Unit XXVI Assignment II

Nathan Windisch

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Contents

1 Sequences and Series

The following are answers to questions set for the first task.

1.1 nth and 17th Terms

Find a formula for the **nth** term of this sequence and find the **17th** term using your NTH term formula. Also calculate the **sum of the first 17 terms of this sequence**.

If the sequence is `-3, 1, 5, 9, 13 ...` then we know that the formula must start with 4X+[SOMETHING] due to the fact that the difference between each number and the last is +4. Now we need to calculate what the other part of the formula is. Not figure this out, we must subtract a number from the first value to enable 4X to line up with our current sequence. This means that we need to subtract 7 from all numbers in the current formula in order for them to be accurate with our sequence. This means that the other part of our formula is -7, meaning that the formula thus far is 4X+-7 or, more simply, 4X-7. Therefore, the NTH term will be 4X-7.

Now, we need to apply our new found formula to the extended system, meaning that the following occurs:

$$1n..17n = -3, 1, 5, 9, 13, 17, 21, 25, 29, 33, 37, 41, 45, 49, 53, 57, 61$$

This means that the 17th term is 61.

1.2 Sums to Terms and Infinity

Find a formula for the **nth** term of this sequence and find the **10th** term using your NTH term formula. Also calculate the **sum to the 5th term** and the **sum to infinity** of this sequence.

1.2.1 nth Term

If the sequence is `81, -27, 9, -3 ...` then we know that there will not be an easy solution to this problem. This is because there is no obvious correlation between these numbers. To solve this, we will need to find the difference between the first and the second number, which is 108. The difference between the second and the third number is 36, and the difference between 12. From these numbers, we can tell that the difference between each number and the last one is

$$\frac{previousNumber}{3}$$

Because of this, we can calculate that the first part of the formula is

$$a * r^{n-1}$$

We know that the common ratio, which in this case is `r`, is

$$\frac{-1}{-3}$$

This means that we can apply this to the current sequence, resulting in:

$$a * r^{n-1} = 81 * \frac{1}{3}^{n-1}$$

1.2.2 10th Term

Within this section, all I need to do is apply the `10th term` to the previously generated formula, as follows:

$$81 * -\frac{1}{3}^{10-1}$$

We can condense this further, giving us:

$$81 * -\frac{1}{3}^{9}$$

Now we merely need to calculate the right side of the equation:

$$81 * -\frac{1}{19683}$$

And substitute the `1` with `81` as it is a multiplication of the numerator.

$$-\frac{81}{19683}$$

Now we just condense the equation:

$$-\frac{1}{243}$$

1.2.3 Sum to 5th Term

The formula that we need to perform this equation is as follows:

$$S_n = \frac{a_1(r^n - 1)}{r - 1}$$

In a similar fashion to the previous question, I shall now just substitute the algebraic numbers within the sample formula with my own data:

$$\frac{81(-\frac{1}{3}^5 - 1)}{-\frac{1}{3} - 1}$$

We can condense this down into the following equation:

$$\frac{81(-0.004115226.. - 1)}{-1.\dot{3}}$$

Now we just expand the brackets:

$$\frac{81 * -1.004115226..}{-1.\dot{3}}$$

And finally we do the final calculation on the left side of the equation:

$$-\frac{81.\dot{3}}{1.\dot{3}}$$

This gives us the final number of:

$$61$$

1.2.4 Sum to Infinity

To generate a `Sum to Infinity` you need to use the following formula:

$$S = \frac{a}{(1-r)}$$

As in all the previous iterations of this question, I just need to substitute the formula with my own data, as follows:

$$\frac{81}{(1 - -\frac{1}{3})}$$

Now we need to cancel out the negatives:

$$\frac{81}{(1 + \frac{1}{3})}$$

We can now combine the numbers on the bottom of the fraction together:

$$\frac{81}{(1 + 1\dot{3})}$$

This gives us the final number of:

$$60.75$$

1.3 Equations

Find the solution to

$$\sum_{r=1}^{6}(3r - 2r^2 + r^3)$$

Substituting the Rs for 1s.

$$\sum_{r=1}^{6}((3 \times 1) - (2 \times 1^2) + (1^3))$$

Substituting the Rs for 2s.

$$\sum_{r=2}^{6}((3 \times 2) - (2 \times 2^2) + (2^3))$$

Substituting the Rs for 3s.

$$\sum_{r=3}^{6}((3 \times 3) - (2 \times 3^2) + (3^3))$$

Substituting the Rs for 4s.

$$\sum_{r=4}^{6}((3 \times 4) - (2 \times 4^2) + (4^3))$$

Substituting the Rs for 5s.

$$\sum_{r=5}^{6}((3 \times 5) - (2 \times 5^2) + (5^3))$$

Substituting the Rs for 6s.

$$\sum_{r=6}^{6}((3 \times 6) - (2 \times 6^2) + (6^3))$$

Working out the brackets where R = 1.

$$\sum_{r=1}^{6}(3-(2\times 1)+1)$$

Working out the brackets where R = 2.

$$\sum_{r=2}^{6}(6-(2\times 4)+8)$$

Working out the brackets where R = 3.

$$\sum_{r=3}^{6}(9-(2\times 9)+27)$$

Working out the brackets where R = 4.

$$\sum_{r=4}^{6}(12-(2\times 16)+64)$$

Working out the brackets where R = 5.

$$\sum_{r=5}^{6}(15-(2\times 25)+125)$$

Working out the brackets where R = 6.

$$\sum_{r=6}^{6}(18-(2\times 36)+216)$$

Final solution within the brackets where R = 1.

$$\sum_{r=1}^{6}(3-2+1)$$

Final solution within the brackets where R = 2.

$$\sum_{r=2}^{6}(6-8+8)$$

Final solution within the brackets where R = 3.

$$\sum_{r=3}^{6}(9-18+27)$$

Final solution within the brackets where R = 4.

$$\sum_{r=4}^{6}(12-32+64)$$

Final solution within the brackets where R = 5.

$$\sum_{r=5}^{6}(15-50+125)$$

Final solution within the brackets where R = 6.

$$\sum_{r=6}^{6}(18-72+216)$$

Final solution without the brackets where R = 1.

$$\sum_{r=1}^{6}(2)$$

Final solution without the brackets where R = 2.

$$\sum_{r=2}^{6}(6)$$

Final solution without the brackets where R = 3.

$$\sum_{r=3}^{6}(18)$$

Final solution without the brackets where R = 4.

$$\sum_{r=4}^{6}(44)$$

Final solution without the brackets where R = 5.

$$\sum_{r=5}^{6}(90)$$

Final solution without the brackets where R = 6.

$$\sum_{r=6}^{6}(162)$$

Therefore we need to add up all the numbers to get the final figure.

$$\sum(2+6+18+44+90+162)$$

This means that the final answer is:

$$322$$

1.4 Balls in Bags

Five balls are in a bag, 3 are red and 2 are yellow. Once a ball is chosen at random the ball is put back into the bag and the bag is shaken well.

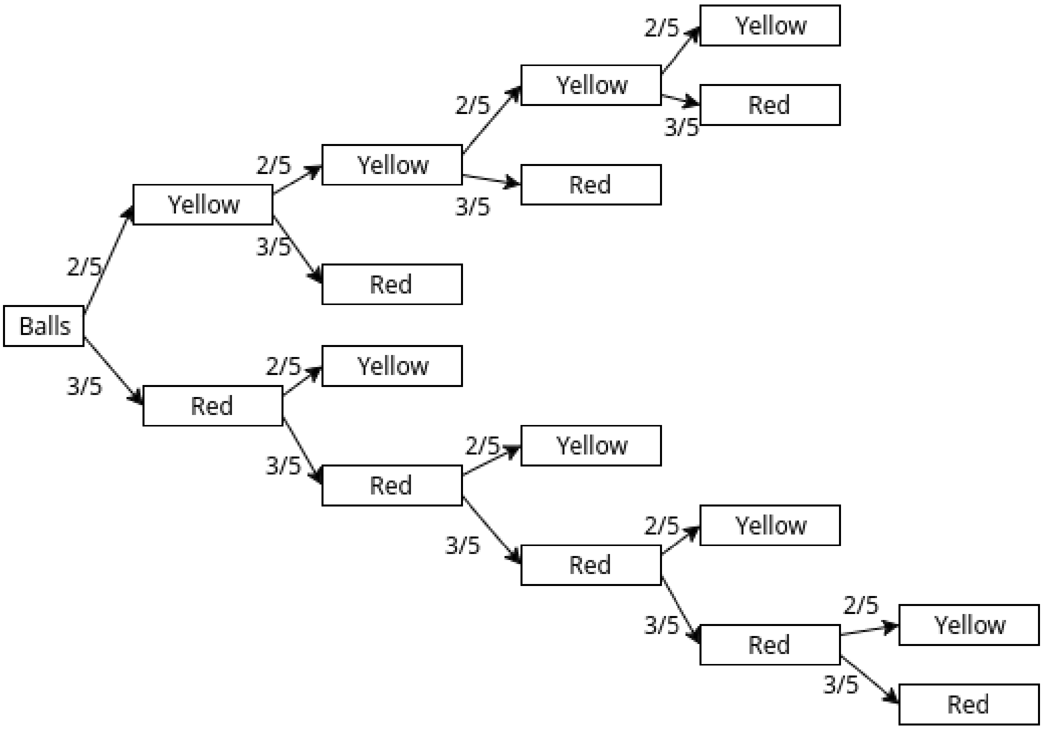


Figure 1: Probability Table.

1.4.1 What is the probability that a yellow ball is selected?

The answer to the first question is

$$\frac{2}{5}$$

This is because there is a total of five balls in the bag, and two of those are yellow meaning that there is a two in five chance of ever getting a yellow ball.

1.4.2 What is the probability 2 yellow balls are selected consecutively?

The answer to the second question is

$$\frac{4}{10}$$

This is because there can be a maximum of 2 balls taken out if the answer is correct, and they both need to be yellow. Because of this, the chance of getting the first ball is two in five, as is the second.

1.4.3 Draw a probability tree and use it to find the probability that a yellow ball is selected 4 times in a row.

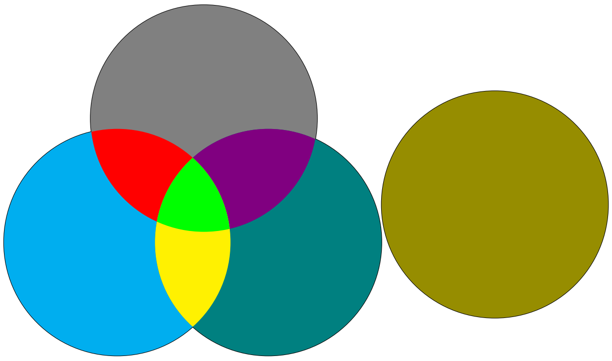
The answer to the third question is

$$\frac{16}{625}$$

This is because 2 x 2 x 2 x 2 is 16 and 5 x 5 x 5 x 5 is 625. We multiply these numbers as the probability of getting one Yellow is two out of five, so therefore we need to multiply it by itself four times as we want to get the total value of all four balls being yellow.

1.5 Venn Diagrams

1.5.1 The Diagram



In this Venn diagram, the:

1. Cyan part is for the students that only take Computer Science.
   - This number is 70 students.
2. Gray part is for the students that only take Engineering.
   - This number is 83 students.
3. Teal part is for the students that only take Mathematics.
   - This number is 0 students.
4. Olive part is for the students that take none of the above.
   - This number is 10 students.
5. Yellow part is for the students that take both Computer Science and Mathematics.
   - This number is 15 students.
6. Violet part is for the students that take both Engineering and Mathematics.
   - This number is 12 students.
7. Red part is for the students that take both Computer Science and Engineering.
   - This number is 0 students.

8. Green part is for the students that take all the subjects, Computer Science, Engineering and Mathematics.

    - This number is 0 students.

1.5.2 Probability: Computer Science but not Mathematics

The total number of all of these students is

$$70 + 83 + 0 + 10 + 15 + 12 + 0 + 0 = 190$$

This means that the probability of a random Computer Science student that does not take Mathematics is

$$\frac{70}{190}$$

Which, simplified is:

$$\frac{35}{95}$$

And simplifying it even more makes:

$$\frac{7}{19}$$

1.5.3 Probability: Engineering with or without other subjects

The total number of all of these students is:

$$70 + 83 + 0 + 10 + 15 + 12 + 0 + 0 = 190$$

This means that the probability of a random Engineering student that either does or does not take another subject is:

$$\frac{83 + 12}{190}$$

Which, simplified is:

$$\frac{95}{190}$$

And simplifying it even more makes:

$$\frac{1}{2}$$

1.6 Betting Game

A betting game involves one player throwing a six sided die to represent an attack and the other player throwing a four sided die to represent a defence.

1.6.1 Draw a probability space diagram for this game.

+	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	8
3	4	5	6	7	8	9
4	5	6	7	8	9	10

1.6.2 What is the most likely total score(s) from both dice?

The most likely total score when both dice are thrown is 4, 5, 6 and 7 as they have an equal amount of percentage within the table.

$$\frac{4}{24}$$

is the percentage for each of the four numbers. Simplified, this is

$$\frac{1}{6} \text{ or } 1.\dot{6}$$

1.6.3 What is the least likely score(s) and why?

The least likely total score when both dice are thrown is 2 and 10 as they have an equal amount of percentage within the table.

$$\frac{1}{24}$$

is the percentage for each of the two numbers. This cannot be simplified as the previous fraction has the lowest common numerator.

2 Number Systems

The following table needs to be completed and two more rows need to be added. The following is the original table.

2.1 Tables

	Denary	Binary	Octal	Hexadecimal
a	22	-	-	13
b	-	-	13	-
c	41	-	-	-
d	-	10100	-	-
e	-	-	36	-
f	-	-	-	2A
g	271	-	-	-
h	-	-	-	-
i	-	-	-	-

The following is my updated version of the table.

	Denary	Binary	Octal	Hexadecimal
a	22	10110	26	16
b	11	1011	13	B
c	41	101001	51	29
d	14	10100	24	14
e	30	11110	36	1E
f	42	101010	52	2A
g	271	100001111	417	10F
h	135	100000111	207	87
i	87	101011	127	57

3 Number System Calculations

3.1 Hexadecimal Calculations

3.1.1 Hexadecimal Addition

I need to add together two hexadecimal functions that are found within the previous table.

$$a + f = 22 + 42 = 64$$

Within the previous equation I used the denary numbers for the a and f values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a hexadecimal number, which is in Base16.

$$64_{10} = 40_{16}$$

As a result, we can conclude that:

$$a + f = 40$$

3.1.2 Hexadecimal Multiplication

I need to multiply two hexadecimal functions together, which were found within the previous table.

$$g * f = 271 * 42 = 11382$$

Within the previous equation I used the denary numbers for the g and f values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a hexadecimal number, which is in Base16.

$$11382_{10} = 2C76_{16}$$

As a result, we can conclude that:

$$g * f = 2C76$$

3.1.3 Hexadecimal Subtraction

I need to subtract one hexadecimal value from another, which were found within the previous table.

$$f - b = 42 - 11 = 31$$

Within the previous equation I used the denary numbers for the f and b values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a hexadecimal number, which is in Base16.

$$31_{10} = 1F_{16}$$

As a result, we can conclude that:

$$f - b = 1F$$

3.2 Octal Calculations

3.2.1 Octal Addition

I need to add two octal functions together, which were found within the previous table.

$$a + e = 22 + 30 = 52$$

Within the previous equation I used the denary numbers for the a and e values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a octal number, which is in Base8.

$$52_{10} = 64_8$$

As a result, we can conclude that:

$$a - e = 64$$

3.2.2 Octal Subtraction

I need to subtract one octal value from another, which were found within the previous table.

$$e - b = 30 - 11 = 19$$

Within the previous equation I used the denary numbers for the e and b values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into an octal number, which is in Base8.

$$19_{10} = 23_8$$

As a result, we can conclude that:

$$e - b = 23$$

3.3 Binary Calculations

3.3.1 Binary Addition

I need to add two binary functions together, which were found within the previous table.

$$a + d = 22 + 14 = 36$$

Within the previous equation I used the denary numbers for the a and d values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a binary number, which is in Base2.

$$36_{10} = 100100_2$$

As a result, we can conclude that:

$$a + d = 100100$$

3.3.2 Binary Multiplication

I need to multiply two binary functions together, which were found within the previous table.

$$a * d = 22 * 14 = 308$$

Within the previous equation I used the denary numbers for the a and d values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a binary number, which is in Base2.

$$308_{10} = 100110100_2$$

As a result, we can conclude that:

$$a * d = 100110100$$

3.4 Additional Equations

I also have to perform two more additional equations of my own choice.

3.4.1 Hexadecimal Addition

I need to add together two hexadecimal functions that are found within the previous table.

$$e + c = 30 + 41 = 71$$

Within the previous equation I used the denary numbers for the a and f values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a hexadecimal number, which is in Base16.

$$71_{10} = 47_{16}$$

As a result, we can conclude that:

$$e + c = 47$$

3.4.2 Binary Subtraction

I need to subtract one binary value from another, which were found within the previous table.

$$f - d = 42 - 14 = 28$$

Within the previous equation I used the denary numbers for the a and d values, meaning that the output number was in denary.

Because of this, I had to convert the denary number, which was in Base10 into a binary number, which is in Base2.

$$28_{10} = 11100_2$$

As a result, we can conclude that:

$$f - d = 11100$$

4 Data Task

4.1 Data

4.1.1 Hypothesis and Source Validity

The data that I shall be collecting and working with free data that was generated by the `US Bureau of Labour Statistics`, meaning that it can be considered valid and reliable. The data is about the unemployment rate within the United States from 1994 to 2004, inclusive. The data is in the form of percentages and all people within the data are aged 16 or over. The data is over 30 years and has a percentage for each month. I shall be using this data to generate a mean, median of each year, by adding up all of the numbers within the set. I shall also use this data to determine averages. My hypothesis is that more people will be hired around December due to the need for more people as there are more roles to be filled due to the festivities.

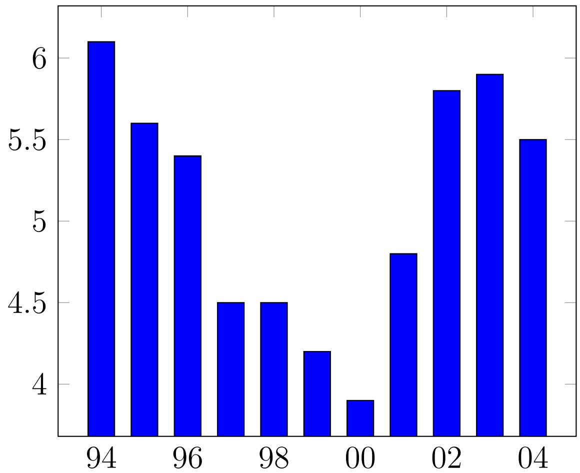
Data Validation is important as it shows how reliable or trust worthy data can be. There are a few different ways in which data can be validated, and these are as follows:

- Monitoring: Data should be kept track of in real time, to ensure that the data is consistently accurate.
- Geocoding: A standardised system of keeping track of where data is from, corrects data to both US and Worldwide postal standards.
- Standardisation: Ensuring that all the data within a set is formatted to a particular rule set, such as all numbers being to 3 decimal points or single character values for cardinal directions.
- Linking/Matching: Comparing data with one another so that similar records can be matched. Can also be used to find duplicate data using "fuzzy matching" such the Regular Expression library: `libtre`.

4.1.2 Data Set

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVG
1994	6.6	6.6	6.5	6.4	6.1	6.1	6.1	6.0	5.9	5.8	5.6	5.5	6.1
1995	5.6	5.4	5.4	5.8	5.6	5.6	5.7	5.7	5.6	5.5	5.6	5.6	5.6
1996	5.6	5.5	5.5	5.6	5.6	5.3	5.5	5.1	5.2	5.2	5.4	5.4	5.4
1997	5.3	5.2	5.2	5.1	4.9	5.0	4.9	4.8	4.9	4.7	4.6	4.7	4.5
1998	4.6	4.6	4.7	4.3	4.4	4.5	4.5	4.5	4.6	4.5	4.4	4.4	4.5
1999	4.3	4.4	4.2	4.3	4.2	4.3	4.3	4.2	4.2	4.1	4.1	4.0	4.2
2000	4.0	4.1	4.0	3.8	4.0	4.0	4.0	4.1	4.0	3.9	3.9	3.9	3.9
2001	4.2	4.2	4.3	4.4	4.3	4.5	4.6	4.9	5.0	5.4	5.6	5.7	4.8
2002	5.6	5.7	5.7	5.9	5.8	5.8	5.8	5.7	5.7	5.7	5.9	6.0	5.8
2003	5.8	5.9	5.8	6.0	6.1	6.1	6.2	6.1	6.1	6.0	5.9	5.7	5.9
2004	5.6	5.6	5.7	5.6	5.6	5.6	5.5	5.4	5.4	5.5	5.4	5.5	5.5

4.1.3 Frequency Diagram



In the above graph, the X axis is the year and the Y axis is the average unemployment rate percentage over the year.

4.1.4 Mean, Median and Mode

Mean The Mean is the total of all of the numbers in the dataset, divided by the amount of numbers that are in the dataset. The total of all of the numbers within the dataset is 681.3, and the total amount of numbers within the dataset is 120 as there are 12 months over 10 years. Therefore, when we multiply the total of all the numbers in the dataset with the amount of data that there is we get: **681.3 * 120 = 81756**

Median The Median is the centre value within the dataset. This means that the middle months are June and July, and the middle years are 1998 and 1999. The result of this is that we need to get the values for both of those, and then work out an average. The unemployment percentage rate in June 1998 was 4.5, July 1998 was 4.5, June 1999 was 4.3 and July 1999 was 4.3. This means that the average all of these numbers is 4.4, as it is in the centre is all four of the numbers, due to there being only two unique numbers. The result of this is that the median is **5.4**.

Mode The mode is the value that is the most common number within the dataset. With the dataset that we are currently using, the most common number is **5.6**.

Range The range is the difference between the lowest number within the dataset and the highest number within the dataset. In our dataset, the lowest number is 3.8 and the highest number is 6.6, so the difference between these numbers is 2.8. This means that we have to add half of 2.8 to 3.8, meaning that the number in between the highest and lowest number is **5.2**.

Interquartile Range The Interquartile Range is a method of getting the variability of a dataset. It works by dividing the data into quartiles, meaning that the dataset has been split into four equal parts, and the value of each of these parts are called the *first*, *second* and *third quartiles*, or **Q1**. **Q2** and **Q3**, respectively.

4.1.5 Box Plot

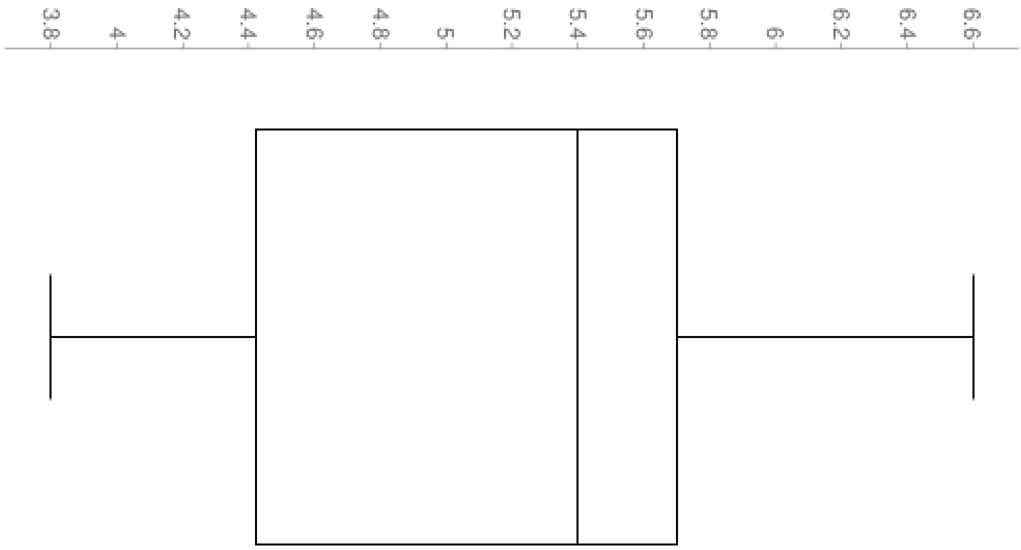


Figure 2: A box plot generated from the data.

The values within the box plot are as follows:

$$PopulationSize : 132$$

$$Q1 = 4.425$$

$$Q3 = 5.7$$

$$IQRange = 1.275$$

$$Outliers : None$$

Variance The variance is a way to measure how far a set of numbers is spread out.

To calculate the variance, we first need to get the mean value. After this we need to subtract it from each piece of data that we have. Then we square all the numbers that we have thus far, to ensure that they are positive. Now we need to add them all together and divide this number by the total number of values in the dataset. This results in the variance for your dataset.

4.1.6 Conclusion

Judging from the information I have gathered, it seems the amount of people who are unemployed started high within 1994 and dropped down to it's lowest in 2000, after which it steadily increased. This would mean that every 5 years or so the amount of unemployed people fluctuates, as it started at its highest at the start of the chart and was at it's lowest 6 years later, then 4 years after that it went really high and started to dip again. I suspect that this is due to the fact that recessions and other economic crises happen once every 5 or so years, meaning that the amount of people who have jobs will fluctuate along with it. I would like to be able to see more data from the next 15 years to see if this is possible, but sadly this is only a "what if" scenario due to the fact that 15 years after 2004 is 2019, which hasn't happened yet.

5 Recursion

In computing, a recursive method is a piece of self-contained code that will call upon its self repeatedly. These are often used in algorithms such as specialized sorting algorithms, that are designed to go through large amounts of data quickly. For example, a Non-Recursive algorithm would be a loop that would go through each element of data and check if it is the data that it is looking for, if it was, the code would return the value and stop the loop. This means that if the piece of data happens to be at the beginning of the data set, the code is very quick. But if the data is at the end of the data set, it can take a long time to get to the correct piece of data, as it must check each piece of data in order. A Recursive Sorting algorithm would be a Binary Search. This would check the middle value of the data set, if it was not the value it was looking for, it would recursively call its self to check for the middle value of the 2 halves of the data set. The code would keep doing this until it found the piece of data it was looking for. This method is efficient for large data sets.

6 Number Systems

6.1 Binary

Binary is the simplest form of data transfer, and is used by computers to transfer information. Binary is represented by 0s and 1s, and different combinations can mean different things. Binary can also be interpreted differently, so the same combination of 0s and 1s can mean more than one thing. One use of binary is to represent numbers and letters but there are different ways of doing so, such as ASCII and Unicode. This is how Binary can be converted to ASCII.

6.2 Hexadecimal

Hexadecimal is a shorthand way of representing binary. It is easier to read and understand for a person, so it is often used instead of binary in places where a person might need to right the information. For example, Hex is used to represent colours on computer systems, the colours are split between Red, Blue and Green, and sometimes a transparency value. For example, FFFFFF converts to pure white, while 000000 is pure black.

6.3 Octal

Octal is not often used in computer systems anymore, as computers are now based on multiples of 4 rather than 3, which means hexadecimal is used more often. However, Octal is still used on Unix system permissions as there are 3 groups, User, Group, and Others. And its file permissions are set to read, write, and execute, and as an Octal character can represent 3 Binary characters, it makes it very well suited for this task.

7 Network Planning

7.1 Different Amounts of Hosts

When creating a subnet for different static amounts of hosts, only a specific number of IP addresses will be needed. Due to the fact that IP addresses are generated using Base 2, the lowest number that can fit all the hosts will be required, but this may not be the same number of hosts.

7.1.1 1,000 Hosts

For instance, when generating a subnet for 1,000 hosts, the lowest Base2 value that can allow for 1,000 hosts is $2^1 0$, or 1024. This means that we want to be able to get the largest number that is as close to 1,000 as possible. To do this we shall use groups of 255 within an IP address until we get to the largest amount of 1s and 0s that we can manage without going over. For reference, I shall show the binary numbers used within this calculation.

$$11111111 = 25511111111 = 25511111100 = 25200000000 = 000$$

Therefore, if we add all of these numbers together we get:

$$255 + 255 + 255 + 252 = 1024$$

Shortening this down, you can display this as /22 as there are 22 1s within the binary representation of 1024. Separating this up, you could also show the number as `255.255.252.0`.

7.1.2 200 Hosts

A subnet for 200 hosts with the lowest Base2 value that can allow for 200 hosts would be 2^8, or 256. I shall now do the same thing as before and use binary to show that my calculations are correct.

$$11111111 = 25511111111 = 25511111111 = 25500000000 = 000$$

Therefore, if we add all of these numbers together we get:

$$255 + 255 + 255 = 256$$

Shortening this down, you can display this as /24 as there are 24 1s within the binary representation of 256. Separating this up, you could also show the number as `255.255.255.0`.

7.1.3 30 Hosts

A subnet for 30 hosts with the lowest Base2 values that can allow for 30 hosts would be 2^5, or 32. I shall now do the same thing as the last two times and use binary to show that my calculations are correct.

$$11111111 = 25511111111 = 25511111111 = 25511100000 = 224$$

Therefore, if we add all of these numbers together we get:

$$255 + 255 + 255 + 224 = 32$$

Shortening this down, you can display this as /27 as there are 27 1s within the binary representation of 256. Separating this up, you could also show the number as `255.255.255.224`.

7.2 IPv4 & IPv6

IPv4 & IPv6 are types of Internet Protocol, a method of communicating across the Internet. IPv4 was the original method that was used to assign unique identifiers to computers on a network, but the amount of IPv4 addresses was quickly overtaken by the amount of computers and other networked devices. Because of this, it meant that a new protocol had to be developed. Enter IPv6, a new protocol that allows up to

$$3.4 \times 10^3 8$$

addresses. This is more than the estimated amount of stars in the universe, which is a mere

$$10^2 2$$

, meaning that we should never ever run out of addresses. IPv4 addresses look something like `127.0.0.1`, meaning that there are a total of

$$256^4$$

as each collection of number can be a range from 0 to 255, giving a total of 256 numbers that can be made up into a total of `4,294,967,296` addresses available. IPv6 looks like this `3ffe:1900:4545:3:200:f8ff:fe21:67cf` and, as aforementioned, has a very large amount of permutations. IPv6 is compromised of 8 sections of 4 hexadecimal number/letter combinations, giving it a total of `65536` unique combinations per segment. This is the reason why IPv6 exists, as we have run out of unique addresses in IPv4 and we need to expand our frontier. Luckily IPv6 is not a finite, physical resource so it can be generated infinitely.

7.3 Classes of Networks

There are many different classes of networks that need to be discussed. They are called Class A, Class B and Class C and they can be distinguished by the subnet mask that they use. The following is a table of differences in classes.

Class	First ID	Last ID
A	1.0.0.0	126.0.0.0
B	128.0.0.0	191.255.0.0
C	192.0.0.0	223.255.255.0

When looking at this table, you can see that the Last ID will be identical to the subnet mask for the network. The First ID will be the same as the first IP address that is assigned on the system. When looking at this table you can deduce the following things:

1. Class A can have many devices connected to a network, but a low number of networks.

    - This is used by ISPs due to the fact that they can have many devices connected.

2. Class B can have medium amount of devices connected to a network and a medium number of networks.

3. Class C can have a small amount of devices connected to a network, but a high number of networks.

    - This is used by home owners due to having the ability to have a large amount of subnets.

7.4 Classless Inter-Domain Routing (CIDR)

Classless Inter-Domain Routing, or CIDR, is a way of letting more IP Addresses to be connected to a device without damaging or changing the current infrastructure. While subnetting works by letting more networks connect together; allowing more IP Addresses to be used in their own private networks, CIDR or supernetting performs the subnetting processes on individual IP Addresses, meaning that more subnets can be created and allowing more IPs and sockets to connect to a single network.