# Final Project - Using Probability and Applied Statistics in Describing Data from Genshin Impact

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## Contents

## Using Probability and Applied Statistics in Describing Data from Genshin Impact

Genshin Impact is a single player, open-world game where the player explores the world of Teyvat released in 2020 and created by the company Hoyoverse, “a video game development and publishing company based in Shanghai, China” (Healy, 2023). The player starts with the main character, either choosing to play as Aether or Lumine, but as they progress, they will obtain many of the other playable characters and there is currently, as of this report, a total of 74 playable characters, excluding the main character.

In the game, the player is able to make teams containing four characters or playing with one character. Characters can be obtained through story quests, events, or the gacha portion of the game and each character has a vision, weapon, rarity, and other details pertaining to their stats like defense and health. For visions they are essentially elements that characters have. They are either of the seven, with simplified terms in parentheses, being cryo (ice), hydro (water), dendro (plant), pyro (fire), electro (electric), anemo (wind), and geo (earth).

This report aims to learn about the data set of the game's characters and what sets each of them apart other than their character themes by utilizing the content learned from the class. Each chapter contains problems that were based off of the problems from the textbook. At the end of this report, there are two Appendices, Appendix A are the problems from the textbook and Appendix B are the problems based on the textbook problems. There is no appendix for the solutions as they will be in the report.

## Problems and Data

### Chapter 1

So to begin, when obtaining characters in the game, as always they start at level 1 and each character has a different set number of health points (hp).

#### *Relative Frequency Histogram*

**Problem 1:** Given data of the character's health from level 1, construct a relative frequency histogram for the data.

(See the Appendix A for **Exercise 1.3** that this problem is based off of).

Since there are 75 characters, including the main character that the player chooses to start with, I have not included the data like it does in Exercise 1.3 on page 6. To solve this problem, I copied the column 'hp_1_20' and pasted it into another sheet in the Excel workbook. I then highlighted the column again on the new sheet and inserted a PivotTable, dragged the hp data to Rows and Values and grouped the hp by 100. Below are the results with the PivotTable and the PivotChart in Figure 1. As well as the mean, variance and standard deviation for the next problem, 2a, 2b, and 2c.

**Figure 1**

Relative Frequency Histogram of Characters HP at Level 1

| Row Labels | Count of hp_1_20 |
|---|---|
| 763-862 | 32.00% |
| 863-962 | 12.00% |
| 963-1062 | 42.67% |
| 1063-1162 | 8.00% |
| 1163-1262 | 5.33% |
| **Grand Total** | **100.00%** |

| | |
|---|---|
| Count: | 75 |
| Sum: | 71627 |
| Mean: | 955 |
| Variance: | 967.9324324 |
| Stand. Dev: | 31.1116125 |

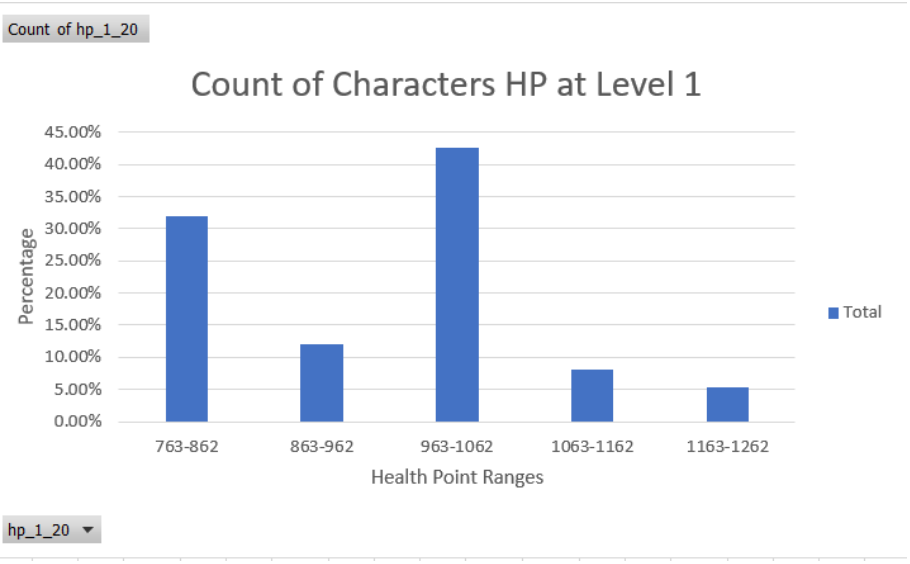



Figure 1 shows that out of 75 characters, about 42% of them have their hp at level 1 in the range of 963-1062. While about 32% fall in the 763-862 range with the second, fourth, and fifth ranges being the least at 12%, 8%, and 5.33% respectively.

***Mean, Variance, and Standard Deviation***

**Problem 2a, 2b, 2c:** Continuing with the data set of the hp at level 1, find the mean, variance, and standard deviation.

Still using the data from the Relative Frequency Histogram section, I found the mean or average by using Definition 1.1 from the *Mathematical Statistics with Applications* textbook and it is denoted by $\mu$ (Wackerly et al., 2008, p. 9):

$$\mu = \bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$$

Thus, the average number of health points playable characters have at level 1 is 955.

The variance can be found with the following under Definition 1.2 and is denoted by $\sigma^2$ (Wackerly et al., 2008, p. 10):

$$\sigma^2 = s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2$$

Simply it can be found by summing up the values and dividing by one less of the total size of the data. The variance was found to be about 967.93.

Lastly is find the standard deviation which is the square root of the variance and is seen in Definition 1.3 and is denoted by $\sigma$ (Wackerly et al., 2008, p. 10):

$$\sigma = s = \sqrt{s^2}$$

From that, the square root of 967.93 is:

$$\sigma = \sqrt{967.93} = 31.11$$

In summary of the results for the character hp at level 1, of the 76 characters there are an average health points of 955 with a variance of about 967.93 and a standard deviation of 31.11 health points. Of the characters, 42% fall in the range of 963-1062 with the second highest percentage of 32% fall in the range of 763-862.

## Chapter 2

### *Sets and Probabilities*

The biggest thing in the game is team building and the player can make teams of four containing any character that they have to use. There is more to teams such as elemental synergy which gives the team buffs, however that will not be touched in this report.

**Problem 3:** Suppose there is a team that contains four characters and we are interested in the gender of the characters. Let $F$ denote that the character is female and $M$ that the character is male. There are five points in the set S of possible observations:

$$S = \{FFFF,\ FFFM,\ FFMM,\ FMMM,\ MMMM\}$$

Let $A$ denote the subset of possibilities containing no males; $B$, the subset containing two males; and $C$, the subset containing at least one male. List the elements of

$A,\ B,\ C,\ A \cap B,\ A \cup B,\ A \cap C,\ A \cup C,\ B \cap C,\ B \cup C,$ and $C \cap \overline{B}$.

(See the Appendix A for **Exercise 2.1** that this problem is based off of).

To solve, this is basically breaking these down into the three sets of A, B, and C, and then using them to solve the elements for what is wanted. To keep the report more readable and manageable in page length, I put the solution into a table.

| | | |
|---|---|---|
| $A = \{FFFF\}$ | $B = \{FFMM\}$ | $C = \{FFFM,\ FFMM,\ FMMM,\ MMMM\}$ |
| $A \cap B = \ \emptyset$ | $A \cup B = \{FFFF,\ FFMM\}$ | $A \cap C = \ \emptyset$ |
| $A \cup C = S$ | $B \cap C = \{FFMM\}$ | $B \cup C = C$ |
| $C \cap \overline{B} = \{FFFM,\ FMMM,\ MMMM\}$ | | |

Characters are also from the different regions of Teyvat and the playable characters can come from the following regions: Mondstadt, Liyue, Inazuma, Sumeru, and Fontaine.

**Problem 4:** From the data set of the 75 characters, it is found that 19 characters are from the Mondstadt region, 18 characters wield a sword, and 4 characters wield a sword and are from Mondstadt. Find the number of these characters who were:

**a.** characters who wield a sword, were from Mondstadt, or both.

**b.** characters who wield a sword and are from another region.

**c.** characters who wield another weapon and are from another region.

(See the Appendix A for **Exercise 2.6** that this problem was based off of).

To solve this, I separated the information given into three parts.

$A = 19\ from\ Mondstadt \qquad B = 18\ wield\ a\ sword \qquad C = 4\ wield\ a\ sword\ from\ Mondstadt$

**a.** Characters who wield a sword, were from Mondstadt, or both can be solved by adding B with the subtraction of C from A like so, $B + (A - C) = 18 + (19 - 4)$ resulting in 33 characters.

**b.** For characters who wield a sword and are from another region, it can be solved by subtracting C from B. $B - C = 18 - 4$ resulting in 14 characters.

**c.** For characters who wield another weapon and are from another region, it can be solved by subtracting B and C from A from the total number of characters. The total number of characters will be denoted as $S = 75$. $S - B - (A - C) = 75 - 18 - (19 - 4)$ resulting in 42 characters who are not from Mondstadt and wield another weapon than a sword.

**Problem 5:** From the data set, if a character is selected from the number of characters, find the probabilities of the events defined below with the information given in the following table:

| Has Pyro Vision | Uses bow | |
|---|---|---|
| | Yes | No |

| | | |
|---|---|---|
| Yes | .04 | .12 |
| No | .16 | .6 |

**a.** Has a pyro vision.

**b.** Has a pyro vision, but does not use a bow.

**c.** Uses a bow whether they have a pyro vision or not.

(See the Appendix A for **Exercise 2.14** that this problem was based off of).

Before solving, there may have been errors when calculating the probabilities for this problem. For having a pyro vision and using a bow the number is 3. For having a pyro vision, but not using a bow it is 9. For no pyro vision, but yes to using a bow is 12 and for no pyro vision and not using a bow, the number of characters is 45 and I got it by subtracting the number of characters that have a pyro vision and subtracted the number of characters that use a bow from the total 75. Having that addressed, below is the solution to the problem.

**a.** The probability that a character has a pyro vision is $.04 + .12$ which is .16 or 16%.

**b.** The probability that a character has a pyro vision, but does not use a bow is .12 or 12%.

**c.** The probability of a character using a bow whether having a pyro vision or not is $.04 + .16$ which is .2 or 20%.

The final problem for this section involves when the player joins a co-op world, meaning they are playing with another player, they are only able to play with two characters while the other player has the other two player slots in a team because it is a team of four.

**Problem 6:** If a player has all 75 playable characters, what is the probability that they will choose an electro and a hydro character for their team at random? Note: there are a total of 12 electro and 12 hydro characters.

(See the Appendix A for **Exercise 2.57** that this problem was based off of).

To solve this, we will need to utilize the combinations formula which can be found on page 46 (Wackerly et al., 2008):

$$C_r^n = \binom{n}{r} = \frac{n!}{r!\,(n-r)!}$$

First we have to find the total number of ways to get two characters from the total:

$$\binom{75}{2} = 2775\ ways$$

Next we would want to find the number of ways to get an electro and a hydro character. Using the note from the problem, we can solve it by multiplying the combination of electro and hydro.

$$\binom{12}{1}\binom{12}{1} = 24$$

Finally to find the probability of choosing an electro and hydro character is by dividing the multiplied combination of electro and hydro by the total number of ways in getting 2 characters from the total, so the answer is:

$$P(A) = \frac{24}{2775} = .008648$$

To put it more in English, the result is thus the chance of choosing an electro and hydro at random is a .9% from the total number of playable characters which is a very small chance.

**Chapter 3**

***Binomial Probability Distribution***

**Problem 7:** When choosing a character for a team, they are independent from each other. Each character has a probability of $p = .2$ of coming from any of the five regions of Teyvat. Let $Y$ equal the number of characters that come from the Liyue region when chosen on a team.

- **a.** Find the probability distribution for $Y$.
- **b.** Find the probability that all four characters are from Liyue.

(See Appendix A for **Exercise 3.45** that this problem was based off of).

**a.** Find the probability distribution for $Y$ is as follows. First we have to establish the probability of success and failure as well as what the total is. For this problem, probability of success, p, is $p = .2$ which means that the probability of failure, q, is $q = .8$. The total is 4. So the solution for part a is:

$$p(y) = \binom{4}{y} (.2)^{y} (.8)^{4-y}$$

**b.** Using the solution from part a, we can use it to solve for the probability that all four characters are from Liyue.

$$p(4) = \binom{4}{4} (.2)^{4} (.8)^{4-4} = .0016$$

The answer to part b is that there is a .16% chance that all four characters on a team come from the Liyue region.

***Geometric Probability Distribution***

**Problem 8:** Suppose there is a .6% chance of getting a 5 star cryo character from the featured character banner gacha. Find the probability that the first cryo character is successfully gotten on the twentieth pull. Also find the expected mean and variance.
(See Appendix A for **Exercise 3.67** that this problem was based off of).

To solve, we will need the formula for geometric probability distribution which is on page 115 (Wackerly et al., 2008):

$$p(y) = q^{y-1} p$$

From the problem, $y = 20$, $p = .006$, and $q = 1 - p = .994$. So plugging the numbers into the formula will give the result of .005352.

$$p(y = 20) = (.994)^{20-1} (.006) = .005352$$

So there is a .54% chance of getting a five star cryo character on the twentieth pull on a feature character banner in the gacha. For the expected mean and variance, the formulas can be found on page 116 (Wackerly et al., 2008):

$$\mu = E(Y) = \frac{1}{p}$$

$$\sigma^2 = V(Y) = \frac{1-p}{p^2}$$

As usual, it is just plugging in the numbers according to the values in the formula. So, for the expected mean, it is: $\mu = \frac{1}{p} = \frac{1}{.006} = 166.67$ and the expected variance is:

$\sigma^2 = \frac{1-p}{p^2} = \frac{1-.006}{.006^2} = 27611.11$ with a standard deviation of $166.17$. So the expected number of how many pulls it will take to get a five star cryo character is about 166 pulls with a standard deviation of 166 pulls with a probability of .6%.

***Negative Binomial Probability Distribution***

**Problem 9:** Out of the 75 characters, if a player is building teams and the probability of picking a dendro character is 12%, what is the probability that the third character will have a dendro vision on the fourth team built?

(See Appendix A for **Example 3.14** that this problem was based off of).

This utilizes the negative binomial probability distribution formula which can be found on page 122 (Wackerly et al., 2008):

$$p(y) = \binom{y-1}{r-1} p^r q^{y-r}$$

From the formula and problem, the $p = .12$, $q = .88$, $r = 3$, and $y = 4$.

$$p(y = 4) = \binom{4-1}{3-1} (.12)^3 (.88)^{4-1} = .00353$$

So the probability of the third character on the fourth build team to have a dendro vision is a .4% chance.

***Hypergeometric Probability Distribution***

**Problem 10:** A player wants to build a team of claymore and polearm characters. There are 13 claymores and 13 polearm characters. What is the probability that the team is built with

**a.** all 4 being polearm wielders?

**b.** three or fewer are polearm wielders?

**c.** at least one is a claymore wielder?

(See Appendix A for **Exercise 3.107** that this problem was based off of).

The formula for hypergeometric probability distribution is the following (Wackerly et al., 2008, p, 126):

$$p(y) = \frac{\binom{r}{y}\binom{N-r}{n-y}}{\binom{N}{n}}$$

**a.** From the problem, we have $N = 26$, $n = 4$, $r = 4$, $y = 4$. When plugged in, the probability of the team built with all four characters wielding polearms is .0000668 or there is a .00688% chance for it to happen.

**b.** For three or fewer polearm users on the team, will need to use: $P(x \leq 3) = 1 - P(4)$. Replacing $P(4)$ with the answer from part a will result in the probability of having three or fewer polearm users in the team to have a .9999332 or a 99.9% chance of it happening.

**c.** With having at least one claymore wielder, it will be the same percentage as part b because the number of polearm and claymore characters are the same.

**Chapter 4**

***Uniform Distribution***

In the game, characters have ascensions which "...allows a Character to go past their initial level cap, as well as providing additional bonuses in itself" and these bonuses are increasing their max level, base statistics, and also unlocking new talents (Genshin Impact Walkthrough Team, 2022). To ascend, they require materials that can be obtained by fighting weekly bosses and which is why they are also called ‘talent_weekly’ in the data set.

Furthermore, for Figure 2 below, you can see that the total for counting the weekly talents do not match the total number of characters a player can have and that is because for

the main character, they are able to change their vision or element and they require different ascension material. Currently in the game, there are five that the player can switch between and that is why the number expected, 75, increased to 79 to account for the four other elements the character can use.

**Problem 11:** From a histogram, it is found that the count for the talent weekly ascension material is for the most part uniformly distributed from 1 to 3 for 18 out of the 26 materials and can be seen in Figure 2. However, if the histogram was uniformly distributed between 1 and 4, find the probability if a new material is added to the game and how many characters would need to use that new material

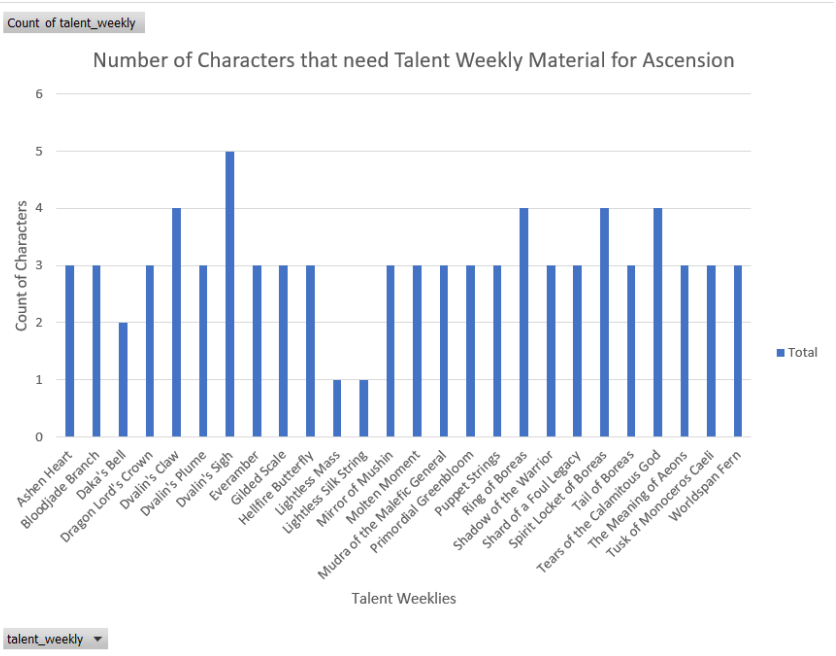
**a.** is below 2 characters.

**b.** exceeds 2 characters.

**Figure 2**

Histogram of Number of Characters and Weekly Ascension Materials

| Row Labels | Count of talent_weekly |
|---|---|
| Ashen Heart | 3 |
| Bloodjade Branch | 3 |
| Daka's Bell | 2 |
| Dragon Lord's Crown | 3 |
| Dvalin's Claw | 4 |
| Dvalin's Plume | 3 |
| Dvalin's Sigh | 5 |
| Everamber | 3 |
| Gilded Scale | 3 |
| Hellfire Butterfly | 3 |
| Lightless Mass | 1 |
| Lightless Silk String | 1 |
| Mirror of Mushin | 3 |
| Molten Moment | 3 |
| Mudra of the Malefic General | 3 |
| Primordial Greenbloom | 3 |
| Puppet Strings | 3 |
| Ring of Boreas | 4 |
| Shadow of the Warrior | 3 |
| Shard of a Foul Legacy | 3 |
| Spirit Locket of Boreas | 4 |
| Tail of Boreas | 3 |
| Tears of the Calamitous God | 4 |
| The Meaning of Aeons | 3 |
| Tusk of Monoceros Caeli | 3 |
| Worldspan Fern | 3 |
| **Grand Total** | **79** |




(See Appendix A for **Exercise 4.45** that this problem was based off of).

To solve this problem, we will use a formula given during a class lecture on uniform distribution (Hoy, Byron, personal communication, November 10, 2023), however the section can be found on page 174 of the textbook (Wackery et al., 2008):

$$p(c \leq x \leq d) = \frac{d-c}{b-a}$$

From the problem, the range we are working with is 1-4 which will be $a$ and $b$.

**a.** Will want to find if the probability of the number of characters less than 2 that will use the next new material. From here, the $d = 2$ and $c = 1$.

$$P(y < 2) = \frac{2-1}{4-1} = \frac{1}{3} = .33333\ldots$$

So the probability that less than 2 characters will use the new material is about 33%.

**b.** Next, solve for the probability that the number of characters will exceed 2. Here, $d = 4$ and $c = 2$.

$$P(y > 2) = \frac{4-2}{4-1} = \frac{2}{3} = .6666\ldots 7$$

The probability that the number of characters will exceed 2 for the new material is 66%.

**Chapter 5**

***Bivariate and Multivariate Probability Distributions***

**Problem 12:** Of the 16 characters that wield catalysts, four have a hydro vision, two have a pyro vision, and two have a cryo vision. Four are to be selected to build a team. Let $X$ denote the number of characters that have a pyro vision and $Y$ denote the number of characters that have a cryo vision. Assuming that the four are randomly selected from the 16 available, find the joint probability function of $X$ and $Y$. After that, verify if it satisfies Theorem 5.1.
(See Appendix A for **Exercise 5.3** that this problem was based off of).

To solve this, the solution is the same process from Example 5.5 in the textbook and the formula we will use is below with the numbers from the problem and $X = y_1$ and $Y = y_2$ (Wackerly et al., 2008, p. 237):

$$p(y_1, y_2) = P(Y_1 = y_1, Y_2 = y_2) = \frac{\binom{2}{y_1}\binom{2}{y_2}\binom{4}{4-y_1-y_2}}{\binom{16}{4}}$$

Where $0 \leq y_1$, $0 \leq y_2$, and $y_1 + y_2 \leq 4$.

Using this, we can find the table of the joint probability function to be below.

| | X | | | | |
|---|---|---|---|---|---|
| Y | | 0 | 1 | 2 | Total |
| | 0 | 1/1820 | 8/1820 | 6/1820 | 15/1820 |
| | 1 | 8/1820 | 24/1820 | 8/1820 | 40/1820 |
| | 2 | 6/1820 | 8/1820 | 1/1820 | 15/1820 |
| | Total | 15/1820 | 40/1820 | 15/1820 | 70/1820 |

So, does this satisfy Theorem 5.1? Theorem 5.1 is found on page 225 (Wackerly et al., 2008) which is:

1. $p(y_1, y_2) \geq 0$ for all $y_1, y_2$.

2. $\sum_{y_1, y_2} p(y_1, y_2) = 1$, where the sum is over all values $(y_1, y_2)$ that are assigned nonzero probabilities.

For the joint probability table, the first condition is satisfied however the second one is not because the sum of the probabilities does not equal 1. They actually equal $\frac{70}{1820} = .0385$ or 3.9%.

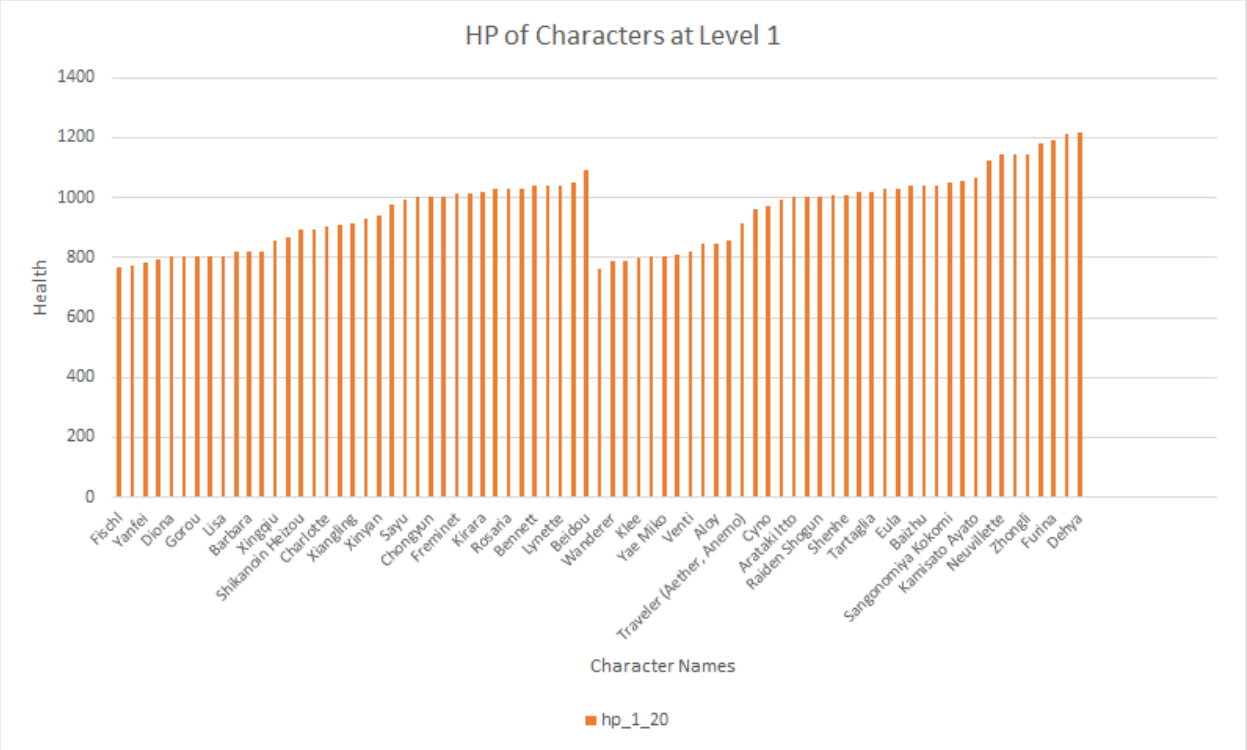
## Discussion

To reiterate the goal of this report, it was to learn about the data set of the game's characters and what sets each of them apart other than their character themes by utilizing the content learned from the class. However, seeing the differences with the problems I chose and with the data set I found, it turned out to be difficult. In the end, the report was more on using the content learned in class to figure out probabilities of building teams with the available characters or how many characters have certain visions or weapons, or what region they came from.

For example, in the Chapter 1 section, Problem 1 in creating a relative frequency histogram, I could not find a cause as to why the base hp characters have at level 1 had a gap where there are 42% of characters in the 963-1162 range and 32% are in the 763-862 range. Before doing this problem, I had thought the base hp was determined by the character's rarity or the vision they have causing that gap. In Excel, I made a graph of the character’s hp at level 1, but sorted by rarity and it can be seen in Figure 3.

**Figure 3**

HP of Characters at Level 1 Sorted by Rarity




*Note.* To the left and then towards the last highest point in the middle, they are the hp of characters with a rarity of 4 and the second half are characters with a rarity of 5.
Going with what I had assumed before with rarities being the reason for the hp difference of rarity 5's versus 4's, I would have thought the graph would not have a "gap" between the last rarity 4 and the first rarity 5 characters and the hp would have been in increasing order. However, the graph proved me wrong in my assumption.

Next, a summary of the solutions of the data I had procured from the problems I created. For the Chapter 1 section, of the 75 characters for hp at level 1, 42% fall in the 963-1062 range, 32% fall in the 763-862 range, 12% fall in the 863-962 range, 8% fall in the 1063-1162 range, and 5.33% fall in the 1163-1262 range. With that, there is a mean of 955 hp, a variance of 967.93 hp, and a standard deviation of 31.11 hp.

For the Chapter 2 section, of Problem 4, 33 characters wield a sword or come from the region of Mondstadt, 14 characters who wield a sword come from a different region, and 42 characters do not wield a sword and do not come from the Mondstadt region. From Problem 5,

16% of characters have a pyro vision, 12% has a pyro vision, but does not wield a bow, and 20% of characters use a bow whether they have a pyro vision or not. From Problem 6, the probability of the two characters being chosen in a co-op world that are electro and hydro is .9%.

For the Chapter 3 section, Problem 7 the probability that all four characters chosen when building a team are from the Liyue region is .16%. From Problem 8, the probability of getting a cryo character from the feature character banner gacha is .54% with the mean of 166.67 and the variance of 27611.11 and standard deviation of 166.17. So the expected number of how many pulls it will take to get a five star cryo character with a probability of .6% is about 166 pulls with a standard deviation of 166 pulls. From Problem 9, the probability the third character on a fourth team built has a dendro vision is .4%. Lastly, from Problem 10, the probability of all four characters on the team wield polearms is .00688%, and the probability of having three or fewer polearm users and having at least one claymore wielder is the same at 13 claymore and polearm wielders.

For the Chapter 4 and 5 sections, Problem 11, the probability of a new material getting used by a number of characters below 2 is 33.3% while the probability of it being used by more than 2 is 66.6%. Then for Problem 12, the joint probability function turned out to be:

$$p(y_1, y_2) = P(Y_1 = y_1, Y_2 = y_2) = \frac{\binom{2}{y_1}\binom{2}{y_2}\binom{4}{4-y_1-y_2}}{\binom{16}{4}}$$

And satisfied the first condition where all values were greater than or equal to 0 of Theorem 5.1, but failed at the second condition where the sum of all values equaled 1.

Furthermore, a potential problem I could have made was to find the probability of two characters having the same birthday, but I found it somewhat difficult to implement. There is also one additional thing is that the player can set their own birthday or another birthday after choosing Aether or Lumine and that can cause more pairings. From the data set, when sorting

by the ‘birthday’ column, there are actually two matches for two people having the same birthday.

Lastly, I will discuss a bit about the sections in the textbook that I was not able to make problems for and other difficulties. Mainly, some sections were not applicable such as the poisson probability distribution and Tchebysheff’s theorem in chapter 3. Finally for the last two chapters, I had difficulties in trying to think of problems that would fit the content as there were functions and integrals, but that is mainly because of myself.

## References

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## Appendix A

## Textbook Problems

**1.3** Of great importance to residents of central Florida is the amount of radioactive material present in the soil of reclaimed phosphate mining areas. Measurements of the amount of $^{238}U$ in 25 soil samples were as follows (measurements in picocuries per gram):

| | | | | |
|---|---|---|---|---|
| .74 | 6.47 | 1.90 | 2.69 | .75 |
| .32 | 9.99 | 1.77 | 2.41 | 1.96 |
| 1.66 | .70 | 2.42 | .54 | 3.36 |
| 3.59 | .37 | 1.09 | 8.32 | 4.06 |
| 4.55 | .76 | 2.03 | 5.70 | 12.48 |

Construct a relative frequency histogram for these data.

(Wackerly et al., 2008, p. 6).

**2.1** Suppose a family contains two children of different ages, and we are interested in the gender of these children. Let $F$ denote that a child is female and $M$ that the child is male and let a pair such as $FM$ denote that the older child is female and the younger is male. There are four points in the set $S$ of possible observations:

$$S = \{FF,\ FM,\ MF,\ MM\}$$

Let $A$ denote the subset of possibilities containing no males; $B$, the subset containing two males; and $C$, the subset containing at least one male. List the elements of $A,\ B,\ C,\ A \cap B,\ A \cup B,\ A \cap C,\ A \cup C,\ B \cap C,\ B \cup C$, and $C \cap \overline{B}$.

(Wackerly et al., 2008, p. 25).

**2.6** From a survey of 60 students attending a university, it was found that 9 were living off campus, 36 were undergraduates, and 3 were undergraduates living off campus. Find the number of these students who were

**a** undergraduates, were living off campus, or both

**b** undergraduates living on campus

**c** graduate students living on campus

(Wackerly et al., 2008, p. 26).

**2.14** A survey classified a large number of adults according to whether they were diagnosed as needing eyeglasses to correct their reading vision and whether they use eyeglasses when reading. The proportions falling into the four resulting categories are given in the following table:

| | Uses Eyeglasses for Reading | |
|---|---|---|
| Needs glasses | Yes | No |
| Yes | .44 | .14 |
| No | .02 | .40 |

If a single adult is selected from the large group, find the probabilities of the events defined below. The adult

**a** needs glasses.

**b** needs glasses but does not use them.

**c** uses glasses whether the glasses are needed or not.

(Wackerly et al., 2008, p. 33).

**2.57** Two cards are drawn from a standard 52-card playing deck. What is the probability that the draw will yield an ace and a face card?
(Wackerly et al., 2008, p. 50).

**3.45** A fire-detection device utilizes three temperature-sensitive cells acting independently of each other in such a manner that any one or more may activate the alarm. Each cell possesses a probability of $p = .8$ of activating the alarm when the temperature reaches 100◦ Celsius or more. Let $Y$ equal the number of cells activating the alarm when the temperature reaches 100◦.

a. Find the probability distribution for $Y$.
b. Find the probability that the alarm will function when the temperature reaches 100◦.

(Wackerly et al., 2008, p. 111).

**3.67** Suppose that 30% of the applicants for a certain industrial job possess advanced training in computer programming. Applicants are interviewed sequentially and are selected at random from the pool. Find the probability that the first applicant with advanced training in programming is found on the fifth interview.
(Wackerly et al., 2008, p. 119).

**Example 3.14** A geological study indicates that an exploratory oil well drilled in a particular region
should strike oil with probability .2. Find the probability that the third oil strike comes on the fifth well drilled.
(Wackerly et al., 2008, p. 122).

**3.107** Seeds are often treated with fungicides to protect them in poor draining, wet environments. A small-scale trial, involving five treated and five untreated seeds, was conducted prior to a large-scale experiment to explore how much fungicide to apply. The seeds were planted in wet soil, and the number of emerging plants were counted. If the solution was not effective and four plants actually sprouted, what is the probability that

**a.** all four plants emerged from treated seeds?

**b.** three or fewer emerged from treated seeds?

**c.** at least one emerged from untreated seeds?

(Wackerly et al., 2008, p. 129).

**4.45** Upon studying low bids for shipping contracts, a microcomputer manufacturing company finds that intrastate contracts have low bids that are uniformly distributed between 20 and 25, in units of thousands of dollars. Find the probability that the low bid on the next intrastate shipping contract

a. is below $22,000.

b. is in excess of $24,000.

(Wackerly et al., 2008, p. 177).

**5.3** Of nine executives in a business firm, four are married, three have never married, and two are divorced. Three of the executives are to be selected for promotion. Let $Y_1$ denote the number of married executives and $Y_2$ denote the number of never-married executives among the three selected for promotion. Assuming that the three are randomly selected from the nine available, find the joint probability function of $Y_1$ and $Y_2$.

(Wackerly et al., 2008, p. 232).

## Appendix B

## Problems Created for Report

**Problem 1 (Ch. 1)** Given data of the character's health from level 1, construct a relative frequency histogram for the data.

(Found on pg. 3)

**Problem 2a, 2b, 2c (Ch. 1)** Continuing with the data set of the hp at level 1, find the mean, variance, and standard deviation.

(Found on pg. 4)

**Problem 3 (Ch. 2)** Suppose there is a team that contains four characters and we are interested in the gender of the characters. Let $F$ denote that the character is female and $M$ that the character is male. There are five points in the set S of possible observations:

$$S = \{FFFF,\ FFFM,\ FFMM,\ FMMM,\ MMMM\}$$

Let $A$ denote the subset of possibilities containing no males; $B$, the subset containing two males; and $C$, the subset containing at least one male. List the elements of $A,\ B,\ C,\ A \cap B,\ A \cup B,\ A \cap C,\ A \cup C,\ B \cap C,\ B \cup C$, and $C \cap \overline{B}$.

(Found on pg. 6)

**Problem 4 (Ch. 2)** From the data set of the 75 characters, it is found that 19 characters are from the Mondstadt region, 18 characters wield a sword, and 4 characters wield a sword and are from Mondstadt. Find the number of these characters who were:

- **a.** characters who wield a sword, were from Mondstadt, or both.
- **b.** characters who wield a sword and are from another region.
- **c.** characters who wield another weapon and are from another region.

(Found on pg. 7)

**Problem 5 (Ch. 2)** From the data set, if a character is selected from the number of characters, find the probabilities of the events defined below with the information given in the following table:

| Has Pyro Vision | Uses Bow | |
|---|---|---|
| | Yes | No |
| Yes | .04 | .12 |
| No | .16 | .6 |

**a.** Has a pyro vision.

**b.** Has a pyro vision, but does not use a bow.

**c.** Uses a bow whether they have a pyro vision or not.

(Found on pg. 7)

**Problem 6 (Ch. 2)** If a player has all 75 playable characters, what is the probability that they will choose an electro and a hydro character for their team at random? Note: there are a total of 12 electro and 12 hydro characters.

(Found on pg. 8)

**Problem 7 (Ch. 3)** When choosing a character for a team, they are independent from each other. Each character has a probability of $p = .2$ of coming from any of the five regions of Teyvat. Let $Y$ equal the number of characters that come from the Liyue region when chosen on a team.

**a.** Find the probability distribution for $Y$.

**b.** Find the probability that all four characters are from Liyue.

(Found on pg. 9)

**Problem 8 (Ch. 3)** Suppose there is a .6% chance of getting a cryo character from the gacha. Find the probability that the first cryo character is successfully gotten on the twentieth pull. Also find the expected mean and variance.

(Found on pg. 10)

**Problem 9 (Ch. 3)** Out of the 75 characters, if a player is building teams and the probability of picking a dendro character is 12%, what is the probability that the third character will have a dendro vision on the fourth team built?

(Found on pg. 11)

**Problem 10 (Ch. 3)** A player wants to build a team of claymore and polearm characters. There are 13 claymores and 13 polearm characters. What is the probability that the team is built with

**a.** all 4 being polearm wielders?

**b.** three or fewer are polearm wielders?

**c.** at least one is a claymore wielder?

(Found on pg. 11)

**Problem 11 (Ch. 4)** From a histogram, it is found that the count for the talent weekly ascension material is for the most part uniformly distributed from 1 to 3 for 18 out of the 26 materials and can be seen in Figure 2. However, if the histogram was uniformly distributed between 1 and 4, find the probability if a new material is added to the game and how many characters would need to use that new material

**a.** is below 2 characters.

**b.** exceeds 2 characters.

[Go to the page to see the figure, it is not essential in solving the problem, but gives a visual of the data represented].

(Found on pg. 13)

**Problem 12 (Ch. 5)** Of the 16 characters that wield catalysts, four have a hydro vision, two have a pyro vision, and two have a cryo vision. Four are to be selected to build a team. Let $X$ denote the number of characters that have a pyro vision and $Y$ denote the number of characters that have a cryo vision. Assuming that the four are randomly selected from the 16 available, find the joint probability function of $X$ and $Y$. After that, verify if it satisfies Theorem 5.1.

(Found on pg. 14)