
        assertEquals(alpha,       the_list.get(THREE));
        assertEquals(beta,        the_list.get(FOUR));
        assertEquals(eta,         the_list.get(FIVE));
        assertEquals(SENTINEL,    the_list.get(SIX));
}


// Event_Interaction.dequeue_set()
@Test
public void test_event_interaction_15_01_00_dequeue_set() {
        // The Setup
        Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, FIVE, ZERO);
        Cannon        beta  = new Cannon(TEN, NEGATIVE_ONE, ZERO);
        DropTower     gamma = new DropTower(TWO, THREE, ZERO);
        Ball          delta = Ball.generate_Baseball(NEGATIVE_ONE, SEVEN, ZERO);
        Collision collision = new Collision();
        ArrayList<Actor_Object> alpha_list = new ArrayList<Actor_Object>();
        alpha_list.add((Actor_Object)alpha);
        ArrayList<Actor_Object> beta_list  = new ArrayList<Actor_Object>();
        beta_list.add((Actor_Object)beta);
        ArrayList<Actor_Object> gamma_list = new ArrayList<Actor_Object>();
```

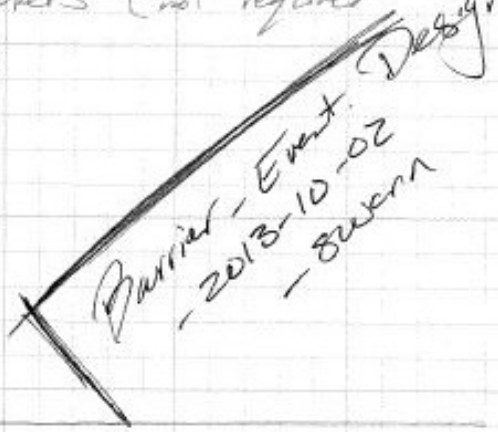
```
        gamma_list.add((Actor_Object)gamma);
        ArrayList<Actor_Object> delta_list = new ArrayList<Actor_Object>();
        delta_list.add((Actor_Object)delta);
        LinkedList<Actor_Object> the_list = collision.get_list();
        // all add
        collision.enqueue_set(alpha_list);
        collision.enqueue_set(beta_list);
        collision.enqueue_set(gamma_list);
        collision.enqueue_set(delta_list);
        the_list = collision.get_list();
        assertEquals(FOUR*TWO, the_list.size(), ZERO);
        // null sentinel checks
        Ball SENTINEL = null;
        assertEquals(SENTINEL,    the_list.get(ONE));
        assertEquals(SENTINEL,    the_list.get(THREE));
        assertEquals(SENTINEL,    the_list.get(FIVE));
        assertEquals(SENTINEL,    the_list.get(SEVEN));
        // alpha remove
        collision.dequeue_set();
        the_list = collision.get_list();
        assertEquals(THREE*TWO, the_list.size(), ZERO);
        assertEquals(beta,  the_list.get(ZERO));
        assertEquals(gamma, the_list.get(ONE*TWO));
        assertEquals(delta, the_list.get(TWO*TWO));
        // beta remove
        collision.dequeue_set();
        the_list = collision.get_list();
        assertEquals(TWO*TWO, the_list.size(), ZERO);
        assertEquals(gamma, the_list.get(ZERO));
        assertEquals(delta, the_list.get(ONE*TWO));
        // gamma remove
        collision.dequeue_set();
        the_list = collision.get_list();
        assertEquals(ONE*TWO, the_list.size(), ZERO);
        assertEquals(delta, the_list.get(ZERO*TWO));
        // gamma remove
        collision.dequeue_set();
        the_list = collision.get_list();
        assertEquals(ZERO, the_list.size(), ZERO);
}


// Event_Interaction.dequeue_set()
@Test
public void test_event_interaction_15_02_00_dequeue_set() {
        // The Setup
        Collision collision = new Collision();
        //LinkedList<Actor_Object> the_list = collision.get_list();
        try {
                collision.dequeue_set();
        }
        catch (IndexOutOfBoundsException e){
                // do nothing just pass
        }
}
```

module :: Item/Barrier_Event.java
test/design :: test_barrier_general_10_01_00_constructor_equivalence
description :: design of the normalized behaviors of all barrier events



Event Interaction

-> Linked List
  - to use non-sentinel markers (not required)
-> (abstract) execute()
-> (abstract) check()
-> enqueue()
-> dequeue()
-> get_list()



Barrier_Event (float value, enum_plane)

-> enum_plane listings
-> value as a float field
-> (abstract) get_value()
-> (abstract) set_value()

Bounce_Barrier_Event

-> execute()
  -> change in 'x' vector (re-direction)

Pass_Through_Barrier Event

-> execute()
  -> change 'x' min/max to 'x' max/min

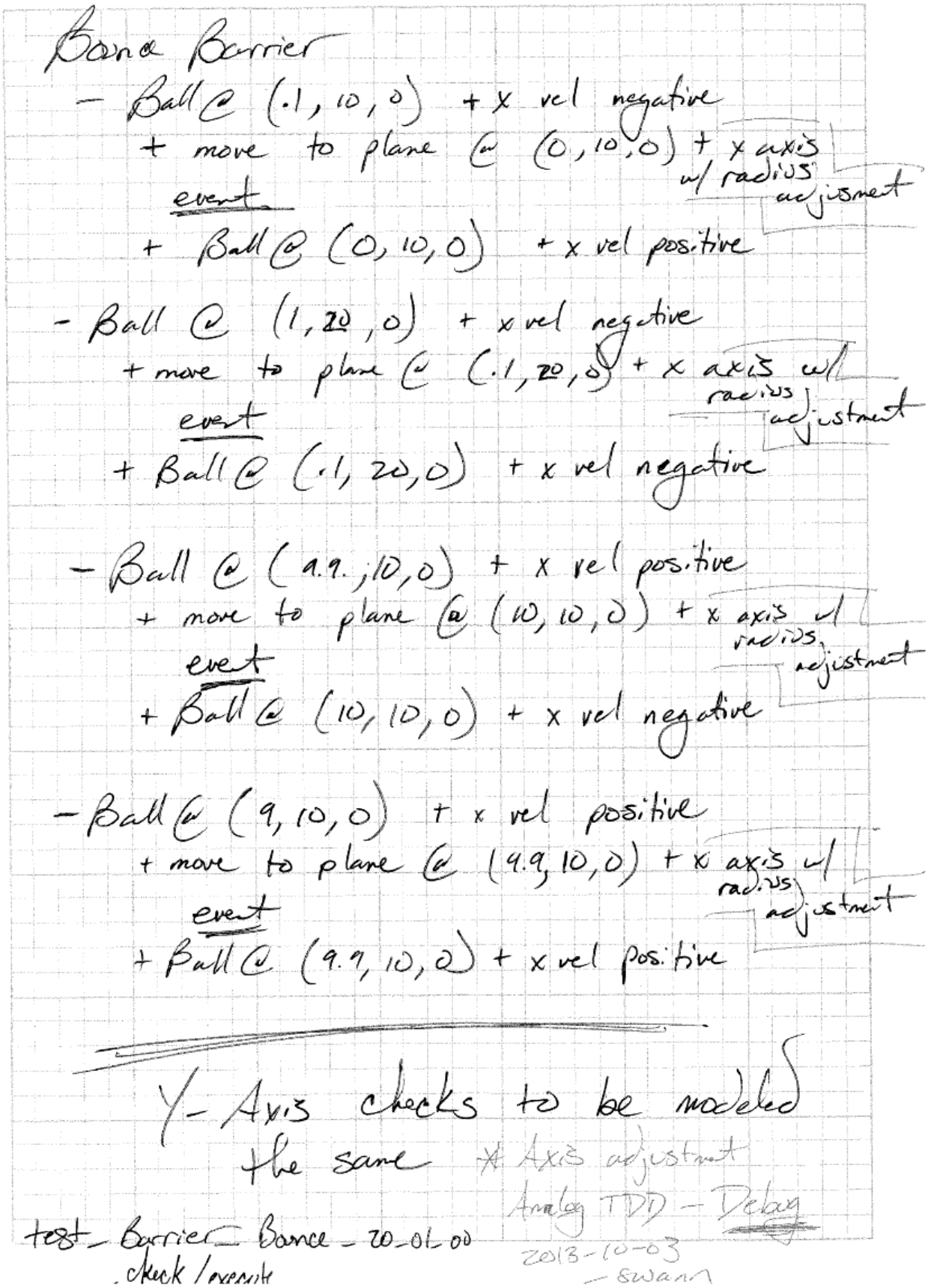
Non_Render_Barrier_Event

-> execute()
  -> <actor_object>.set_visibility(false);

test notes :: explores full battery of normalized behaviors across the three barrier event classes

```
// Barrier_Event Constructor equivalence
//  --> set_value()
//  --> get_value()
//  --> get_axis()
//  --> Pass_Through
@Test
public void test_barrier_general_10_01_00_constructor_equivalence() {
        // The Setup
        Bounce_Barrier_Event       alpha = new Bounce_Barrier_Event(ZERO, Barrier_Event.axis_enumeration.X,
                                           Barrier_Event.axis_control.STAY_HIGHER);
        Pass_Through_Barrier_Event beta  = new Pass_Through_Barrier_Event(ONE, TEN, Barrier_Event.axis_enumeration.X,
                                           Barrier_Event.axis_control.STAY_HIGHER);
        Non_Render_Barrier_Event   delta = new Non_Render_Barrier_Event(TWO, Barrier_Event.axis_enumeration.X,
                                           Barrier_Event.axis_control.STAY_HIGHER);
        Bounce_Barrier_Event       gamma = new Bounce_Barrier_Event((float) .2, Barrier_Event.axis_enumeration.Y,
                                           Barrier_Event.axis_control.STAY_LOWER);
        Pass_Through_Barrier_Event iota  = new Pass_Through_Barrier_Event((float) .009, TEN,
                                           Barrier_Event.axis_enumeration.Y, Barrier_Event.axis_control.STAY_LOWER);
        Non_Render_Barrier_Event   eta   = new Non_Render_Barrier_Event((float) 14.77,
                                           Barrier_Event.axis_enumeration.Y, Barrier_Event.axis_control.STAY_LOWER);
        // Battery One
        assertEquals(ZERO, alpha.get_value(), A_THOUSANDTH);
        assertEquals(ONE,  beta.get_value(),  A_THOUSANDTH);
        assertEquals(TWO,  delta.get_value(), A_THOUSANDTH);
        assertEquals((float) .2,    gamma.get_value(), A_THOUSANDTH);
        assertEquals((float) .009,  iota.get_value(),  A_THOUSANDTH);
        assertEquals((float) 14.77, eta.get_value(),   A_THOUSANDTH);

        assertEquals(Barrier_Event.axis_enumeration.X, alpha.get_axis());
        assertEquals(Barrier_Event.axis_enumeration.X,  beta.get_axis());
        assertEquals(Barrier_Event.axis_enumeration.X, delta.get_axis());
        assertEquals(Barrier_Event.axis_enumeration.Y, gamma.get_axis());
        assertEquals(Barrier_Event.axis_enumeration.Y,  iota.get_axis());
        assertEquals(Barrier_Event.axis_enumeration.Y,   eta.get_axis());

        assertEquals(Barrier_Event.axis_control.STAY_HIGHER, alpha.get_axis_control());
        assertEquals(Barrier_Event.axis_control.STAY_HIGHER,  beta.get_axis_control());
        assertEquals(Barrier_Event.axis_control.STAY_HIGHER, delta.get_axis_control());
        assertEquals(Barrier_Event.axis_control.STAY_LOWER, gamma.get_axis_control());
        assertEquals(Barrier_Event.axis_control.STAY_LOWER,  iota.get_axis_control());
        assertEquals(Barrier_Event.axis_control.STAY_LOWER,   eta.get_axis_control());
        // Battery Two
        alpha.set_value((float) .7);
        beta.set_value( (float) .7);
        delta.set_value((float) .7);
        gamma.set_value((float) .7);
        iota.set_value( (float) .7);
        eta.set_value(  (float) .7);
        assertEquals((float) .7,  gamma.get_value(), A_THOUSANDTH);
        assertEquals((float) 0.7,  iota.get_value(), A_THOUSANDTH);
        assertEquals((float) .7,    eta.get_value(), A_THOUSANDTH);
        assertEquals((float) .7,  alpha.get_value(), A_THOUSANDTH);
        assertEquals((float) 0.7,  beta.get_value(), A_THOUSANDTH);
        assertEquals((float) 0.7, delta.get_value(), A_THOUSANDTH);
        // Battery_Three
        assertEquals(TEN,  iota.get_opposing_value(), A_THOUSANDTH);
        assertEquals(TEN,  beta.get_opposing_value(), A_THOUSANDTH);
        iota.set_opposing_value( (float) -.001 );
        beta.set_opposing_value( (float) 12345.6789 );
        assertEquals((float) -.001,       iota.get_opposing_value(), A_THOUSANDTH);
        assertEquals((float) 12345.6789,  beta.get_opposing_value(), A_THOUSANDTH);
}
```

module	::	Item/Bounce_Barrier_Event.java && Item.Pass_Through_Barrier.java
test/design	::	test_bounce_barrier_20_01_00_check && test_bouce_barrier_20_02_00_execute && test_pass_through_barrier_20_01_00_check && test_pass_through_barrier_20_02_00_execute
description	::	design of the specific check and execute behaviors for bounce and pass through barriers



test notes :: explores functionality associated with both bounce barrier and pass through barrier; above test scenario recycled for pass through barriers with slight logic modifications

```
// Bounce_Barrier_Event.check/execute()
@Test
public void test_barrier_bounce_20_01_00_check() {
        // The setup
        Ball alpha;
        Ball beta;
        float[] velocity_spread;
        Bounce_Barrier_Event omicron;
        LinkedList<Actor_Object> flag_list;
        ArrayList<Actor_Object> the_list = new ArrayList<Actor_Object>();
        //
        // X Axis Sweep
        //
        // Battery One --> No changes yet
        alpha   = Ball.generate_Baseball((float) .1, TEN, ZERO);
        beta    = Ball.generate_Baseball(ONE,        TEN, ZERO);
        omicron = new Bounce_Barrier_Event(ZERO-alpha.get_shape().get_radius(),
                                           Barrier_Event.axis_enumeration.Y,
                                           Barrier_Event.axis_control.STAY_HIGHER);
        alpha.update_velocity(ZERO-FIVE*TEN, ZERO, ZERO);
        beta.update_velocity (ZERO-FIVE*TEN, ZERO, ZERO);
        the_list.add(alpha);
        the_list.add(beta);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ZERO, flag_list.size());
        // alpha has changed vel, beta does not
        alpha.update_location(ZERO,      TEN, ZERO);
        beta.update_location((float) .1, TEN, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,   flag_list.size());
        assertEquals(alpha, flag_list.get(ZERO));
        velocity_spread = alpha.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],  ZERO);
        assertEquals(ZERO, velocity_spread[ONE],  ZERO);
        assertEquals(FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);
        // beta has changed vel, alpha does not
        omicron.clean_list();
        beta.update_location(ZERO, TEN, ZERO);
        alpha.update_location(ONE, TEN, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,  flag_list.size());
        assertEquals(beta, flag_list.get(ZERO));
        velocity_spread = beta.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],  ZERO);
        assertEquals(ZERO, velocity_spread[ONE],  ZERO);
        assertEquals(FIVE*TEN*beta.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);
        velocity_spread = alpha.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],  ZERO);
        assertEquals(ZERO, velocity_spread[ONE],  ZERO);
        assertEquals(FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);

        // Battery Two --> No changes yet
        alpha   = Ball.generate_Baseball((float) 9.9, TEN, ZERO);
        beta    = Ball.generate_Baseball(NINE,        TEN, ZERO);
        omicron = new Bounce_Barrier_Event(TEN+alpha.get_shape().get_radius(),
                                           Barrier_Event.axis_enumeration.Y,
                                           Barrier_Event.axis_control.STAY_LOWER);
        the_list = new ArrayList<Actor_Object>();
        alpha.update_velocity(FIVE*TEN, ZERO, ZERO);
        beta.update_velocity (FIVE*TEN, ZERO, ZERO);
        the_list.add(alpha);
        the_list.add(beta);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ZERO, flag_list.size());
        // alpha has changed vel, beta does not
        alpha.update_location(TEN,        TEN, ZERO);
        beta.update_location((float) 9.9, TEN, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,   flag_list.size());
        assertEquals(alpha, flag_list.get(ZERO));
        velocity_spread = alpha.get_velocity();
        assertEquals(ZERO,      velocity_spread[TWO],  ZERO);
        assertEquals(ZERO,      velocity_spread[ONE],  ZERO);
        assertEquals(ZERO-FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);
        // beta has changed vel, alpha does not
        omicron.clean_list();
```

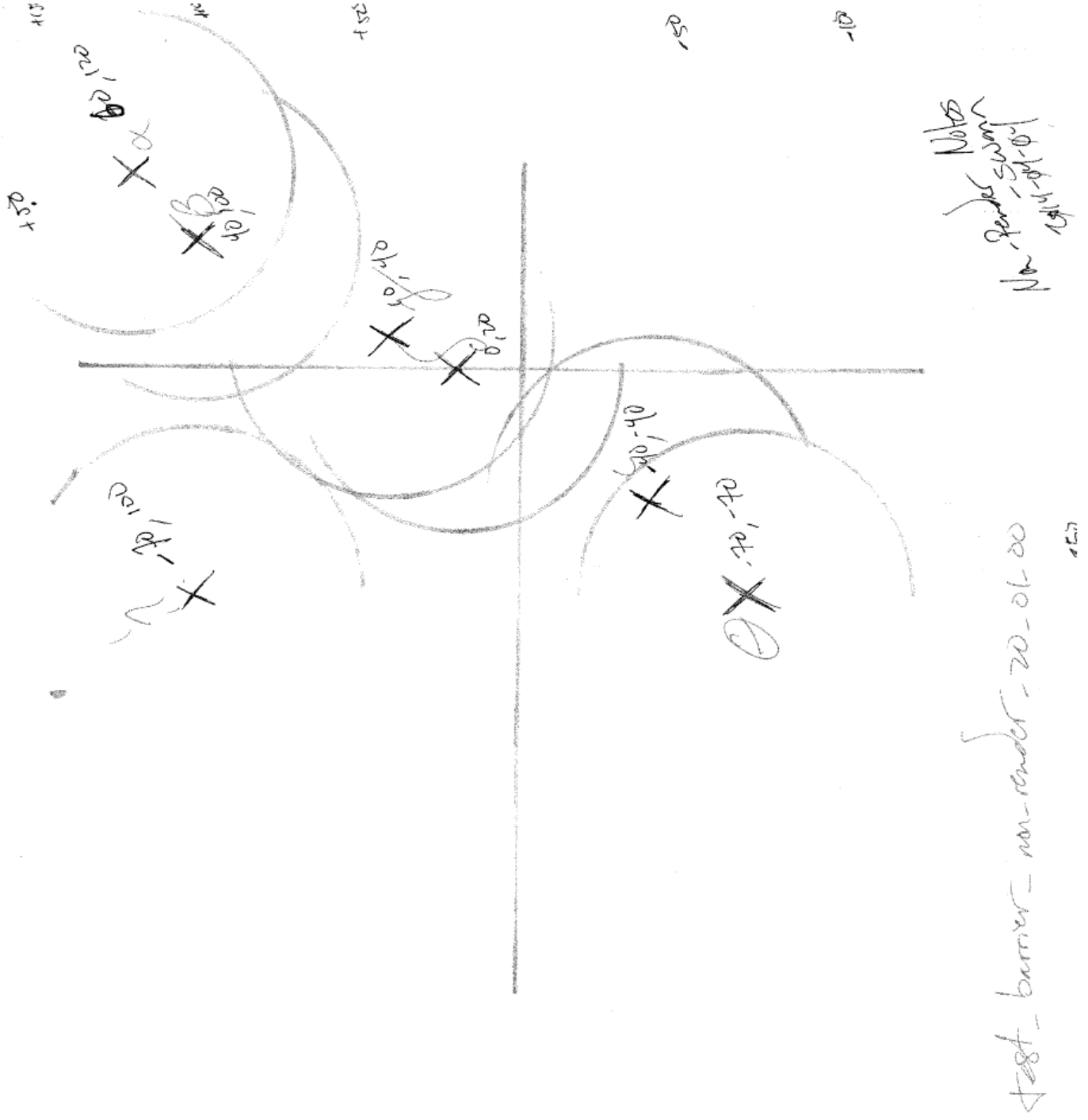
```
beta.update_location(TEN,   TEN, ZERO);
alpha.update_location(NINE, TEN, ZERO);
omicron.check(the_list);
omicron.execute();
flag_list = omicron.get_list();
assertEquals(ONE,  flag_list.size());
assertEquals(beta, flag_list.get(ZERO));
velocity_spread = beta.get_velocity();
assertEquals(ZERO, velocity_spread[TWO],       ZERO);
assertEquals(ZERO, velocity_spread[ONE],       ZERO);
assertEquals(ZERO-FIVE*TEN*beta.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);
velocity_spread = alpha.get_velocity();
assertEquals(ZERO, velocity_spread[TWO],       ZERO);
assertEquals(ZERO, velocity_spread[ONE],       ZERO);
assertEquals(ZERO-FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);

//
// Y Axis Sweep
//
// Battery Three --> No changes yet
alpha   = Ball.generate_Baseball(TEN, (float) .1, ZERO);
beta    = Ball.generate_Baseball(TEN,        ONE, ZERO);
omicron = new Bounce_Barrier_Event(ZERO-alpha.get_shape().get_radius(),
                                   Barrier_Event.axis_enumeration.X,
                                   Barrier_Event.axis_control.STAY_HIGHER);
alpha.update_velocity(ZERO, ZERO-FIVE*TEN, ZERO);
beta.update_velocity (ZERO, ZERO-FIVE*TEN, ZERO);
the_list.add(alpha);
the_list.add(beta);
omicron.check(the_list);
omicron.execute();
flag_list = omicron.get_list();
assertEquals(ZERO, flag_list.size());
// alpha has changed vel, beta does not
alpha.update_location(TEN,      ZERO, ZERO);
beta.update_location(TEN, (float) .1, ZERO);
omicron.check(the_list);
omicron.execute();
flag_list = omicron.get_list();
assertEquals(ONE,   flag_list.size());
assertEquals(alpha, flag_list.get(ZERO));
velocity_spread = alpha.get_velocity();
assertEquals(ZERO, velocity_spread[TWO],  ZERO);
assertEquals(ZERO, velocity_spread[ZERO], ZERO);
assertEquals(FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ONE],  ZERO);
// beta has changed vel, alpha does not
omicron.clean_list();
beta.update_location(TEN, ZERO, ZERO);
alpha.update_location(TEN, ONE, ZERO);
omicron.check(the_list);
omicron.execute();
flag_list = omicron.get_list();
assertEquals(ONE,  flag_list.size());
assertEquals(beta, flag_list.get(ZERO));
velocity_spread = beta.get_velocity();
assertEquals(ZERO, velocity_spread[TWO],  ZERO);
assertEquals(ZERO, velocity_spread[ZERO], ZERO);
assertEquals(FIVE*TEN*beta.get_coefficient_of_restitution(), velocity_spread[ONE],  ZERO);
velocity_spread = alpha.get_velocity();
assertEquals(ZERO, velocity_spread[TWO],  ZERO);
assertEquals(ZERO, velocity_spread[ZERO], ZERO);
assertEquals(FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ONE],  ZERO);

// Battery Four --> No changes yet
alpha   = Ball.generate_Baseball(TEN, (float) 9.9, ZERO);
beta    = Ball.generate_Baseball(TEN,        NINE, ZERO);
omicron = new Bounce_Barrier_Event(TEN+alpha.get_shape().get_radius(),
                                   Barrier_Event.axis_enumeration.X,
                                   Barrier_Event.axis_control.STAY_LOWER);
the_list = new ArrayList<Actor_Object>();
alpha.update_velocity(ZERO, FIVE*TEN, ZERO);
beta.update_velocity (ZERO, FIVE*TEN, ZERO);
the_list.add(alpha);
the_list.add(beta);
omicron.check(the_list);
omicron.execute();
flag_list = omicron.get_list();
assertEquals(ZERO, flag_list.size());
// alpha has changed vel, beta does not
alpha.update_location(TEN,        TEN, ZERO);
beta.update_location(TEN, (float) 9.9, ZERO);
omicron.check(the_list);
omicron.execute();
flag_list = omicron.get_list();
assertEquals(ONE,   flag_list.size());
assertEquals(alpha, flag_list.get(ZERO));
velocity_spread = alpha.get_velocity();
assertEquals(ZERO,      velocity_spread[TWO],  ZERO);
assertEquals(ZERO,      velocity_spread[ZERO], ZERO);
assertEquals(ZERO-FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ONE],  ZERO);
```

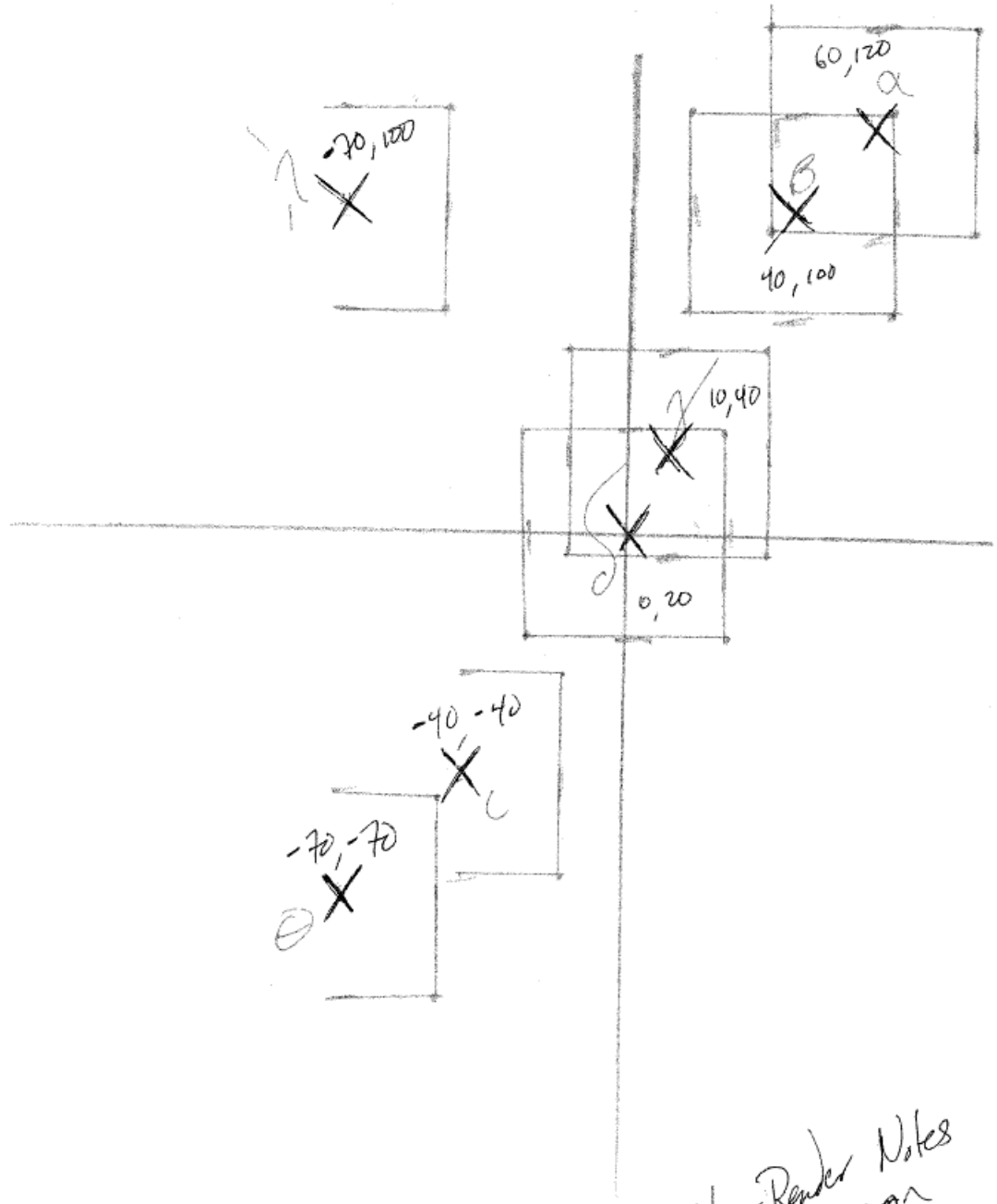
```
        // beta has changed vel, alpha does not
        omicron.clean_list();
        beta.update_location(TEN,  TEN,  ZERO);
        alpha.update_location(TEN, NINE, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,  flag_list.size());
        assertEquals(beta, flag_list.get(ZERO));
        velocity_spread = beta.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],      ZERO);
        assertEquals(ZERO, velocity_spread[ZERO],     ZERO);
        assertEquals(ZERO-FIVE*TEN*beta.get_coefficient_of_restitution(), velocity_spread[ONE], ZERO);
        velocity_spread = alpha.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],      ZERO);
        assertEquals(ZERO, velocity_spread[ZERO],     ZERO);
        assertEquals(ZERO-FIVE*TEN*alpha.get_coefficient_of_restitution(), velocity_spread[ONE], ZERO);
}


// Bounce_Barrier_Event.check/execute()
@Test
public void test_barrier_bounce_20_02_00_check_execute() {
        // The setup
        Standard_Mass gamma;
        Standard_Mass delta;
        Cannon the_cannon;
        float[] velocity_spread;
        Bounce_Barrier_Event omicron;
        LinkedList<Actor_Object> flag_list;
        ArrayList<Actor_Object> the_list = new ArrayList<Actor_Object>();
        //
        // X Axis Sweep
        //
        // Battery One --> No changes yet
        gamma   = Standard_Mass.generate_fifty_g_mass((float) .1, TEN, ZERO);
        delta    = Standard_Mass.generate_fifty_g_mass(ONE,       TEN, ZERO);
        the_cannon = new Cannon(ZERO, ZERO, ZERO);

        omicron = new Bounce_Barrier_Event((float) (ZERO-FIVE*TEN/TWO),
                                           Barrier_Event.axis_enumeration.Y,
                                           Barrier_Event.axis_control.STAY_HIGHER);
        gamma.update_velocity(ZERO-FIVE*TEN, ZERO, ZERO);
        delta.update_velocity(ZERO-FIVE*TEN, ZERO, ZERO);
        the_list.add(gamma);
        the_list.add(delta);
        the_list.add(the_cannon);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ZERO, flag_list.size());
        // alpha has changed vel, beta does not
        gamma.update_location((float) -.1, TEN, ZERO);
        delta.update_location((float) .1,  TEN, ZERO);
        // # ANALOG -->
        //   Found update_location bug... does not update radius or points
        //    ~swann 2013-10-07
        //  -------------------------------
        // Logged into github; issue #19
        // Solved via <Shape.set_location() Override>
        // Time to fix :: 45-60 seconds
        // test re-run and test pass
        //    ~swann 2013-10-07
        //gamma.get_shape().set_radius(gamma.get_shape().get_radius());
        //delta.get_shape().set_radius(delta.get_shape().get_radius());
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,   flag_list.size());
        assertEquals(gamma, flag_list.get(ZERO));
        velocity_spread = gamma.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],  ZERO);
        assertEquals(ZERO, velocity_spread[ONE],  ZERO);
        assertEquals(FIVE*TEN*gamma.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);
        // beta has changed vel, alpha does not
        omicron.clean_list();
        delta.update_location((float) -.1, TEN, ZERO);
        gamma.update_location(ONE,  TEN, ZERO);
        // DO NOT DELETE --> needed for above Analog tag
        //  ~swann 2013-10-07
        //gamma.get_shape().set_radius(gamma.get_shape().get_radius());
        //delta.get_shape().set_radius(delta.get_shape().get_radius());
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,  flag_list.size());
        assertEquals(delta, flag_list.get(ZERO));
        velocity_spread = delta.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],  ZERO);
        assertEquals(ZERO, velocity_spread[ONE],  ZERO);
```

```
        assertEquals(FIVE*TEN*delta.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);
        velocity_spread = gamma.get_velocity();
        assertEquals(ZERO, velocity_spread[TWO],  ZERO);
        assertEquals(ZERO, velocity_spread[ONE],  ZERO);
        assertEquals(FIVE*TEN*gamma.get_coefficient_of_restitution(), velocity_spread[ZERO], ZERO);
}


// Pass_Through_Barrier_Event.check/execute()
@Test
public void test_barrier_pass_through_20_01_00_check_execute() {
        // not designed or installed
        // ~swann 2013-10-03

        // The setup
        Ball alpha;
        Ball beta;
        float[] location_spread;
        Pass_Through_Barrier_Event omicron;
        LinkedList<Actor_Object> flag_list;
        ArrayList<Actor_Object> the_list = new ArrayList<Actor_Object>();
        //
        // X Axis Sweep
        //
        // Battery One --> No changes yet
        alpha   = Ball.generate_Baseball((float) .1, TEN, ZERO);
        beta    = Ball.generate_Baseball(ONE,        TEN, ZERO);
        omicron = new Pass_Through_Barrier_Event(ZERO,
                                                 TEN,
                                    Barrier_Event.axis_enumeration.Y,
                                    Barrier_Event.axis_control.STAY_HIGHER);
        the_list.add(alpha);
        the_list.add(beta);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ZERO, flag_list.size());
        // alpha has changed vel, beta does not
        alpha.update_location(ZERO,      TEN, ZERO);
        beta.update_location((float) .1, TEN, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,   flag_list.size());
        assertEquals(alpha, flag_list.get(ZERO));
        location_spread = alpha.get_location();
        assertEquals(TEN, location_spread[ZERO], ZERO);
        // beta has changed vel, alpha does not
        omicron.clean_list();
        beta.update_location(ZERO, TEN, ZERO);
        alpha.update_location(ONE, TEN, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,  flag_list.size());
        assertEquals(beta, flag_list.get(ZERO));
        location_spread = beta.get_location();
        assertEquals(TEN, location_spread[ZERO], ZERO);

        //
        // Y Axis Sweep
        //
        // Battery One --> No changes yet
        alpha   = Ball.generate_Baseball(ONE, (float) 9.9, ZERO);
        beta    = Ball.generate_Baseball(ONE,        NINE, ZERO);
        omicron = new Pass_Through_Barrier_Event(TEN,
                                                 ZERO,
                                    Barrier_Event.axis_enumeration.X,
                                    Barrier_Event.axis_control.STAY_LOWER);
        the_list = new ArrayList<Actor_Object>();
        the_list.add(alpha);
        the_list.add(beta);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ZERO, flag_list.size());
        // alpha has changed vel, beta does not
        alpha.update_location(ONE,          TEN, ZERO);
        beta.update_location( ONE, (float) 9.9, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(ONE,   flag_list.size());
        assertEquals(alpha, flag_list.get(ZERO));
        location_spread = alpha.get_location();
        assertEquals(ZERO, location_spread[ONE], ZERO);
        // beta has changed vel, alpha does not
        omicron.clean_list();
        beta.update_location(ZERO, TEN, ZERO);
        alpha.update_location(ONE, TEN, ZERO);
```

```
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(TWO,  flag_list.size());
        assertEquals(alpha, flag_list.get(ZERO));
        assertEquals(beta,  flag_list.get(ONE));
        location_spread = beta.get_location();
        assertEquals(ZERO, location_spread[ONE], ZERO);
        location_spread = alpha.get_location();
        assertEquals(ZERO, location_spread[ONE], ZERO);
}
```

module :: Item/Non_Render_Barrier_Event.java
test/design :: test_non_render_barrier_20_01_00_check_execute && test_non_render_barrier_20_02_00_check_execute
description :: design of the specific check and execute behaviors for bounce and pass through barriers





test_barrier_non-render_20-0200

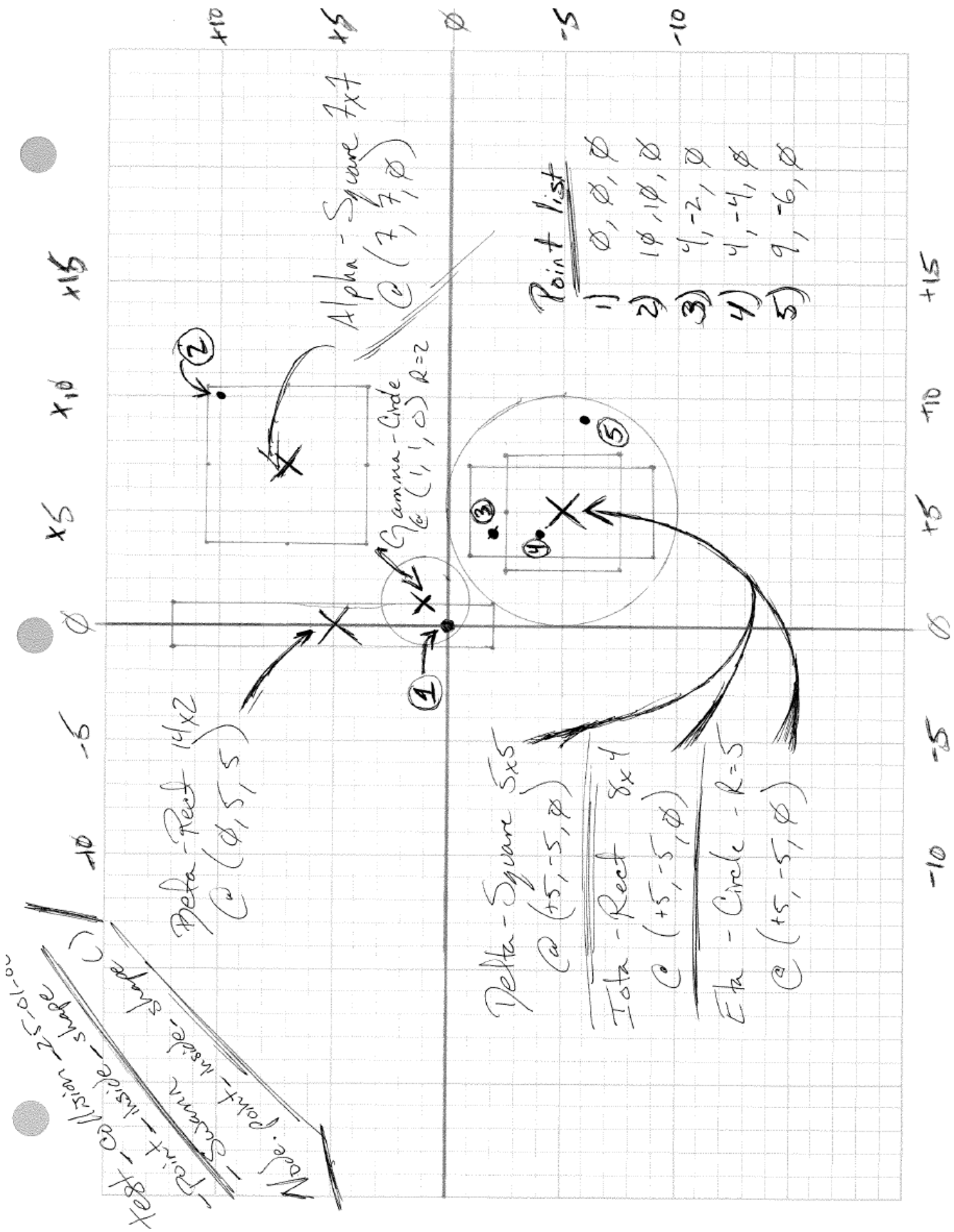
Non-Render Notes
- Swaman
7/8/14-04-04

test notes :: explores functionality associated with non render barriers

```
// Non_Render_Barrier_Event.check_execute()
@Test
public void test_barrier_non_render_20_01_00_check_execute() {
        // The setup
        Ball alpha, beta, gamma, delta, iota, theta, eta;
        Cannon the_cannon;
        Non_Render_Barrier_Event omicron;
        LinkedList<Actor_Object> flag_list;
        ArrayList<Actor_Object> the_list = new ArrayList<Actor_Object>();
        //
        // X Axis Sweep
        //
        // Battery One --> No changes yet
        alpha   = Ball.generate_Baseball(60,  120, ZERO);
        beta    = Ball.generate_Baseball(40,  100, ZERO);
        gamma   = Ball.generate_Baseball(10,  40,  ZERO);
        delta   = Ball.generate_Baseball(0,   20,  ZERO);
        iota    = Ball.generate_Baseball(-40, -40, ZERO);
        theta   = Ball.generate_Baseball(-70, -70, ZERO);
        eta     = Ball.generate_Baseball(-70, 100, ZERO);
        the_cannon = new Cannon(ZERO, ZERO, ZERO);
        omicron = new Non_Render_Barrier_Event( ZERO,
                                    Barrier_Event.axis_enumeration.Y,
                                    Barrier_Event.axis_control.STAY_HIGHER);

        the_list.add(alpha);
        the_list.add(beta);
        the_list.add(gamma);
        the_list.add(delta);
        the_list.add(iota);
        the_list.add(theta);
        the_list.add(eta);
        the_list.add(the_cannon);
        // Should have two objects not visible
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(THREE, flag_list.size());
        assertEquals(alpha.get_visibility(), true);
        assertEquals(beta.get_visibility(),  true);
        assertEquals(gamma.get_visibility(), true);
        assertEquals(delta.get_visibility(), true);
        assertEquals(iota.get_visibility(),  false);
        assertEquals(theta.get_visibility(), false);
        assertEquals(eta.get_visibility(),   false);
        assertEquals(the_cannon.get_visibility(), true);
        // Movement and re-check
        omicron.clean_list();
        alpha.update_location(10, 1000, ZERO);
        beta.update_location(-400,  35, ZERO);
        gamma.update_location(-50, ZERO, ZERO);
        delta.update_location(-24, ZERO, ZERO);
        iota.update_location(-51, ZERO, ZERO);
        the_cannon.update_location(-1000, ZERO, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(FIVE, flag_list.size());
        assertEquals(alpha.get_visibility(), true);
        assertEquals(beta.get_visibility(),  false);
        assertEquals(gamma.get_visibility(), false);
        assertEquals(delta.get_visibility(), true);
        assertEquals(iota.get_visibility(),  false);
        assertEquals(theta.get_visibility(), false);
        assertEquals(eta.get_visibility(),   false);
}


// Non_Render_Barrier_Event.check_execute()
@Test
public void test_barrier_non_render_20_02_00_check_execute() {
        // The setup
        Standard_Mass alpha, beta, gamma, delta, iota, theta, eta;
        Cannon the_cannon;
        Non_Render_Barrier_Event omicron;
        LinkedList<Actor_Object> flag_list;
        ArrayList<Actor_Object> the_list = new ArrayList<Actor_Object>();
        //
        // X Axis Sweep
        //
        // Battery One --> No changes yet
        alpha   = Standard_Mass.generate_fifty_g_mass(60,  120, ZERO);
        beta    = Standard_Mass.generate_fifty_g_mass(40,  100, ZERO);
        gamma   = Standard_Mass.generate_fifty_g_mass(10,  40,  ZERO);
        delta   = Standard_Mass.generate_fifty_g_mass(0,   20,  ZERO);
        iota    = Standard_Mass.generate_fifty_g_mass(-40, -40, ZERO);
        theta   = Standard_Mass.generate_fifty_g_mass(-70, -70, ZERO);
```

```
        eta     = Standard_Mass.generate_fifty_g_mass(-70, 100, ZERO);
        the_cannon = new Cannon(ZERO, ZERO, ZERO);
        omicron = new Non_Render_Barrier_Event( ZERO,
                                    Barrier_Event.axis_enumeration.Y,
                                    Barrier_Event.axis_control.STAY_HIGHER);
        the_list.add(alpha);
        the_list.add(beta);
        the_list.add(gamma);
        the_list.add(delta);
        the_list.add(iota);
        the_list.add(theta);
        the_list.add(eta);
        the_list.add(the_cannon);
        // Should have two objects not visible
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(THREE, flag_list.size());
        assertEquals(alpha.get_visibility(), true);
        assertEquals(beta.get_visibility(),  true);
        assertEquals(gamma.get_visibility(), true);
        assertEquals(delta.get_visibility(), true);
        assertEquals(iota.get_visibility(),  false);
        assertEquals(theta.get_visibility(), false);
        assertEquals(eta.get_visibility(),   false);
        assertEquals(the_cannon.get_visibility(), true);
        // Movement and re-check
        omicron.clean_list();
        alpha.update_location(10, 1000, ZERO);
        beta.update_location(-400,  35, ZERO);
        gamma.update_location(-50, ZERO, ZERO);
        delta.update_location(-10, ZERO, ZERO);
        iota.update_location(-51, ZERO, ZERO);
        the_cannon.update_location(-1000, ZERO, ZERO);
        omicron.check(the_list);
        omicron.execute();
        flag_list = omicron.get_list();
        assertEquals(FIVE, flag_list.size());
        assertEquals(alpha.get_visibility(), true);
        assertEquals(beta.get_visibility(),  false);
        assertEquals(gamma.get_visibility(), false);
        assertEquals(delta.get_visibility(), true);
        assertEquals(iota.get_visibility(),  false);
        assertEquals(theta.get_visibility(), false);
        assertEquals(eta.get_visibility(),   false);
}
```

module :: Item/Collision.java
test/design :: test_collision_25_01_00_point_inside_shape
description :: design of the specific check indicating whether a given node is within another shape



test notes :: explores support functionality determining whether a given shape's node exists within another shape

```
// Collision.point_inside_shape()
//  --> Heterogeneous Test
@Test
public void test_collision_25_01_00_point_inside_shape() {
        // The setup
        Node one  = new Node(0,   0, 0),
             two  = new Node(10, 10, 0),
             tre  = new Node(4,  -2, 0),
             four = new Node(4,  -4, 0),
             five = new Node(9,  -6, 0);
        // Simple Shapes
        Square alpha   = new Square(    7,  7,  7,  7,  7);
        Square delta   = new Square(    5, -5,  0,  5,  5);
        Rectangle beta = new Rectangle( 0,  5,  0, 14,  2);
        Rectangle iota = new Rectangle( 5, -5,  0,  8,  4);
        Circle gamma   = new Circle(    1,  1,  0,  2);
        Circle eta     = new Circle(    5, -5,  0,  5);
        // Complex Shape
        Shape omega    = new Shape(     5, -5,  0);
        omega.add_shape(delta);
        omega.add_shape(iota);
        omega.add_shape(eta);
        // Alpha Shape
        assertEquals(Collision.point_inside_shape(one,  alpha),  false);
        assertEquals(Collision.point_inside_shape(two,  alpha),  true);
        assertEquals(Collision.point_inside_shape(tre,  alpha),  false);
        assertEquals(Collision.point_inside_shape(four, alpha),  false);
        assertEquals(Collision.point_inside_shape(five, alpha),  false);
        // Beta Shape
        assertEquals(Collision.point_inside_shape(one,  beta),  true);
        assertEquals(Collision.point_inside_shape(two,  beta),  false);
        assertEquals(Collision.point_inside_shape(tre,  beta),  false);
        assertEquals(Collision.point_inside_shape(four, beta),  false);
        assertEquals(Collision.point_inside_shape(five, beta),  false);
        // Gamma Shape
        assertEquals(Collision.point_inside_shape(one,  gamma),  true);
        assertEquals(Collision.point_inside_shape(two,  gamma),  false);
        assertEquals(Collision.point_inside_shape(tre,  gamma),  false);
        assertEquals(Collision.point_inside_shape(four, gamma),  false);
        assertEquals(Collision.point_inside_shape(five, gamma),  false);
        // Delta Shape
        assertEquals(Collision.point_inside_shape(one,  delta),  false);
        assertEquals(Collision.point_inside_shape(two,  delta),  false);
        assertEquals(Collision.point_inside_shape(tre,  delta),  false);
        assertEquals(Collision.point_inside_shape(four, delta),  true);
        assertEquals(Collision.point_inside_shape(five, delta),  false);
        // Iota Shape
        assertEquals(Collision.point_inside_shape(one,  iota),  false);
        assertEquals(Collision.point_inside_shape(two,  iota),  false);
        assertEquals(Collision.point_inside_shape(tre,  iota),  true);
        assertEquals(Collision.point_inside_shape(four, iota),  true);
        assertEquals(Collision.point_inside_shape(five, iota),  false);
        // Eta Shape
        assertEquals(Collision.point_inside_shape(one,  eta),  false);
        assertEquals(Collision.point_inside_shape(two,  eta),  false);
        assertEquals(Collision.point_inside_shape(tre,  eta),  true);
        assertEquals(Collision.point_inside_shape(four, eta),  true);
        assertEquals(Collision.point_inside_shape(five, eta),  true);
        // Omega Shape
        assertEquals(Collision.point_inside_shape(one,  omega),  false);
        assertEquals(Collision.point_inside_shape(two,  omega),  false);
        assertEquals(Collision.point_inside_shape(tre,  omega),  true);
        assertEquals(Collision.point_inside_shape(four, omega),  true);
        assertEquals(Collision.point_inside_shape(five, omega),  true);
}
```

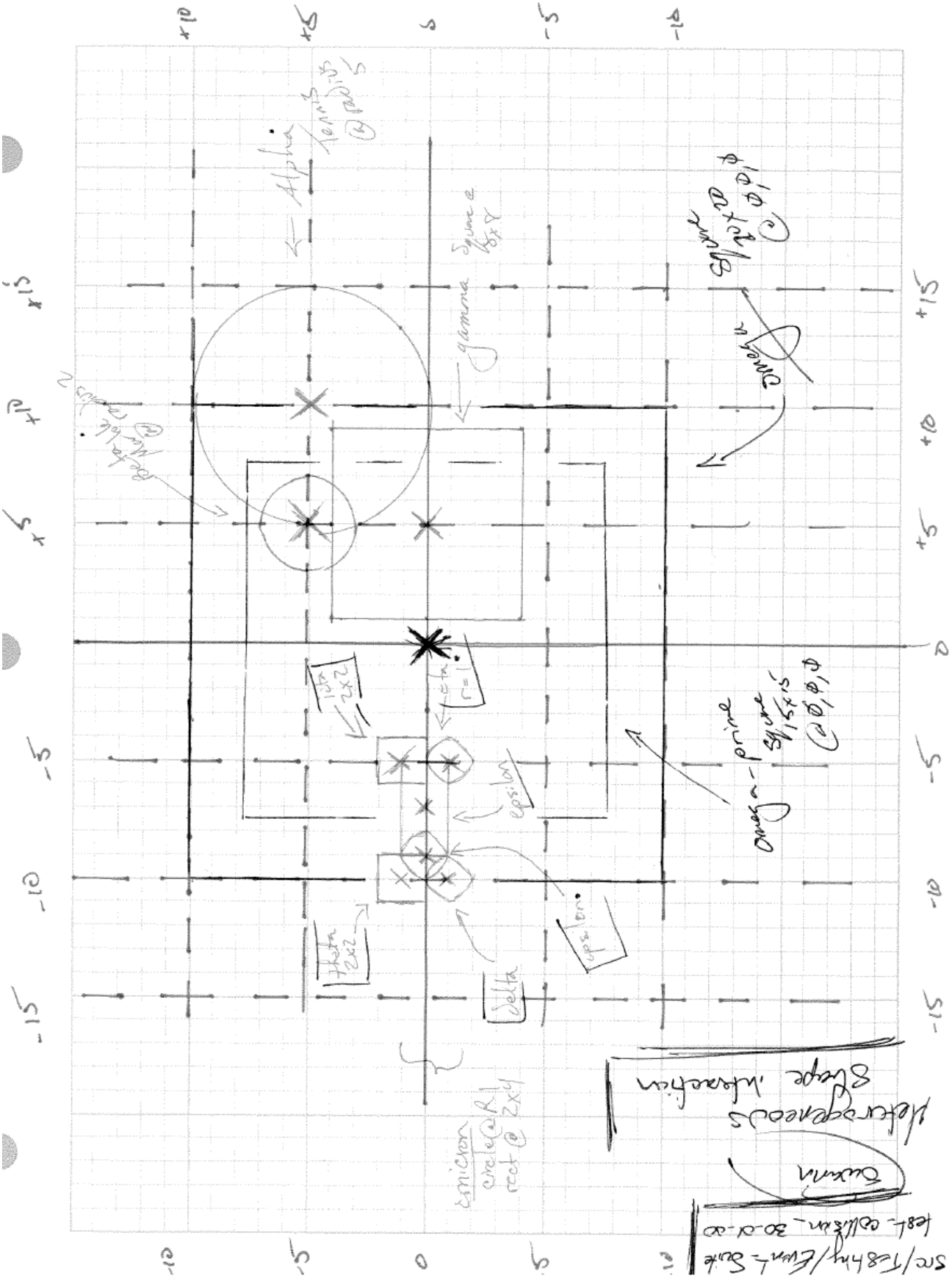
function notes :: implementation of `point_inside_shape()`

```
/**
 * Controls the logic path for determining whether or not a
 *
 * @param vertex_node  : The point/node for comparison
 * @param target_shape : The show for comparison
 *
 * @return { boolean } : Boolean variable representing whether the point is
 *                       inside the shape.
 */
public static boolean point_inside_shape( Node vertex_node, Shape target_shape ) {

        if ( target_shape.is_composite() ) {

                return Collision.point_inside_complex_shape( vertex_node, target_shape );
        }
        else {
                return Collision.point_inside_simple_shape(  vertex_node, target_shape );
```

```
        }
} // end Collision.point_inside_shape()


/**
 * Determines whether or not a point is within the bounds of a simple shape.
 *
 * @param vertex_node  : The point/node for comparison
 * @param target_shape : The show for comparison
 *
 * @return { boolean } : Boolean variable representing whether the point is
 *                       inside the shape.
 */
public static boolean point_inside_simple_shape( Node vertex_node, Shape target_shape ) {

        boolean output = false;

        // What to do if Circle shape.
        if (target_shape instanceof Circle){

                // Point must be within radius only.
                if (target_shape.get_radius() > Node.distance_between_nodes(vertex_node,
                                                                target_shape.get_primary_node())) {
                        output = true;
                } // end internal IF
        } // end instanceof IF

        // What to do if NOT Circle shape.
        else {

                Node head_node = target_shape.get_head_point();

                // tracking variable : if NOT ~ 360 at the end, node is not inside
                float tracker  = ZERO;

                while( head_node.has_next() ) {

                        if ( head_node.is_edge_closed() ) {

                                tracker += Node.get_angle(vertex_node,
                                                          head_node,
                                                          head_node.get_next());
                        } // end internal IF

                        head_node = head_node.get_next();
                } // end WHILE

                Node top_node = target_shape.get_head_point();

                // Wrap around to front node.
                if ( head_node.is_edge_closed() ) {

                        tracker += Node.get_angle( vertex_node,
                                                   head_node,
                                                        top_node);
                } // end IF

                // If angle summation ~360 --> node is within the shape
                //
                //  This therom was originally grabbed from Wolfram Alpha's website
                //     I have since not been able to locate the function. If I can find
                //     another reference, I will supply it.
                //         ~ swann 2013-11-19
                //
                if ( tracker < TOP && tracker > BOTTOM ) {

                        output = true;
                }

        } // end ELSE

        return output;
} // end Collision.point_inside_simple_shape()


/**
 * Determines whether or not a point is within the bounds of a complex shape.
 *
 * @param vertex_node  : The point/node for comparison
 * @param target_shape : The show for comparison
 *
 * @return output      : Boolean variable representing whether the point is
 *                       inside the shape.
 */
public static boolean point_inside_complex_shape( Node vertex_node, Shape target_shape ) {

        boolean output = false;

        for (int i = ZERO ; i < target_shape.get_composite_list().size() ; i++ ) {
```

```
                if (Collision.point_inside_shape(vertex_node,
                                                 target_shape.get_composite_list().get(i))) {
                        output = true;
                }
        } // end FOR

        return output;
} // end Collision.point_inside_complex_shape()
```

module :: Item/Collision.java
test/design :: test_collision_30_01_00_collision_check
function :: Collision.check() && Collision.execute()
description :: design of the specific check determining whether or not different shape objects collide



test notes :: explores functionality determining whether different shapes collide

```
// Collision.collision_check()
//  --> Heterogeneous Test
@Test
public void test_collision_30_01_00_collision_check() {
        // The Setup
        // Simple Shapes
        Circle alpha      = new Circle(TEN,  FIVE, FIVE, FIVE);
        Circle beta        = new Circle(FIVE, FIVE, FIVE, TWO);
        Circle delta      = new Circle(-10,  -1,   -1,   ONE);
        Circle eta        = new Circle(-5,   -1,   -1,   ONE);
        Circle upsilon    = new Circle(-9,   ZERO, ZERO, ONE);
        Square gamma      = new Square(FIVE, ZERO, ZERO, EIGHT, EIGHT);
        Square theta      = new Square(-10,  ONE,  ONE,  TWO,   TWO);
        Square iota       = new Square(-5,   ONE,  ONE,  TWO,   TWO);
        Square omega      = new Square(ZERO, ZERO, ZERO, 20,    20);
        Square omega_p     = new Square(ZERO, ZERO, ZERO, 15,    15);
        Rectangle epsilon = new Rectangle(-7,  ZERO, ZERO, TWO, FOUR);
        // Complex Shapes
        Shape omicron     = new Shape(-9,   ZERO, ZERO);
        omicron.add_shape( upsilon );
        omicron.add_shape( epsilon );
        omicron.calculate_radius();
        assertEquals(omicron.get_radius(), Math.pow(17, A_HALF), A_HUNDREDTH);
        // Alpha Shape
        assertEquals(Collision.collision_check( alpha, alpha   ), false);
        assertEquals(Collision.collision_check( alpha, beta    ),  true);
        assertEquals(Collision.collision_check( alpha, gamma   ),  true);
        assertEquals(Collision.collision_check( alpha, delta   ), false);
        assertEquals(Collision.collision_check( alpha, eta     ), false);
        assertEquals(Collision.collision_check( alpha, upsilon ), false);
        assertEquals(Collision.collision_check( alpha, epsilon ), false);
        assertEquals(Collision.collision_check( alpha, iota    ), false);
        assertEquals(Collision.collision_check( alpha, theta   ), false);
        assertEquals(Collision.collision_check( alpha, omega   ),  true);
        assertEquals(Collision.collision_check( alpha, omega_p ),  true);
        // Beta Shape
        assertEquals(Collision.collision_check( beta, alpha   ),  true);
        assertEquals(Collision.collision_check( beta, beta    ), false);
        assertEquals(Collision.collision_check( beta, gamma   ),  true);
        assertEquals(Collision.collision_check( beta, delta   ), false);
        assertEquals(Collision.collision_check( beta, eta     ), false);
        assertEquals(Collision.collision_check( beta, upsilon ), false);
        assertEquals(Collision.collision_check( beta, epsilon ), false);
        assertEquals(Collision.collision_check( beta, iota    ), false);
        assertEquals(Collision.collision_check( beta, theta   ), false);
        assertEquals(Collision.collision_check( beta, omega   ),  true);
        assertEquals(Collision.collision_check( beta, omega_p ),  true);
        // Gamma Shape
        assertEquals(Collision.collision_check( gamma, alpha   ),  true);
        assertEquals(Collision.collision_check( gamma, beta    ),  true);
        assertEquals(Collision.collision_check( gamma, gamma   ), false);
        assertEquals(Collision.collision_check( gamma, delta   ), false);
        assertEquals(Collision.collision_check( gamma, eta     ), false);
        assertEquals(Collision.collision_check( gamma, upsilon ), false);
        assertEquals(Collision.collision_check( gamma, epsilon ), false);
        assertEquals(Collision.collision_check( gamma, iota    ), false);
        assertEquals(Collision.collision_check( gamma, theta   ), false);
        assertEquals(Collision.collision_check( gamma, omega   ),  true);
        assertEquals(Collision.collision_check( gamma, omega_p ),  true);
        // Delta Shape
        assertEquals(Collision.collision_check( delta, alpha   ), false);
        assertEquals(Collision.collision_check( delta, beta    ), false);
        assertEquals(Collision.collision_check( delta, gamma   ), false);
        assertEquals(Collision.collision_check( delta, delta   ), false);
        assertEquals(Collision.collision_check( delta, eta     ), false);
        assertEquals(Collision.collision_check( delta, upsilon ),  true);
        assertEquals(Collision.collision_check( delta, epsilon ), false);
        assertEquals(Collision.collision_check( delta, iota    ), false);
        assertEquals(Collision.collision_check( delta, theta   ),  true);
        assertEquals(Collision.collision_check( delta, omega   ),  true);
        assertEquals(Collision.collision_check( delta, omega_p ), false);
        // Eta Shape
        assertEquals(Collision.collision_check( eta, alpha   ), false);
        assertEquals(Collision.collision_check( eta, beta    ), false);
        assertEquals(Collision.collision_check( eta, gamma   ), false);
        assertEquals(Collision.collision_check( eta, delta   ), false);
        assertEquals(Collision.collision_check( eta, eta     ), false);
        assertEquals(Collision.collision_check( eta, upsilon ), false);
        assertEquals(Collision.collision_check( eta, epsilon ),  true);
        assertEquals(Collision.collision_check( eta, iota    ),  true);
        assertEquals(Collision.collision_check( eta, theta   ), false);
        assertEquals(Collision.collision_check( eta, omega   ),  true);
        assertEquals(Collision.collision_check( eta, omega_p ),  true);
        // Iota Shape
        assertEquals(Collision.collision_check( iota, alpha   ), false);
        assertEquals(Collision.collision_check( iota, beta    ), false);
        assertEquals(Collision.collision_check( iota, gamma   ), false);
```

```
        assertEquals(Collision.collision_check( iota, delta   ), false);
        assertEquals(Collision.collision_check( iota, eta     ),  true);
        assertEquals(Collision.collision_check( iota, upsilon ), false);
        assertEquals(Collision.collision_check( iota, epsilon ),  true);
        assertEquals(Collision.collision_check( iota, iota    ), false);
        assertEquals(Collision.collision_check( iota, theta   ), false);
        assertEquals(Collision.collision_check( iota, omega   ),  true);
        assertEquals(Collision.collision_check( iota, omega_p ),  true);
        // Theta Shape
        assertEquals(Collision.collision_check( theta, alpha   ), false);
        assertEquals(Collision.collision_check( theta, beta    ), false);
        assertEquals(Collision.collision_check( theta, gamma   ), false);
        assertEquals(Collision.collision_check( theta, delta   ),  true);
        assertEquals(Collision.collision_check( theta, eta     ), false);
        assertEquals(Collision.collision_check( theta, upsilon ),  true);
        assertEquals(Collision.collision_check( theta, epsilon ),  true);
        assertEquals(Collision.collision_check( theta, iota    ), false);
        assertEquals(Collision.collision_check( theta, theta   ), false);
        assertEquals(Collision.collision_check( theta, omega   ),  true);
        assertEquals(Collision.collision_check( theta, omega_p ), false);
        // Upsilon Shape
        assertEquals(Collision.collision_check( upsilon, alpha   ), false);
        assertEquals(Collision.collision_check( upsilon, beta    ), false);
        assertEquals(Collision.collision_check( upsilon, gamma   ), false);
        assertEquals(Collision.collision_check( upsilon, delta   ),  true);
        assertEquals(Collision.collision_check( upsilon, eta     ), false);
        assertEquals(Collision.collision_check( upsilon, upsilon ), false);
        assertEquals(Collision.collision_check( upsilon, epsilon ),  true);
        assertEquals(Collision.collision_check( upsilon, iota    ), false);
        assertEquals(Collision.collision_check( upsilon, theta   ),  true);
        assertEquals(Collision.collision_check( upsilon, omega   ),  true);
        assertEquals(Collision.collision_check( upsilon, omega_p ), false);
        // Epsilon Shape
        assertEquals(Collision.collision_check( epsilon, alpha   ), false);
        assertEquals(Collision.collision_check( epsilon, beta    ), false);
        assertEquals(Collision.collision_check( epsilon, gamma   ), false);
        assertEquals(Collision.collision_check( epsilon, delta   ), false);
        assertEquals(Collision.collision_check( epsilon, eta     ),  true);
        assertEquals(Collision.collision_check( epsilon, upsilon ),  true);
        assertEquals(Collision.collision_check( epsilon, epsilon ), false);
        assertEquals(Collision.collision_check( epsilon, iota    ),  true);
        assertEquals(Collision.collision_check( epsilon, theta   ),  true);
        assertEquals(Collision.collision_check( epsilon, omega   ),  true);
        assertEquals(Collision.collision_check( epsilon, omega_p ),  true);
        // Omicron Shape --> Forward
        assertEquals(Collision.collision_check( omicron, alpha   ), false);
        assertEquals(Collision.collision_check( omicron, beta    ), false);
        assertEquals(Collision.collision_check( omicron, gamma   ), false);
        assertEquals(Collision.collision_check( omicron, delta   ),  true);
        assertEquals(Collision.collision_check( omicron, eta     ),  true);
        assertEquals(Collision.collision_check( omicron, iota    ),  true);
        assertEquals(Collision.collision_check( omicron, theta   ),  true);
        assertEquals(Collision.collision_check( omicron, omega   ),  true);
        assertEquals(Collision.collision_check( omicron, omega_p ),  true);
        // Omicron Shape --> Backward
        assertEquals(Collision.collision_check( alpha,   omicron ), false);
        assertEquals(Collision.collision_check( beta ,   omicron ), false);
        assertEquals(Collision.collision_check( gamma,   omicron ), false);
        assertEquals(Collision.collision_check( delta,   omicron ),  true);
        assertEquals(Collision.collision_check( eta,     omicron ),  true);
        assertEquals(Collision.collision_check( iota,    omicron ),  true);
        assertEquals(Collision.collision_check( theta,   omicron ),  true);
        assertEquals(Collision.collision_check( omega,   omicron ),  true);
        assertEquals(Collision.collision_check( omega_p, omicron ),  true);
}
```

Fuction notes :: implementation of primary and support logic for `execute()` and `check()`

```
/**
 * This function controls the routing logic as to which version of the execute functions
 * ought be called. A set of size two can use a simple update mechanism. A set of larger
 * sizes requires a more complex method.
 */
public void execute( ) throws CloneNotSupportedException, RuntimeException {

        // A working set is needed.

        ArrayList<Actor_Object> working_set;

        // While there are more collision sets to execute.

        while ( this.flagged_object_list.size() > ZERO ){

                working_set = dequeue_set();

                // Shouldn't have a set of size zero

                if ( working_set.size() == ZERO ) {
```

```
                        throw new RuntimeException("working set size is ZERO, too low for processing a COLLISION");
                }

                // Shouldn't have a set of size one

                else if ( working_set.size() == ONE ) {

                        throw new RuntimeException("working set size is ONE, too low for processing a COLLISION");
                }

                // For size two, use the simpler calculation method

                else if ( working_set.size() == TWO ) {

                        this.execute_collision_size_two(  working_set );
                }

                // For size three or larger, use the more complex method

                else {

                        this.execute_collision_size_n( working_set );
                } // end IF-ELSE Chain
        } // end while connected to this.flagged_object_list

} // end Collision.execute()


/**
 * This function handles the execution of a collision event on a pair of objects.
 *
 * @param set : ArrayList of two Actor_Objects
 */
public void execute_collision_size_two( ArrayList<Actor_Object> set ) throws CloneNotSupportedException,
RuntimeException {

        Iterator<Actor_Object> working_set_iterator = set.iterator();

        // Get the two Actor_Objects for this collision.

        Actor_Object actor_one;
        Actor_Object actor_two;

        // Initialize both to the first to allow 2-at-a-time iteration.

        actor_one = actor_two = working_set_iterator.next();

        while ( working_set_iterator.hasNext() ){

                // Pull the new actor from the working set.

                actor_one = actor_two;
                actor_two = working_set_iterator.next();

                Vector[] vector_list = this.execute_collision_support(actor_one, actor_two, actor_one.get_mass() +
actor_two.get_mass());

                Vector new_a = Vector.add(new Vector(actor_one.get_velocity()), vector_list[ZERO]);
                Vector new_b = Vector.add(new Vector(actor_two.get_velocity()), vector_list[ONE]);

                // Update each actor with the adjusted velocities.

                actor_one.update_velocity(new_a.get_x_comp(), new_a.get_y_comp(), new_a.get_z_comp());
                actor_two.update_velocity(new_b.get_x_comp(), new_b.get_y_comp(), new_b.get_z_comp());

                // Calculate the popout distance between the two objects.

                float diff = actor_one.get_shape().get_radius() +
                                        actor_two.get_shape().get_radius() -
                                        Node.distance_between_nodes( actor_one.get_shape().get_primary_node(),

        actor_two.get_shape().get_primary_node() );

                Vector a_pos = new Vector(actor_one.get_location());
                Vector b_pos = new Vector(actor_two.get_location());

                // Calculate the ratio of the diff distance which should be applied to each object.

                float diff_one = diff * (actor_one.get_shape().get_radius() / (
                                        actor_one.get_shape().get_radius() +
                                        actor_two.get_shape().get_radius()));

                float diff_two = diff * (actor_two.get_shape().get_radius() / (
                                        actor_one.get_shape().get_radius() +
                                        actor_two.get_shape().get_radius()));

                // Calculate the normal of impact for this collision (Normal vector for collision plane).

                Vector norm_of_impact = Vector.normalize(Vector.subtract(b_pos, a_pos));
```

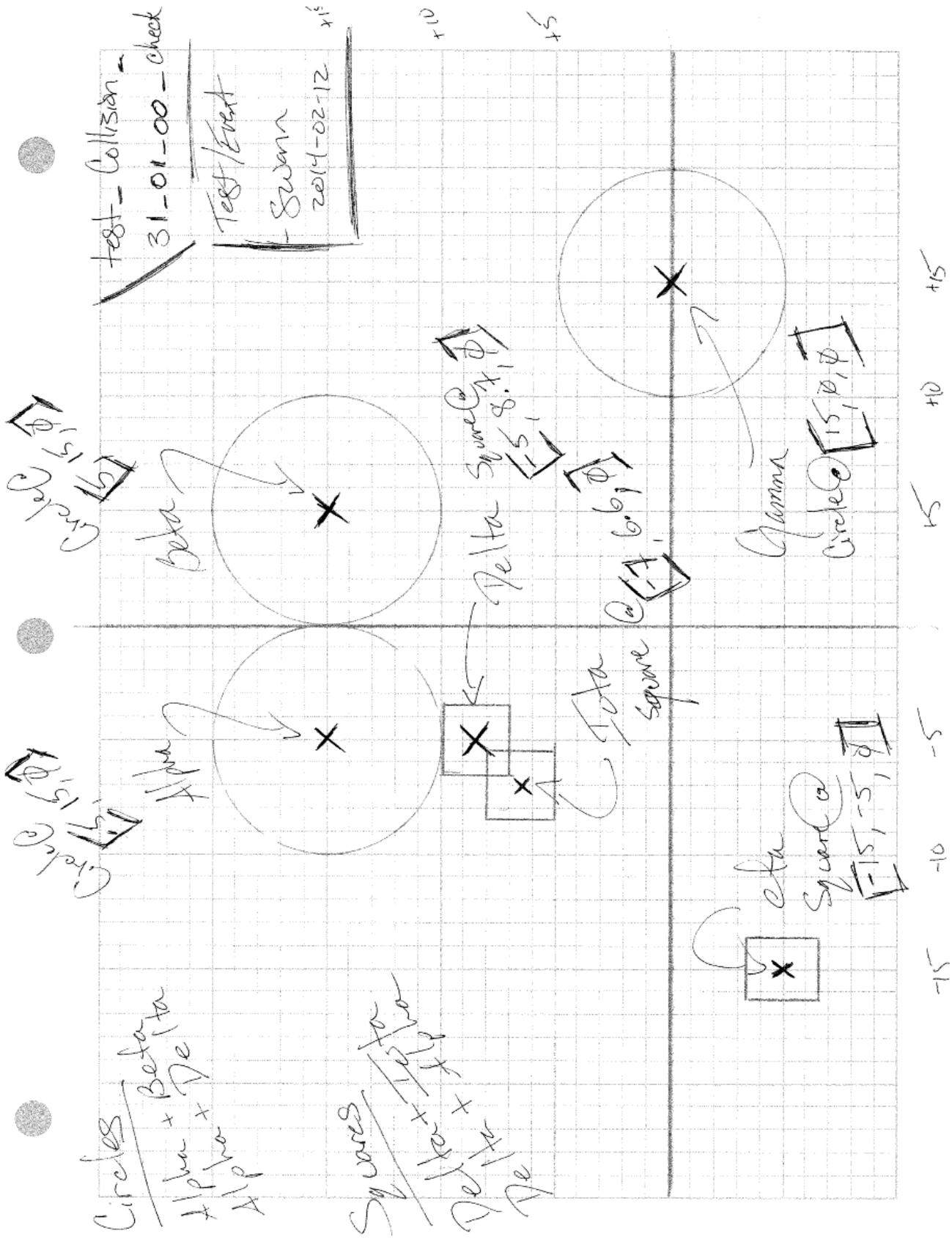
```
                        a_pos = Vector.add(a_pos, Vector.scalar_multiply(norm_of_impact, -diff_one));
                        b_pos = Vector.add(b_pos, Vector.scalar_multiply(norm_of_impact, diff_two));

                        actor_one.update_location(a_pos.get_x_comp(), a_pos.get_y_comp(), a_pos.get_z_comp());
                        actor_two.update_location(b_pos.get_x_comp(), b_pos.get_y_comp(), b_pos.get_z_comp());


                } // end while

        } // end Collision.execute_collision_size_two()


        /**
         * This function handles the execution of a collision event on a number of objects
         * greater than two.
         *
         * @param set : ArrayList of three or more Actor_Objects
         */
        public void execute_collision_size_n( ArrayList<Actor_Object> set )
                                        throws CloneNotSupportedException, RuntimeException {

                // Working object memory reservations
                Actor_Object   first_object, second_object;

                Vector[] vector_list;

                // Make a clone copy
                ArrayList<Actor_Object> copied_set = Event_Interaction.clone_list( set );

                float total_mass = ZERO;

                for ( int i = ZERO ; i < set.size() ; i++ ){

                        total_mass += set.get(i).get_mass();
                }

                // External loop
                for ( int i = ZERO ; i <= set.size() - TWO ; i++ ) {

                        first_object = set.get(i);

                        // Internal loop
                        for ( int j = i + ONE ; j <= set.size() - ONE ; j++ ) {

                                second_object = set.get(j);

                                float[] a = first_object.get_velocity();
                                float[] b = second_object.get_velocity();

                                vector_list = this.execute_collision_support(first_object, second_object, total_mass);

                                Actor_Object first_objectx  = copied_set.get(i);
                                Actor_Object second_objectx = copied_set.get(j);

                                a = first_objectx.get_velocity();
                                b = second_objectx.get_velocity();

                                Vector new_a = Vector.add(new Vector(first_objectx.get_velocity()), vector_list[ZERO]);
                                Vector new_b = Vector.add(new Vector(second_objectx.get_velocity()), vector_list[ONE]);

                                // Update each actor with the adjusted velocities.

                                first_objectx.update_velocity(new_a.get_x_comp(), new_a.get_y_comp(), new_a.get_z_comp());
                                second_objectx.update_velocity(new_b.get_x_comp(), new_b.get_y_comp(), new_b.get_z_comp());

                        } // end internal loop

                } // end external loop

                // Unpacking the clone
                for ( int i = ZERO ; i < set.size() ; i++ ){

                        Actor_Object the_obj     = set.get(i);
                        Actor_Object updated_obj = copied_set.get(i);

                        //Vector v = Vector.scalar_multiply(new Vector(updated_obj.get_velocity()), the_obj.get_mass() /
total_mass );

                        Vector v = new Vector(updated_obj.get_velocity());

                        the_obj.update_velocity(v.get_x_comp(), v.get_y_comp(), v.get_z_comp());
                } // end for loop

        } // end Collision.execute_collision_size_n()


        /**
         * This function handles the execution of a collision event on a number of objects
         * greater than two.
         *
```

```
         * @param alpha : First of two Actor_Objects
         * @param beta  : Second of two Actor_Objects
         *
         * @return {Vector[] } : Array of two Vector Adjustments
         */
        public Vector[] execute_collision_support( Actor_Object alpha, Actor_Object beta, float total_mass )
                                                        throws CloneNotSupportedException, RuntimeException {

                Actor_Object actor_one = (Actor_Object)alpha.clone();
                Actor_Object actor_two = (Actor_Object) beta.clone();
                // Get the actors' locations as vectors.

                Vector a_pos = new Vector(actor_one.get_location());
                Vector b_pos = new Vector(actor_two.get_location());

                // Calculate the normal of impact for this collision (Normal vector for collision plane).

                Vector norm_of_impact = Vector.normalize(Vector.subtract(b_pos, a_pos));

                // Get the actors' velocities as vectors.

                Vector a_vel = new Vector(actor_one.get_velocity());
                Vector b_vel = new Vector(actor_two.get_velocity());

                // Calculate the relative velocity between the two actors.

                Vector relative_velocity = Vector.subtract(b_vel, a_vel);

                // Get the magnitude of the relative velocity along the collision normal.

                float relative_velocity_along_normal = Vector.dot_product(relative_velocity, norm_of_impact);

                // Find the lower coefficient of restitution (elasticity)

                float coeff_of_restitution = Math.min(actor_one.get_coefficient_of_restitution(),
actor_two.get_coefficient_of_restitution());

                // Calculate the impulse magnitude.

                float impulse_scalar = -(1+coeff_of_restitution) * relative_velocity_along_normal;
                impulse_scalar = impulse_scalar / (1/actor_one.get_mass() + 1/actor_two.get_mass());

                // Scale the normal of collision by the impulse magnitude.

                Vector impulse_along_normal = Vector.scalar_multiply(norm_of_impact, impulse_scalar);

                // Using mass ratios (to conserve mass / energy in the system), calculate the velocity adjustments for each
actor.

                Vector a_adjust = Vector.scalar_multiply(impulse_along_normal, -1/actor_one.get_mass());
                Vector b_adjust = Vector.scalar_multiply(impulse_along_normal, +1/actor_two.get_mass());

                Vector[] vector_list = new Vector[TWO];

                vector_list[ZERO] = a_adjust;
                vector_list[ONE]  = b_adjust;

                return vector_list;
        } // end Collision.execute_collision_support()


        /**
         * Checks each object within the sim-space and determines if a boundary
         *
         * @param list_of_objects : All interactive objects within the sim-space.
         *
         * @return { boolean }    : Representing whether or not something has an collision event.
         */
        public boolean check( ArrayList<Actor_Object> list_of_objects ) {

                ArrayList<Actor_Object> flex_list;

                boolean checked = false;

                for (int i = ZERO ; i < list_of_objects.size() ; i++) {

                        for (int j = i + ONE ; j < list_of_objects.size() ; j++) {

                                Actor_Object first_object  = list_of_objects.get(i);
                                Actor_Object second_object = list_of_objects.get(j);

                                // short circuit operation if non-interactive event
                                if ( first_object.get_interactive() == true &&
                                        second_object.get_interactive() == true) {

                                        if ( Collision.collision_check( first_object.get_shape(),

second_object.get_shape() )) {

                                                flex_list = new ArrayList<Actor_Object>();
```

```
                                        flex_list.add( first_object );
                                        flex_list.add(second_object );

                                        this.enqueue_set( flex_list );

                                        checked = true;
                                } // end IF

                        } // end interactive check

                } // end internal for-loop --> J var
        } // end external for-loop --> I var

        return checked;
} // end Collision.check()


/**
 * Ascertains whether a point exists within a given shape.
 *
 * @param vertex_node  : The point/node for comparison
 * @param target_shape : The show for comparison
 *
 * @return output      : Boolean variable representing whether the point is
 *                       inside the shape.
 */
public static boolean collision_check( Shape shape_one, Shape shape_two ) {

        boolean result = false;

        // Identity Check should end quickly
        if (shape_one == shape_two) {

                result = false;
        } // end short circuit

        // Circle vs Circle Check
        else if  (shape_one instanceof Circle && shape_two instanceof Circle) {

                result = Collision.boundary_sphere_incident( shape_one, shape_two );
        } // end IF

        else {

                // Checks boundary spheres. Only enters point by point check if a sphere
                // incident has taken place.
                if ( Collision.boundary_sphere_incident(shape_one, shape_two) ){

                        if (shape_one instanceof Circle) {

                                shape_one.set_head_node(shape_two);
                        }

                        if (shape_two instanceof Circle) {

                                shape_two.set_head_node(shape_one);
                        }

                        // START FORWARD CHECK
                        if ( ! shape_one.is_composite() ){

                                Node head_node = shape_one.get_head_point();

                                if ( Collision.point_inside_shape(head_node, shape_two) ) {

                                        result = true;
                                }

                                while ( result == false && head_node.has_next() ) {

                                        if ( Collision.point_inside_shape(head_node, shape_two) ) {

                                                result = true;
                                        }

                                        head_node = head_node.get_next();
                                }// end while
                        } // end if

                        else {

                                ArrayList<Shape> the_list = shape_one.get_composite_list();

                                for (int i = ZERO; i < the_list.size(); i++) {

                                        Node head_node = the_list.get(i).get_head_point();

                                        if ( Collision.point_inside_shape(head_node, shape_two) ) {

                                                result = true;
```

```
                                        }

                                        while ( result == false && head_node.has_next() ) {

                                                if ( Collision.point_inside_shape(head_node, shape_two) ) {

                                                        result = true;
                                                }

                                                head_node = head_node.get_next();
                                        }// end while
                                }// end for-loop
                        } // end else
                        // END FORWARD CHECK

                        // START REVERSE CHECK
                        if ( ! shape_two.is_composite() ){

                                Node head_node = shape_two.get_head_point();

                                if ( Collision.point_inside_shape(head_node, shape_one) ) {

                                        result = true;
                                }

                                while ( result == false && head_node.has_next() ) {

                                        if ( Collision.point_inside_shape(head_node, shape_one) ) {

                                                result = true;
                                        }

                                        head_node = head_node.get_next();
                                }// end while
                        } // end if

                        else {

                                ArrayList<Shape> the_list = shape_two.get_composite_list();

                                for (int i = ZERO; i < the_list.size(); i++) {

                                        Node head_node = the_list.get(i).get_head_point();

                                        if ( Collision.point_inside_shape(head_node, shape_one) ) {

                                                result = true;
                                        }

                                        while ( result == false && head_node.has_next() ) {

                                                if ( Collision.point_inside_shape(head_node, shape_one) ) {

                                                        result = true;
                                                }

                                                head_node = head_node.get_next();
                                        }// end while
                                } // end for-loop
                        } // end else
                        // END REVERSE CHECK

                } // end Boundary Sphere incident check
        } // end ELSE

        return result;
} // end Collision.collision_check()
```

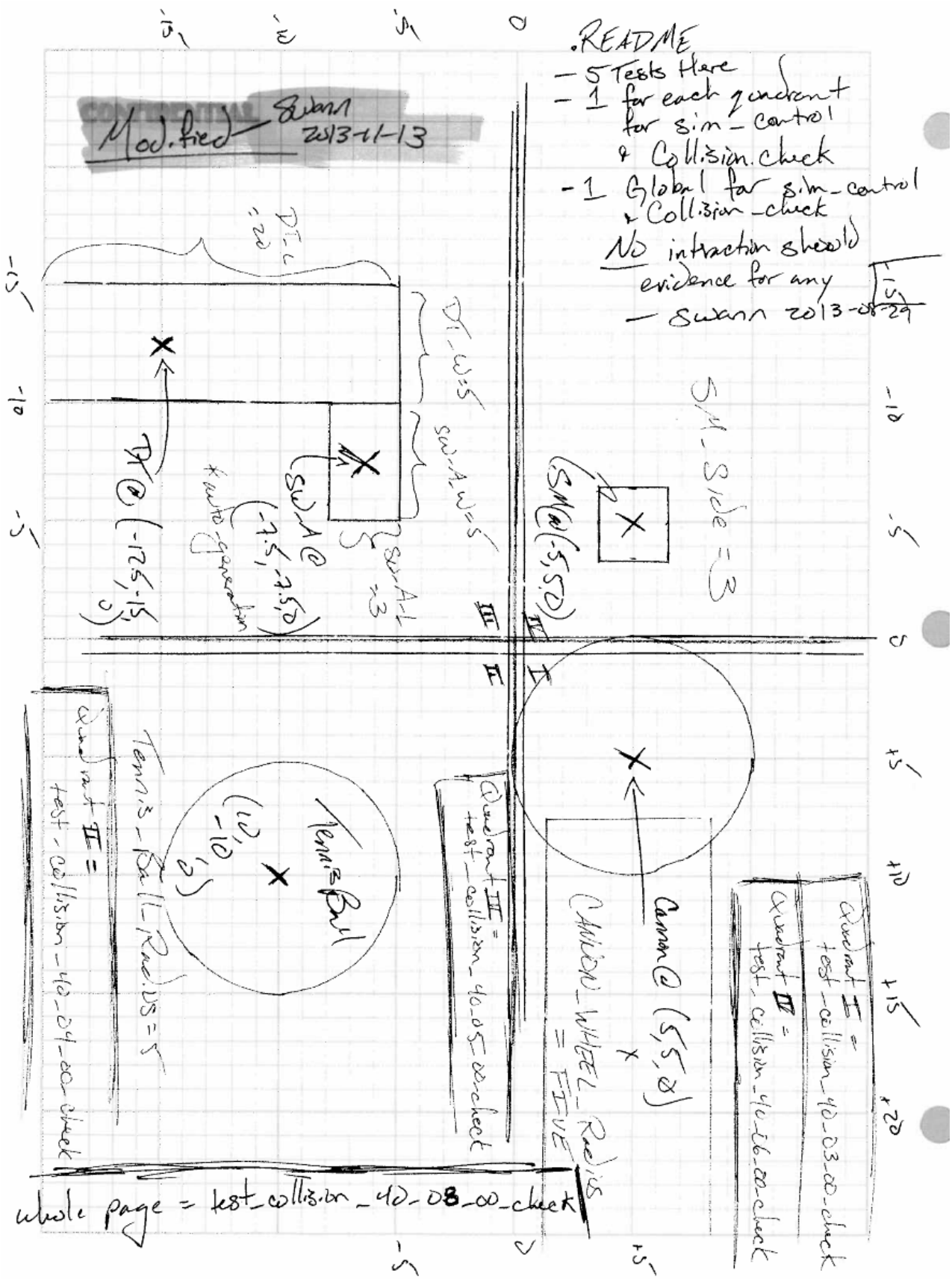
module :: Item/Collision.java
test/design :: test_collision_31_01_00_collision_check
description :: design of the specific check determining whether or not different shape objects collide



test notes :: explores functionality determining whether different shapes collide

```
	// Collision.collision_check()
	//  --> Heterogeneous Test
	@Test
	public void test_collision_31_01_00_collision_check() {
		// The Setup
		Circle Alpha    = new Circle( -5, 15, 0),
		       Beta     = new Circle(  5, 15, 0),
		       Gamma    = new Circle( 15,  0, 0);

		Square Delta    = new Square( -5, (float)8.7, 0, 3, 3),
		       Iota     = new Square( -7, (float)6.6, 0, 3, 3),
		       Eta      = new Square(-15,         -5, 0, 3, 3);

		// Alpha Checks
		assertEquals(Collision.collision_check( Alpha, Alpha ),  false);
		assertEquals(Collision.collision_check( Alpha, Beta  ),  false);
		assertEquals(Collision.collision_check( Alpha, Gamma ),  false);
		assertEquals(Collision.collision_check( Alpha, Delta ),  false);
		assertEquals(Collision.collision_check( Alpha, Iota  ),  false);
		assertEquals(Collision.collision_check( Alpha, Eta   ),  false);

		// Beta Checks
		assertEquals(Collision.collision_check( Beta,  Alpha ),  false);
		assertEquals(Collision.collision_check( Beta,  Beta  ),  false);
		assertEquals(Collision.collision_check( Beta,  Gamma ),  false);
		assertEquals(Collision.collision_check( Beta,  Delta ),  false);
		assertEquals(Collision.collision_check( Beta,  Iota  ),  false);
		assertEquals(Collision.collision_check( Beta,  Eta   ),  false);

		// Gamma Checks
		assertEquals(Collision.collision_check( Gamma, Alpha ),  false);
		assertEquals(Collision.collision_check( Gamma, Beta  ),  false);
		assertEquals(Collision.collision_check( Gamma, Gamma ),  false);
		assertEquals(Collision.collision_check( Gamma, Delta ),  false);
		assertEquals(Collision.collision_check( Gamma, Iota  ),  false);
		assertEquals(Collision.collision_check( Gamma, Eta   ),  false);

		// Delta Checks
		assertEquals(Collision.collision_check( Delta, Alpha ),  false);
		assertEquals(Collision.collision_check( Delta, Beta  ),  false);
		assertEquals(Collision.collision_check( Delta, Gamma ),  false);
		assertEquals(Collision.collision_check( Delta, Delta ),  false);
		assertEquals(Collision.collision_check( Delta, Iota  ),  true);
		assertEquals(Collision.collision_check( Delta, Eta   ),  false);

		// Iota Checks
		assertEquals(Collision.collision_check( Iota,  Alpha ),  false);
		assertEquals(Collision.collision_check( Iota,  Beta  ),  false);
		assertEquals(Collision.collision_check( Iota,  Gamma ),  false);
		assertEquals(Collision.collision_check( Iota,  Delta ),  true);
		assertEquals(Collision.collision_check( Iota,  Iota  ),  false);
		assertEquals(Collision.collision_check( Iota,  Eta   ),  false);

		// Eta Checks
		assertEquals(Collision.collision_check( Eta,   Alpha ),  false);
		assertEquals(Collision.collision_check( Eta,   Beta  ),  false);
		assertEquals(Collision.collision_check( Eta,   Gamma ),  false);
		assertEquals(Collision.collision_check( Eta,   Delta ),  false);
		assertEquals(Collision.collision_check( Eta,   Iota  ),  false);
		assertEquals(Collision.collision_check( Eta,   Eta   ),  false);
	}
```

module :: Item/Collision.java
test/design :: test_collision_40_(03-08)_00_collision_check
description :: design of the specific check determining whether or not different shape objects collide; single sets

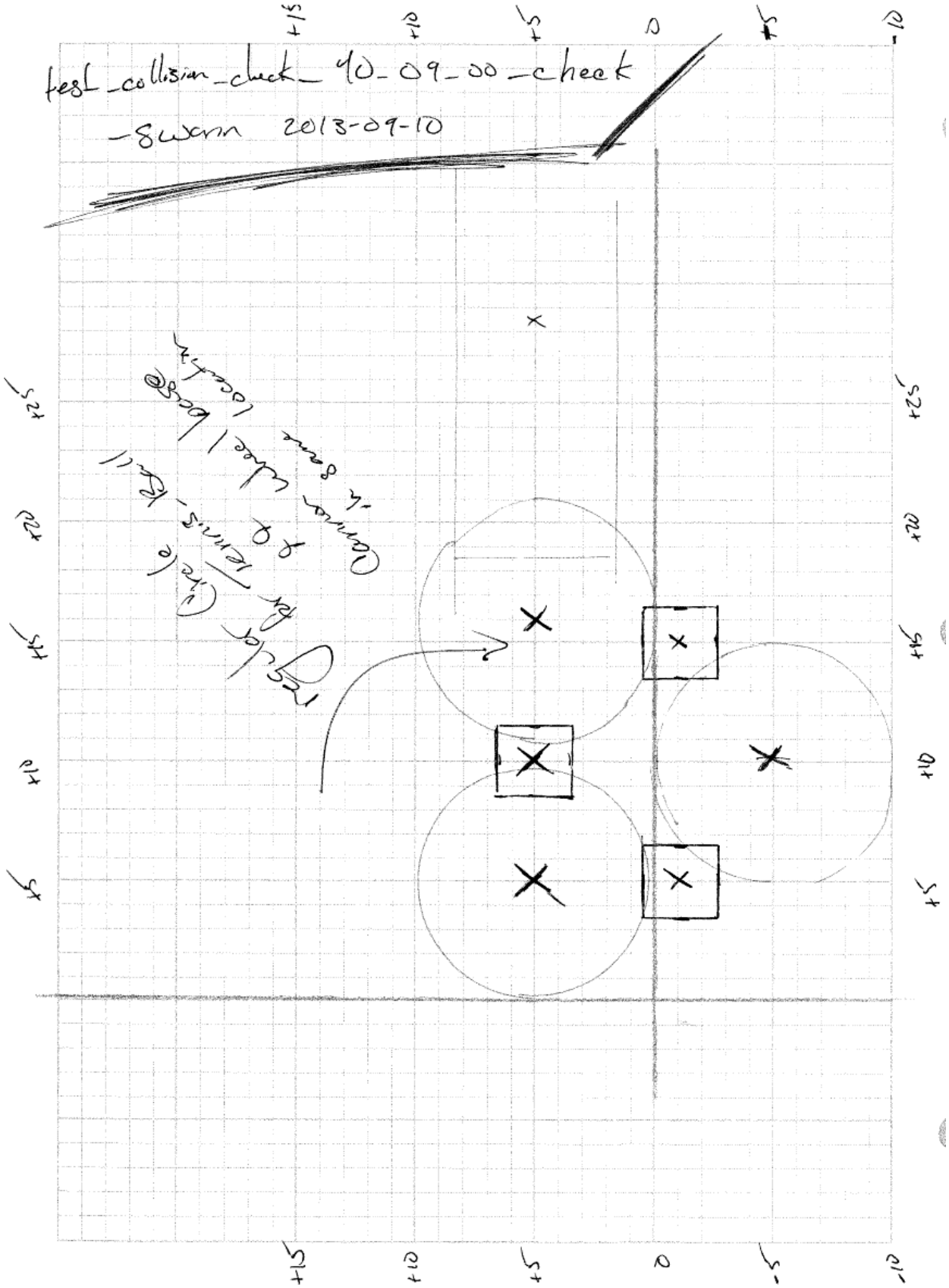


test notes :: explores functional validity of check algorithm against single sets of objects

```
	// Collision.check()
	@Test
	public void test_collision_40_03_00_check() {
		ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		// Quadrant One Test of related analog test design --> see notebook
		// ~swann, 2013-08-29

		test_list.add( new Cannon(FIVE, FIVE, ZERO) );
		assertEquals(test_list.size(), ONE, ZERO);

		collider.check(test_list);
		LinkedList<Actor_Object> THE_list = collider.get_list();

		assertEquals(ZERO, THE_list.size(), ZERO);
	}


	// Collision.check()
	@Test
	public void test_collision_40_04_00_check() {
		ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		// Quadrant Two Test of related analog test design --> see notebook
		// ~swann, 2013-08-29

		test_list.add( Ball.generate_Tennis_Ball(TEN, ZERO-TEN, ZERO) );
		assertEquals(test_list.size(), ONE, ZERO);

		collider.check(test_list);
		LinkedList<Actor_Object> THE_list = collider.get_list();

		assertEquals(ZERO, THE_list.size(), ZERO);
	}


	// Collision.check()
	@Test
	public void test_collision_40_05_00_check() {
		ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		// Quadrant Three Test of related analog test design --> see notebook
		// ~swann, 2013-08-29

		DropTower drop_tower = new DropTower((float) (ZERO-12.5), ZERO-15, ZERO);
		test_list.add( drop_tower );
		test_list.add( drop_tower.swing_arm_generation() );

		assertEquals(test_list.size(), TWO, ZERO);

		collider.check(test_list);
		LinkedList<Actor_Object> THE_list = collider.get_list();

		assertEquals(ZERO, THE_list.size(), ZERO);
	}


	// Collision.check()
	@Test
	public void test_collision_40_06_00_check() {
		ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		// Quadrant Four Test of related analog test design --> see notebook
		// ~swann, 2013-08-29

		test_list.add( Standard_Mass.generate_one_g_mass(ZERO-FIVE, FIVE, ZERO) );
		assertEquals(test_list.size(), ONE, ZERO);

		collider.check(test_list);
		LinkedList<Actor_Object> THE_list = collider.get_list();

		assertEquals(ZERO, THE_list.size(), ZERO);
	}


	// Collision.check()
	@Test
	public void test_collision_40_07_00_check() {
		//ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		// Undefined test number/test structure
		// ~swann, 2013-08-29
	}


	// Collision.check()
	@Test
```

```java
public void test_collision_40_08_00_check() {
        ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

        // ALL Quadrant Test of related analog test design --> see notebook
        // ~swann, 2013-08-29

        DropTower drop_tower = new DropTower((float) (ZERO-12.5), ZERO-15, ZERO);
        test_list.add( drop_tower );
        test_list.add( drop_tower.swing_arm_generation() );
        test_list.add( new Cannon(FIVE, FIVE, ZERO) );
        test_list.add( Standard_Mass.generate_one_g_mass(ZERO-FIVE, FIVE, ZERO) );
        test_list.add( Ball.generate_Tennis_Ball(TEN, ZERO-TEN, ZERO) );

        assertEquals(test_list.size(), FIVE, ZERO);

        collider.check(test_list);
        LinkedList<Actor_Object> THE_list = collider.get_list();

        // console feed of linked list internals.
        // save for now. ANALOG
        //   ~swann, 2013-11-13
        //
        // list has 3 elements, the mass, the ball and a NULL sentinel
        // cannons, swing_arms and drop_towers are ALL NON-interactive at this time
        for ( int i = ZERO ; i < THE_list.size() ; i++ ) {

                if ( THE_list.get(i) == null ) {

                        System.out.println( "null" );
                } else {

                        System.out.println( THE_list.get(i).toString() );
                }
        }
        assertEquals(THREE, THE_list.size(), ZERO);
} // test_collision_40_08_00_check
```

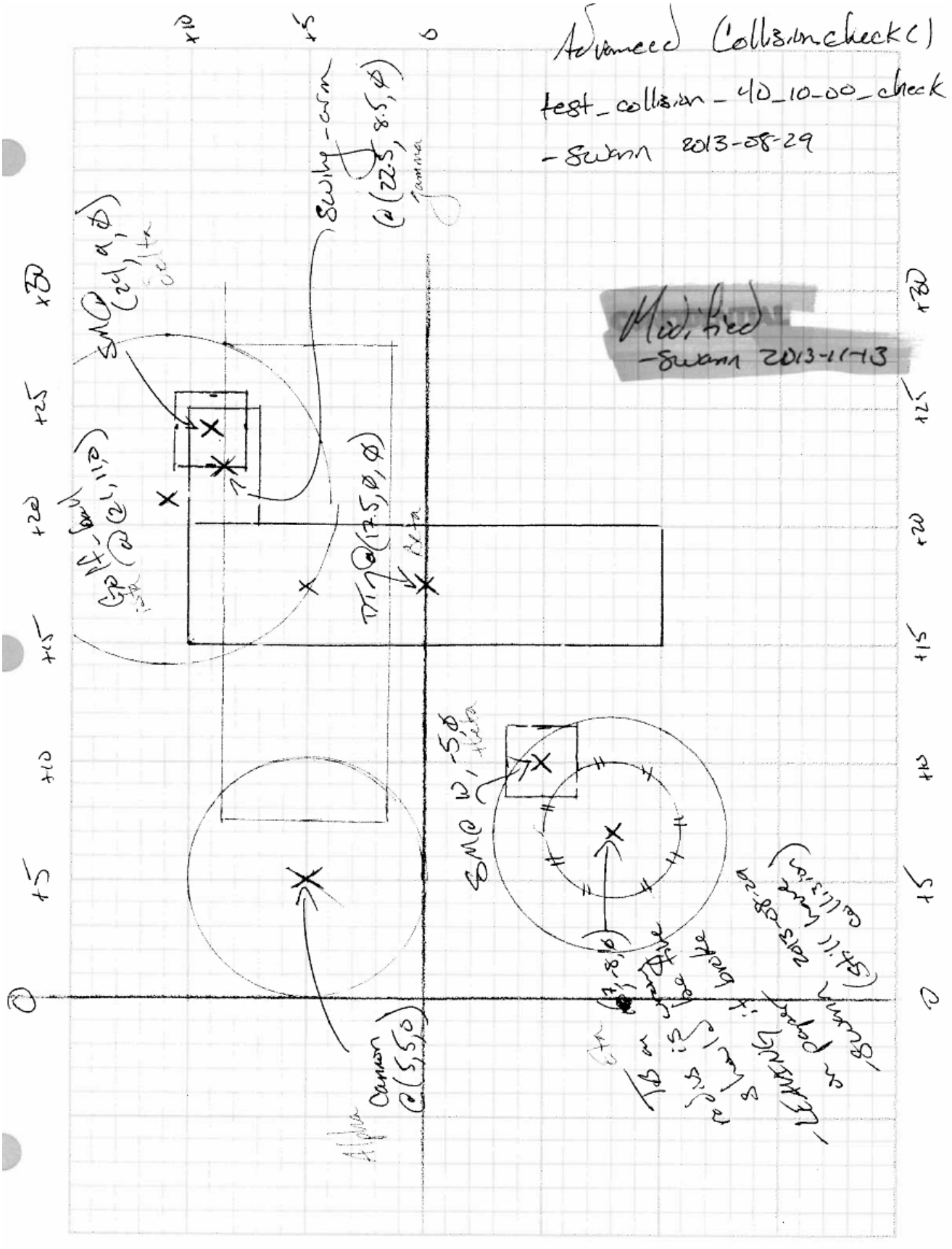
module :: Item/Collision.java
test/design :: test_collision_40_09_00_collision_check
description :: design of the first heterogenous shape collision check; testing functional validity of enqueue/dequeue



test notes :: heterogenous check on shape collisions; also a functional validity test on enqueue and dequeue

```
// Collision.check()
@Test
public void test_collision_40_09_00_check() {
        ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

        // Related to analog test design --> see notebook
        // ~swann, 2013-09-10

        test_list.add( Standard_Mass.generate_one_g_mass(TEN, FIVE, ZERO) );
        test_list.add( Standard_Mass.generate_one_g_mass(FIVE, NEGATIVE_ONE, ZERO) );
        test_list.add( Standard_Mass.generate_one_g_mass(TEN+FIVE, NEGATIVE_ONE, ZERO) );
        test_list.add( Ball.generate_Tennis_Ball(16, FIVE, ZERO) );
        test_list.add( Ball.generate_Tennis_Ball(FIVE, FIVE, ZERO) );
        test_list.add( Ball.generate_Tennis_Ball(TEN, ZERO-FIVE, ZERO) );
        test_list.add( new Cannon(16, FIVE, ZERO) );

        assertEquals(test_list.size(), SEVEN, ZERO);

        collider.check(test_list);
        LinkedList<Actor_Object> THE_list = collider.get_list();

        // 7 Objects, 1 Non-Interactive, 1 Sentinel = 7 total in list
        assertEquals(SEVEN, THE_list.size(), ZERO);
}
```

module :: Item/Collision.java
test/design :: test_collision_40_10_00_collision_check
description :: design of the first heterogenous interactivity collision check; testing functional validity of enqueue/dequeue



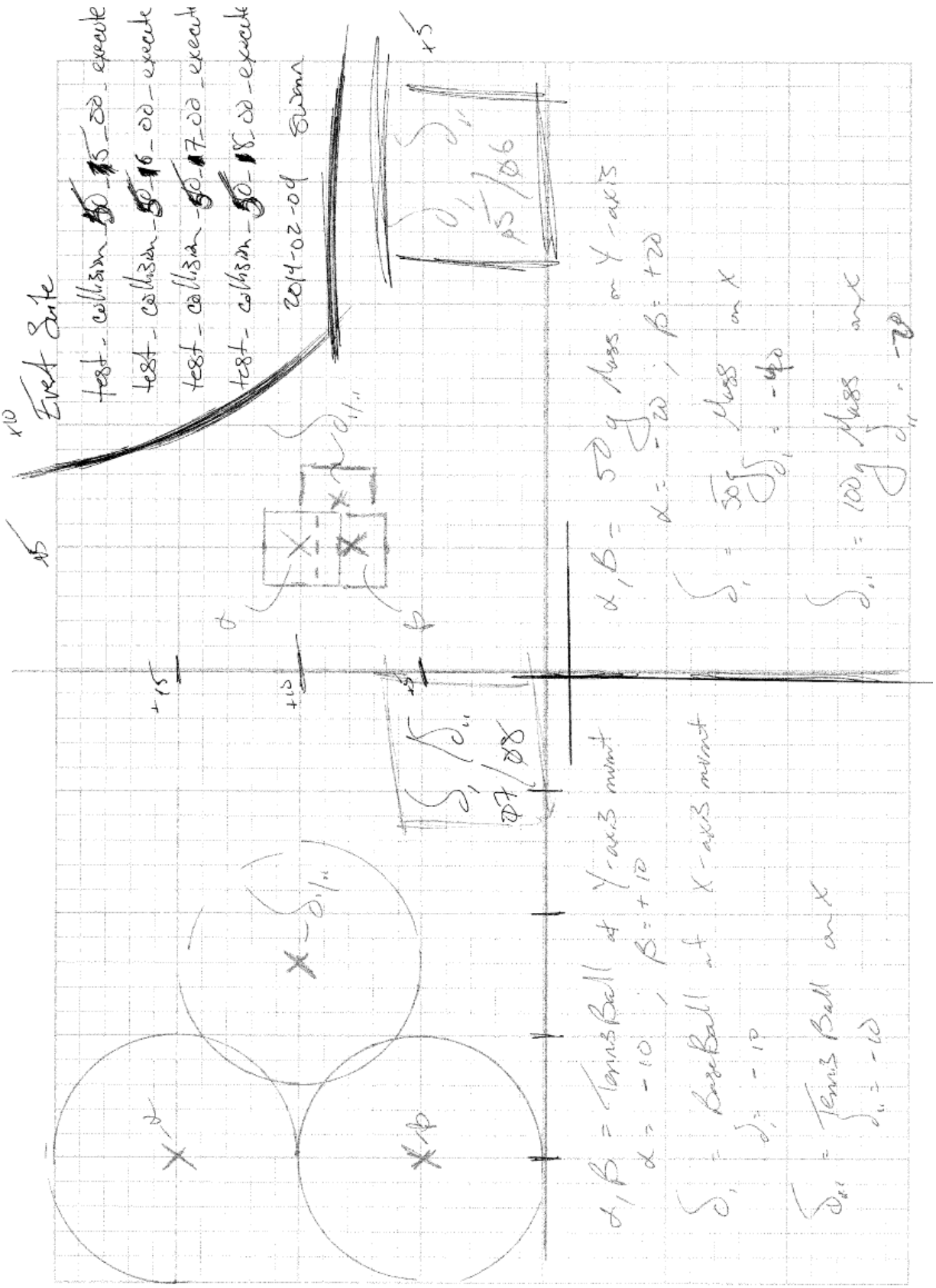
test notes :: heterogenous check on shape collisions; also a functional validity test on interactivity logic within enqueue and dequeue

```
// Collision.check()
@Test
public void test_collision_40_10_00_check() {
        ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

        // Related to analog test design --> see notebook
        // ~swann, 2013-08-29

        DropTower beta      = new DropTower((float) (17.5), ZERO, ZERO);
        SwingArm  gamma     = beta.swing_arm_generation();
        Standard_Mass delta = Standard_Mass.generate_one_g_mass(24, NINE, ZERO);
        Standard_Mass theta = Standard_Mass.generate_one_g_mass(TEN, ZERO-FIVE, ZERO);
        Cannon alpha        = new Cannon(FIVE, FIVE, ZERO);
        Ball eta            = Ball.generate_Tennis_Ball(SEVEN, ZERO-EIGHT, ZERO);
        Ball iota           = Ball.generate_Golf_Ball(21, 11, ZERO);

        // Battery One
        test_list.add( eta   );
        test_list.add( theta );
        assertEquals(test_list.size(), TWO, ZERO);

        collider.check(test_list);
        LinkedList<Actor_Object> THE_list = collider.get_list();

        // eta + beta + null = 3
        assertEquals(THREE, THE_list.size(), ZERO);

        // Battery Two
        test_list = new ArrayList<Actor_Object>();
        test_list.add( delta ); // Standard_Mass
        test_list.add( iota  ); // Ball
        test_list.add( eta   ); // Ball
        test_list.add( theta ); // Standard_Mass
        assertEquals(test_list.size(), FOUR, ZERO);

        collider.check(test_list);
        THE_list = collider.get_list();

        // ORIGINAL NOTATIONS
        //
        //   eta + beta + null = 3
        // delta + itoa + null = 3 ==> 6
        //
        // ---------------------------------------------
        // console feed of linked list internals.
        // save for now. ANALOG
        //   ~swann 2013-11-13
        //
        // list has 5 elements, after re-sizing, the collision sets
        // converge into ONE larger set. the size drops one because of the lost
        // of a flagged sentinel value
        //
        //   eta + beta + delta + itoa + null = 5
        //
        for ( int i = ZERO ; i < THE_list.size() ; i++ ) {

                if ( THE_list.get(i) == null ) {

                        System.out.println( "null" );
                } else {

                        System.out.println( THE_list.get(i).toString() );
                }
        }
        assertEquals(FIVE, THE_list.size(), ZERO);

        // Battery Three - part A
        //
        // ASSUMES SWING ARM NEVER INTERACTIVE
        // ASSUMES CANNON NEVER INTERACTIVE
        test_list = new ArrayList<Actor_Object>();
        test_list.add( alpha ); // Cannon
        test_list.add( beta  ); // DropTower
        test_list.add( gamma ); // SwingArm
        test_list.add( delta ); // Standard_Mass
        test_list.add( iota  ); // Ball
        test_list.add( eta   ); // Ball
        test_list.add( theta ); // Standard_Mass
        assertEquals(test_list.size(), SEVEN, ZERO);

        collider.check(test_list);
        THE_list = collider.get_list();
        collider.clean_list();

        // ORIGINAL NOTATIONS
```

```
//
//   eta + beta + null = 3
// delta + itoa + gamma + null = 4 ==> 7
//
// ---------------------------------------------
// console feed of linked list internals.
// save for now. ANALOG
//   ~swann 2013-11-03
//
// list has 5 elements, after re-sizing, the collision sets
// converge into ONE larger set. the size drops one because of the lost
// of a flagged sentinel value
//
System.out.println("----Battery Three A---------");
for ( int i = ZERO ; i < THE_list.size() ; i++ ) {

        if ( THE_list.get(i) == null ) {

                System.out.println( "null" );
        } else {

                System.out.println( THE_list.get(i).toString() );
        }
}
assertEquals(FIVE, THE_list.size(), ZERO);


// Battery Three - part B
//
// ASSUMES SWING ARM CAN MAYBE BE INTERACTIVE
// ASSUMES CANNON NEVER INTERACTIVE
test_list = new ArrayList<Actor_Object>();
gamma.set_interactive(true);
assertEquals(gamma.get_interactive(), true);
test_list.add( alpha ); // Cannon
test_list.add( beta  ); // DropTower
test_list.add( gamma ); // SwingArm
test_list.add( delta ); // Standard_Mass
test_list.add( iota  ); // Ball
test_list.add( eta   ); // Ball
test_list.add( theta ); // Standard_Mass
assertEquals(test_list.size(), SEVEN, ZERO);

collider.check(test_list);
THE_list = collider.get_list();
collider.clean_list();

//   eta + beta + null = 3
// delta + itoa + null = 3 ==> 6
System.out.println("----Battery Three B---------");
for ( int i = ZERO ; i < THE_list.size() ; i++ ) {

        if ( THE_list.get(i) == null ) {

                System.out.println( "null" );
        } else {

                System.out.println( THE_list.get(i).toString() );
        }
}
assertEquals(SIX, THE_list.size(), ZERO);

// Battery Four
//
//
// ANALOG
// Bug found here from analog test design.
// SwingArm.Swing() appearing to mis-behave.
// Isolated and vixed via <Event_Interaction>.clean_list() installation
// ~swann 2013-09-10
//
test_list = new ArrayList<Actor_Object>();
gamma.swing();
assertEquals(gamma.get_interactive(), false);
test_list.add( alpha ); // Cannon
test_list.add( beta  ); // DropTower
test_list.add( gamma ); // SwingArm
test_list.add( delta ); // Standard_Mass
test_list.add( iota  ); // Ball
test_list.add( eta   ); // Ball
test_list.add( theta ); // Standard_Mass
assertEquals(test_list.size(), SEVEN, ZERO);

collider.check(test_list);
THE_list = collider.get_list();
collider.clean_list();

//   eta + beta + null = 3
// delta + itoa + null = 3 ==> 6
// -------------------------------------
```

```
        //   eta + beta + delta + itoa + null = 5
        // Changes made to reflect the above on 2013-11-13
        System.out.println("----Battery Four---------");
        for ( int i = ZERO ; i < THE_list.size() ; i++ ) {

                if ( THE_list.get(i) == null ) {

                        System.out.println( "null" );
                } else {

                        System.out.println( THE_list.get(i).toString() );
                }
        }
        assertEquals(FIVE, THE_list.size(), ZERO);
} // test_collision_40_10_00_check
```

module :: Item/Collision.java
test/design :: test_collision_50_(05-08)_00_ execute
description :: design of the first heterogenous shape collision execution with calculated velocity vectors

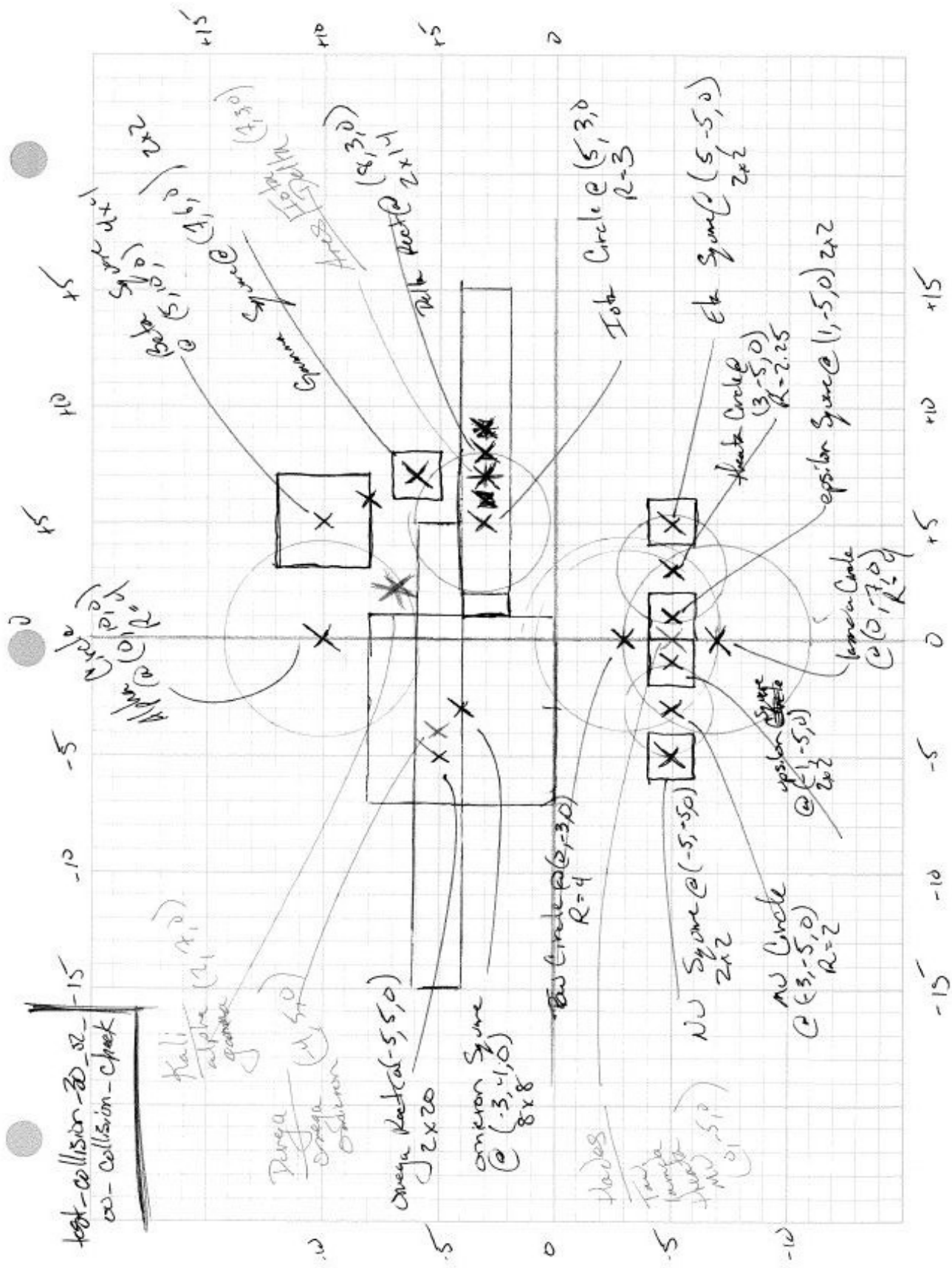


test notes :: heterogenous check on shape collisions related to the mathematics of calculating velocity vectors; new vector values pushed to screen output in this version of the test for manual floating point analysis

```
	// Collision.execute()
	@Test
	public void test_collision_50_05_00_execute() throws CloneNotSupportedException{
		// The Setup
		ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, TEN,   ZERO);
		alpha.update_velocity(ZERO, -20, ZERO);

		Standard_Mass beta  = Standard_Mass.generate_fifty_g_mass(FIVE, EIGHT, ZERO);
		beta.update_velocity(ZERO,  20, ZERO);

		Standard_Mass delta = Standard_Mass.generate_fifty_g_mass(SEVEN, NINE, ZERO);
		delta.update_velocity(-40, ZERO, ZERO);

		test_list.add(alpha);
		test_list.add( beta);
		test_list.add(delta);

		assertEquals(test_list.size(), THREE, ZERO);

		collider.clean_list();

		// Battery
		collider.check(test_list);
		LinkedList<Actor_Object> THE_list = collider.get_list();

		assertEquals(FOUR, THE_list.size(), ZERO);
		assertEquals(alpha, THE_list.get(ZERO));
		assertEquals(beta,  THE_list.get(ONE));
		assertEquals(delta, THE_list.get(TWO));
		assertEquals(null,  THE_list.get(THREE));

		// execute
		collider.execute();
	} // test_collision_50_05_00_execute

	// Collision.execute()
	@Test
	public void test_collision_50_06_00_execute() throws CloneNotSupportedException {
		// The Setup
		ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		Standard_Mass alpha = Standard_Mass.generate_fifty_g_mass(FIVE, TEN,   ZERO);
		alpha.update_velocity(ZERO, -20, ZERO);

		Standard_Mass beta  = Standard_Mass.generate_fifty_g_mass(FIVE, EIGHT, ZERO);
		beta.update_velocity(ZERO,  20, ZERO);

		Standard_Mass delta = Standard_Mass.generate_one_hundred_g_mass(SEVEN, NINE, ZERO);
		delta.update_velocity(-20, ZERO, ZERO);

		test_list.add(alpha);
		test_list.add( beta);
		test_list.add(delta);

		assertEquals(test_list.size(), THREE, ZERO);

		collider.clean_list();

		// Battery
		collider.check(test_list);
		LinkedList<Actor_Object> THE_list = collider.get_list();

		assertEquals(FOUR, THE_list.size(), ZERO);
		assertEquals(alpha, THE_list.get(ZERO));
		assertEquals(beta,  THE_list.get(ONE));
		assertEquals(delta, THE_list.get(TWO));
		assertEquals(null,  THE_list.get(THREE));

		// execute
		collider.execute();
	} //test_collision_50_06_00_execute


	// Collision.execute()
	@Test
	public void test_collision_50_07_00_execute() throws CloneNotSupportedException{
		// The Setup
		ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

		Ball alpha = Ball.generate_Tennis_Ball(-200, 50,   ZERO);
		alpha.update_velocity(ZERO, -10, ZERO);

		Ball beta  = Ball.generate_Tennis_Ball(-200, 149, ZERO);
		beta.update_velocity(ZERO,  10, ZERO);
```

```
        Ball delta = Ball.generate_Baseball(-140, (float) 99.5, ZERO);
        delta.update_velocity(-140, (float) 99.5, ZERO);

        test_list.add(alpha);
        test_list.add( beta);
        test_list.add(delta);

        assertEquals(test_list.size(), THREE, ZERO);

        collider.clean_list();

        // Battery
        collider.check(test_list);
        LinkedList<Actor_Object> THE_list = collider.get_list();

        assertEquals(FOUR, THE_list.size(), ZERO);
        assertEquals(alpha, THE_list.get(ZERO));
        assertEquals(beta,  THE_list.get(ONE));
        assertEquals(delta, THE_list.get(TWO));
        assertEquals(null,  THE_list.get(THREE));

        // execute
        collider.execute();
} // test_collision_50_07_00_execute


// Collision.execute()
@Test
public void test_collision_50_08_00_execute() throws CloneNotSupportedException {
        // The Setup
        ArrayList<Actor_Object> test_list = new ArrayList<Actor_Object>();

        Ball alpha = Ball.generate_Tennis_Ball(-200, 149,   ZERO);
        alpha.update_velocity(ZERO, -10, ZERO);

        Ball beta  = Ball.generate_Tennis_Ball(-200, 50, ZERO);
        beta.update_velocity(ZERO,  10, ZERO);

        Ball delta = Ball.generate_Tennis_Ball(-140, (float) 99.5, ZERO);
        delta.update_velocity(-10, ZERO, ZERO);

        test_list.add(alpha);
        test_list.add( beta);
        test_list.add(delta);

        assertEquals(test_list.size(), THREE, ZERO);

        // Battery
        collider.check(test_list);
        LinkedList<Actor_Object> THE_list = collider.get_list();

        assertEquals(FOUR, THE_list.size(), ZERO);
        assertEquals(alpha, THE_list.get(ZERO));
        assertEquals(beta,  THE_list.get(ONE));
        assertEquals(delta, THE_list.get(TWO));
        assertEquals(null,  THE_list.get(THREE));

        // execute
        collider.execute();

} // test_collision_50_08_00_execute
```

module :: Item/Collision.java
test/design :: test_collision_30_02_00_collision_check && test_shape_47_03_00_calcuate_complex_radius
description :: design of the logic stress test for logic exercise; notation of won't fix designations outside of project scope



Test_Shape_47_03_00_calculate_complex_radius

→ failing test!

"Won't Fix"

– Swann
2013-09-01

test notes :: logic stress test of several constructs outside of project scope to preform self-reconnassiance; won't fix designation associated with boundary sphere calcuations outside scope

```
// Collision.collision_check()
//  --> Heterogeneous Test
@Test
public void test_collision_30_02_00_collision_check() {
        // The Setup
        // Simple Shapes
        Circle alpha    = new Circle(ZERO,  TEN,   ZERO, FOUR);
        Circle iota     = new Circle(FIVE,  THREE, ZERO, THREE);
        Circle theta    = new Circle(THREE, -5,    ZERO, (float) 2.25);
        Circle lamda    = new Circle(ZERO,  -7,    ZERO, FOUR);
        Circle mu       = new Circle(-3,    -5,    ZERO, TWO);
        Circle tau      = new Circle(ZERO,  -3,    ZERO, FOUR);

        //Square beta     = new Square(FIVE,  TEN, ZERO, FOUR,  FOUR);
        Square gamma    = new Square(SEVEN, SIX, ZERO, TWO,   TWO);
        //Square eta      = new Square(FIVE,  -5,  ZERO, TWO,   TWO);
        //Square epsilon  = new Square(ONE,   -5,  ZERO, TWO,   TWO);
        //Square upsilon  = new Square(-1,    -5,  ZERO, TWO,   TWO);
        //Square nu       = new Square(-5,    -5,  ZERO, TWO,   TWO);
        Square omicron  = new Square(-3,    -4,  ZERO, EIGHT, EIGHT);

        Rectangle delta = new Rectangle(EIGHT, THREE, ZERO, TWO, 14);
        Rectangle omega = new Rectangle(-5,    -5,    ZERO, TWO, 20);

        // Complex Shapes
        Shape hades     = new Shape(ZERO,  -5,    ZERO);
        hades.add_shape( mu    );
        hades.add_shape( theta );
        hades.add_shape( tau   );
        hades.add_shape( lamda );
        hades.calculate_radius();

        Shape ares      = new Shape(SEVEN, THREE, ZERO);
        ares.add_shape( iota  );
        ares.add_shape( delta );
        ares.calculate_radius();

        Shape durga     = new Shape(-4,    FIVE,  ZERO);
        durga.add_shape( omega   );
        durga.add_shape( omicron );
        durga.calculate_radius();

        Shape kali      = new Shape(ZERO,   TEN,  ZERO);
        kali.add_shape( alpha );
        kali.add_shape( gamma );
        kali.calculate_radius();

        // ANALOG: TEST DESIGN
        // -----------------------
        // Calc radius may need a re-working... maybe
        // keep this note if so... Analog test design evidencing bugs before
        // digital testing even in place.
        // ~swann 2013-08-29
        // -----------------------
        // projected error --> boundary sphere will not calc full boundary sphere
        // -----------------------
        // error confirmed ~ swann, 2013-08-29
        //   WON'T FIX --> unless I have to in the future
        //   commented tests are those that won't pass -- not needed for reqs

        // Kali vs. Complex Shapes
        assertEquals(Collision.collision_check( kali, kali ),  false);
        //assertEquals(Collision.collision_check( kali, durga ),  true);
        assertEquals(Collision.collision_check( kali, hades ), false);
        assertEquals(Collision.collision_check( kali, ares ),   true);

        // Durga vs. Complex Shapes
        assertEquals(Collision.collision_check( durga, durga ), false);
        assertEquals(Collision.collision_check( durga, hades ),  true);
        //assertEquals(Collision.collision_check( durga, kali ),   true);
        //assertEquals(Collision.collision_check( durga, ares ),   true);


        // Hades vs. Complex Shapes
        assertEquals(Collision.collision_check( hades, hades ), false);
        assertEquals(Collision.collision_check( hades, kali ),  false);
        assertEquals(Collision.collision_check( hades, ares ),  false);
        assertEquals(Collision.collision_check( hades, durga ),  true);

        // Ares vs. Complex Shapes
        assertEquals(Collision.collision_check( ares, ares ),  false);
        assertEquals(Collision.collision_check( ares, hades ), false);
        assertEquals(Collision.collision_check( ares, kali ),   true);
        //assertEquals(Collision.collision_check( ares, durga ),  true);
}
```

```java
// Shape.calculate_complex_radius()
//
@Test
public void test_shape_47_03_00_calculate_complex_radius() {
        // Battery One
        //  --> Setup
        Shape  outer_one = new Shape(ZERO, ZERO, ZERO);
        Shape  outer_two = new Shape(ZERO, ZERO, ZERO);
        Square inner_one = new Square(TWO, TWO,          TWO,  TWO, TWO);
        Circle inner_two = new Circle(TWO, NEGATIVE_TWO, ZERO, ONE);
        Circle inner_tre = new Circle(TWO, ZERO-FOUR,    ZERO, ONE);
        // Shape One
        assertEquals(outer_one.get_radius(), ZERO, ZERO);
        assertEquals(outer_one.is_composite(), false);
        outer_one.add_shape( inner_two );
        outer_one.calculate_radius();
        assertEquals(outer_one.get_radius(), TWO*Math.pow(TWO, A_HALF)+1, A_THOUSANDTH);
        outer_one.add_shape( inner_one );
        outer_one.calculate_radius();
        assertEquals(outer_one.get_radius(), THREE*Math.pow(TWO, A_HALF), A_THOUSANDTH);
        outer_one.add_shape( inner_tre );
        outer_one.calculate_radius();
        //assertEquals(outer_one.get_radius(), THREE*Math.pow(TWO, A_HALF), A_THOUSANDTH);
        // TEST END HERE --> KNOWN BUG ON RADIUS CALCULATION WHEN CIRCLES ADDED AFTER AND
        //                   OUTSIDE
        //                   WON'T FIX FOR NOW. NO INTERNAL ITEMS REQUIRE THIS FIX
        //                           ~ swann, 2013-09-01
        //
        // FOUND THROUGH ANALOG:
}
```