

W₄ O₁ R₁ D₂

G₂ A₁ M₃ E₁ S₁



Student Investigation

7 8 9 10 11 12



Scrabble™

The corner for 35th Avenue and 81st Street in Jackson Heights New York bears a wonderful tribute to Alfred Mosher Butts, the inventor of the board game, Scrabble.



Alfred originally called the game “Lexiko” (Greek: “many words”) but later changed it to “Cris Cross Words”. Alfred contacted numerous game manufacturers, all of them rejected his game, he eventually sold the rights to entrepreneur James Brunot. James manufactured the game for some time in an abandoned school and re-branded the game as Scrabble. Despite selling a few thousand games in 1949, James made a loss, however, by 1952 James and his wife could no longer keep up with orders. One hundred and fifty million sets later, Scrabble is one of the most popular board games in the world!

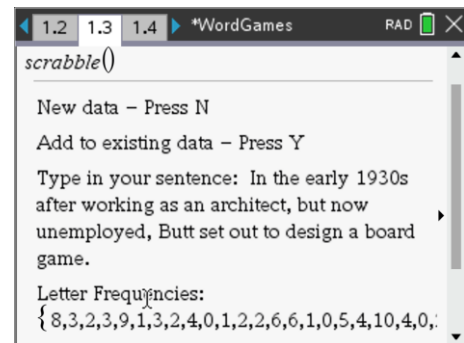
Gathering Data

To ensure the accessibility of the letters in the game reflected those used in day to day language, Alfred examined the letter frequency from a New York Times article. Your task is to run your own comparison and analysis.

Open the TI-Nspire file: **WordGames**

Navigate to Page 1.3 (Calculator Application)

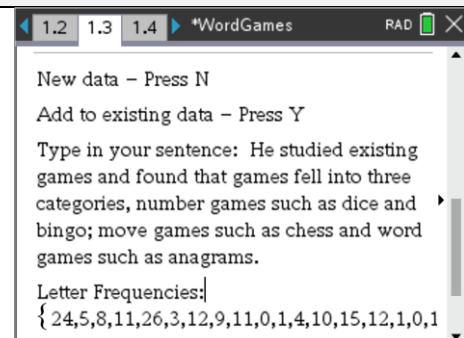
Press the VAR key and select the Scrabble program. You are provided with the option to create a new set of data (N) or add to existing data (Y). The first time you run the program you should type “N” to create a new set of data. A textbox is then provided for you to enter a sentence. Punctuation, numbers and special characters will all be ignored, only letters will be counted.



A sample sentence has been included (above), an extract from the Wikipedia article on Alfred Mosher Butts. It is important to ensure your selected article does not include too many repetitions of a specific word such as a person’s name as this will adversely bias the results.

After you have entered your first sentence, press ENTER to automatically run the Scrabble program again, this time enter “Y” to add to your existing data set. The original sentence will be overwritten but the data is accumulated.

Note: You can type in shorter entries to make typing easier and simply select “Add to existing data” each time.



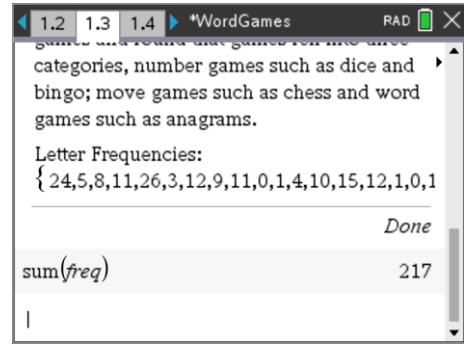
After you have entered several sentences, you can check the total character count via the Calculator application.

Type in: sum(

Select the “freq” variable from the Variable drop down list:

The result represents the total number of letters counted, lower and upper case. The example opposite shows that 217 letters have been counted from the text entered to date.

Letter frequencies are automatically generated by the program and stored in the ‘freq’ list in the spreadsheet application on page 1.2. The lists also include the standard score for each letter in the game of Scrabble (score) and letter frequency in the actual game (game_freq).



A screenshot of a spreadsheet application window titled '*WordGames'. The spreadsheet has four columns: 'A letters', 'B freq', 'C score', and 'D game...'. The data is as follows:

	A letters	B freq	C score	D game...
1	a	30	1	9
2	b	7	3	2
3	c	13	3	2
4	d	17	2	4
5	e	43	1	12
A1	"a"			

Question: 1.

Record the letter frequencies from a sample of more than 1000 letters.

Question: 2.

Express each of the letter frequencies as a percentage.

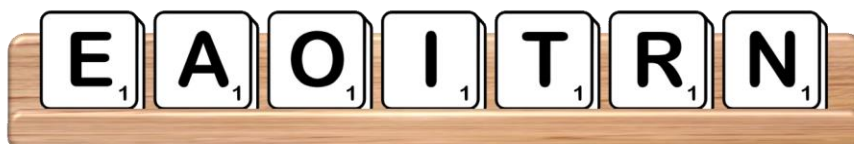
Question: 3.

The letter frequencies in the game of Scrabble have been included below. Compare your results with those from the board game, comment on any *significant* differences.

A ₁ 9	B ₃ 2	C ₃ 2	D ₂ 4	E ₁ 12	F ₄ 2	G ₂ 3	H ₄ 2	I ₁ 9
J ₈ 1	K ₅ 1	L ₁ 4	M ₃ 2	N ₁ 6	O ₁ 8	P ₃ 2	Q ₁₀ 1	R ₁ 6
S ₁ 4	T ₁ 6	U ₁ 4	V ₄ 2	W ₄ 2	X ₈ 1	Y ₄ 2	Z ₁₀ 1	 2

Question: 4.

Compare letter frequency to letter score, comment on your findings.



Question: 5.

The letter tray above includes the seven most common letters in scrabble. If it is your turn first, what is the longest word that you can make using these letters?

Navigate to the Lists and Spreadsheet application. Navigate to the top of the spreadsheet and then continue pressing the UP arrow key until the first column is highlighted.

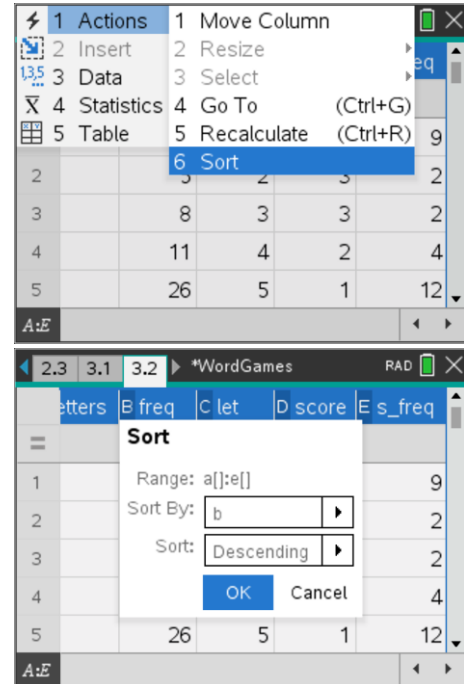
Hold down the shift key and arrow across to highlight all the columns.

Press  and select **Actions > Sort**

The frequency is the data that is to be prioritised, so this is the column to “Sort By”.

[In this document column B holds the frequency data.]

Sort the frequencies in descending order (highest to lowest). All other columns will adjust accordingly, maintaining row correspondence.



Question: 6.

Repeat question 5 using the seven most common letters according to your data.

Note: In the unlikely event that your top seven letters are exactly the same as Scrabble, swap out one of the top seven with your eighth most common letter.

Tlgram

The TV show Lingo and more recently the online game Wordle, and all its variants, combine the popular board game Mastermind™ from the 1970's with the English language. Mastermind is a two-player game. One player creates a code using a hidden combination of coloured pegs, the other player is the code breaker. With each attempt at breaking the code, the code-breaker receives information about which pegs are the right colour and right location and which pegs are simply the right colour (wrong location). Wordle replaces colour pegs with letters, but the letters must form a word, consisting of 5 letters. Wordle players therefore have two advantages over Mastermind players:

- Some letters are more likely to appear in the code than others.
- Letters must form words.

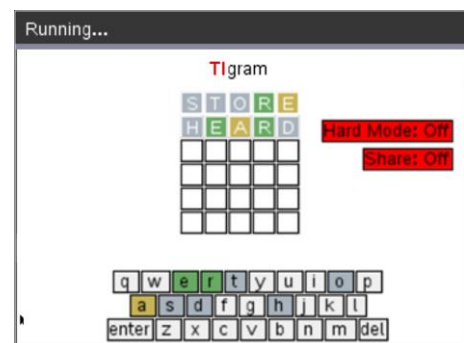
Prior to attempting the following questions, try a couple of games of Tlgram.

Open the TI-Nspire file: **staTlgram**

Navigate to Page 1.2 (Python Shell)

Press Ctrl + R to run the game.

The first word attempted in this puzzle was “STORE”. Three letters (S, T and O) are greyed out, this means they are not in the solution. The R is highlighted in green, this means it is the right letter in the right location. The E is highlighted in yellow, this means it is in the solution, but is currently in the wrong location.



The second word: “HEARD” has three letters that appear in the solution. The letters: E and R are now in the correct location. The letter A is in the solution, but currently in the wrong location. The keyboard at the bottom of the page shows all the letters that have been used to date. The colour coding is also significant here, at a glance you can see which letters use and which ones have not.

Question: 7.

The letter A can go in two other locations, at the start or end of the word. The following words start with AE:

AESOP A person who tells or invents fables.	AECIA Small cup like structure on a specific fungi type.	AEGIS Protection or support of a particular person or organisation	AEGIR A high wave caused by tidal flow	AEDES Particular genus of mosquito	AERIE A nest high on a cliff top	AEON An indefinite period of time
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Aside from the somewhat obscurity of most of the words above, which (if any) could be a solution?

Question: 8.

Based on your response to the previous question, how many possible locations are there for the letter A in this puzzle?

Question: 9.

There are more than 20 possible five letter words that end in RA, but only three of them have an E as the second letter: TERRA, TETRA and ZEBRA. Which one is the correct answer? (Explain)

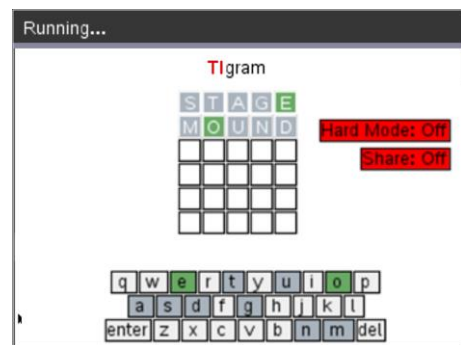
Question: 10.

Based on your letter frequency data, identify some of the best starting words.

Question: 11.

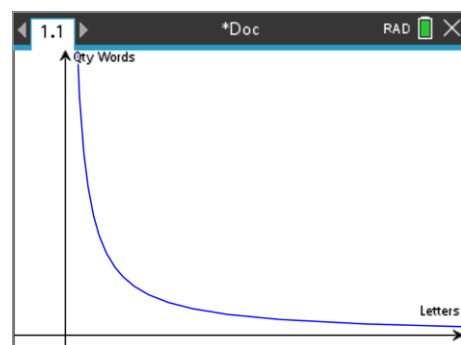
In the game shown opposite the word "STAGE" was used first with only one letter correct. (E) The player chose "MOUND" as their second guess. (Hard Mode Off)

- MOUND is clearly not the correct answer, suggest reasons why a player might elect to choose such a word.
- Focusing on the most frequently used letters (according to your data) and the combination of remaining letters, find words that have O as the second letter and E as the last letter and discuss might be the next best guess.

**Question: 12.**

The graph shown opposite displays a relationship between the most common letters (starting at the origin) and the quantity of words that contain the corresponding letter. For example, looking at the "letters" axis, "E" is adjacent to the origin and "Q, X and Z" are furthest away.

- Emily says you are best to start with a word that only contains the most frequently used letters (close to the origin). Discuss the strengths / weakness of this strategy.
- Daisy says she starts with a word that contains as many unusual letters as possible. Discuss the strengths / weaknesses of this strategy.
- Brian says he starts with a word that has four common letters and one much less frequent. Discuss this strategy.



Question: 13.

Trish and Elizabeth are competing against one another on Tlgram so they share their scores each day.

```

1.1 1.2 1.3 *Tlgram_r...ase RAD 92/98
Python Shell
current streak: 43
Guess Distribution:
0: 0
1: 0
2: 2
3: 15
4: 16
5: 9
6: 1
That's 2:19.10 that you'll never get back.
>>>

```

Trish

```

1.1 1.2 1.3 *Tlgram_r...ase RAD 92/98
Python Shell
current streak: 41
Guess Distribution:
0: 0
1: 0
2: 3
3: 12
4: 19
5: 4
6: 4
That's 3:11.10 that you'll never get back.
>>>

```

Elizabeth

- Based on the data, what is the minimum number of games played by each person?
- Use statistics to help determine who is the best player at this stage of the competition.

Question: 14.

Russell and James have been playing the game a while and have registered the following results:

```

1.1 1.2 1.3 *Tlgram_r...ase RAD 92/98
Python Shell
current streak: 41
Guess Distribution:
0: 0
1: 0
2: 1
3: 11
4: 12
5: 9
6: 8
That's 5:06.66 that you'll never get back.
>>>

```

Russell

```

1.1 1.2 1.3 *Tlgram_r...ase RAD 92/98
Python Shell
current streak: 41
Guess Distribution:
0: 0
1: 0
2: 1
3: 8
4: 12
5: 11
6: 9
That's 9:08.11 that you'll never get back.
>>>

```

James

A quick glance at the results shows that Russell is slightly better than James. Russell describes the game scores as being a bit like golf. He describes the game scores as being a bit like golf. He describes par for any given game as '4', which would make a solution in three turns a 'birdie' and 5 turns a 'bogey'.

- How many 'birdies' has each player scored?
- What is each player's average?
- In golf, a handicap is determined by the difference between the players average and par. Determine the handicap for each player.
- Russell and James decide to apply their respective handicaps a week of games. Russell scores: 3, 5, 4, 6, 4, 4 and 3 turns. James scores 4, 4, 5, 6, 3, 5 and 5 turns. After applying their handicaps, which player is the winner for the week? [Assume the handicap is NOT re-calculated after each game]