The Vigenère Cipher

October 25, 2021

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MOIRP VUWTC WYDDN BGOFG SDXUU

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Key: $k = (k_1, k_2, \ldots, k_n)$.
Encrypt (all arithmetic is mod 26)

$$Enc(m_1, m_2, \ldots, m_N) =$$

$$m_1 + k_1, m_2 + k_2, \ldots, m_n + k_n,$$

$$m_{n+1} + k_1, m_{n+2} + k_2, \ldots, m_{n+n} + k_n,$$

$$\ldots$$

Decrypt Decryption just reverses the process

Three Kinds of Vigenère Ciphers

The following three slides give three kinds of Vig Ciphers. It is a rough way to divide up types of Vig ciphers. There will be some that are not quite in any category.

VIG ONE: Standard Vigenère Ciphers

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We will be studying this type of Vig cipher today.

VIG TWO: The Vig-Book Cipher

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This is called **The Vig-Book Cipher**. We will touch on it briefly later.

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It is usually done with alphabet $\{0, 1\}$ or $\{0, \ldots, 9\}$, not $\{a, \ldots, z\}$.

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- Might not have even been secure then...
- History of Cryptography is hard since, unlike most science, people can discover things and NOT brag about it.

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Important: Very likely that **aiq** encrypted **the same** 3-letter sequence and hence the **length** of the key is a divisor of
87-57=30 102-87=15 162-102=60
The only possible L's are 1,3,5,15.

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Good Enough: We got the key length down to a small finite set.

Important Point About Letter Freq (I)

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e occurs $\sim 13\%$ t occurs $\sim 9\%$ a occurs $\sim 8\%$

Etc- other letters have frequencies that are true for all texts.

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In an English text T of length N, where N is large and $i \ll N$, then if you take **every ith letter of T**:

e occurs $\sim 13\%$ t occurs $\sim 9\%$ a occurs $\sim 8\%$

Etc- have the other letters same frequencies as normal texts.

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Sum Up Point

- If T is English or shifted-English then $f_T \cdot f_T \sim 0.065$ large.
- If T is not English nor shifted-English then $f_T \cdot f_T$ is prob small.

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2. If $f_{T_0} \cdot f_{T_0}$ is large then key length probably IS 10 (or a divisor of 10).
3. If $f_{T_0} \cdot f_{T_0}$ is small then key length probably not 10.

Next slide generalizes this.

Testing if Key Length is L

Our question T is ciphertext coded with Vig Cipher. Eve thinks the key length is L. Let S be **every Lth letter of T**. SO

$$S = T(1)T(L+1)T(2L+1)\cdots T(NL+1)$$

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- If keylength is L then S is a shift of every Lth character from some English Text. Hence $f_S \cdot f_S \sim 0.065$.
- If keylength is not L then S is a ... a real mess!! $f_S \cdot f_S$ will be small.

Upshot We have a test whether some text is from the shift-cipher or not. We will use it on the every-Lth-letter text of T.

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- Just to make sure, check another stream.

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Question Computers reduce the need for cleverness. Is this good or bad?

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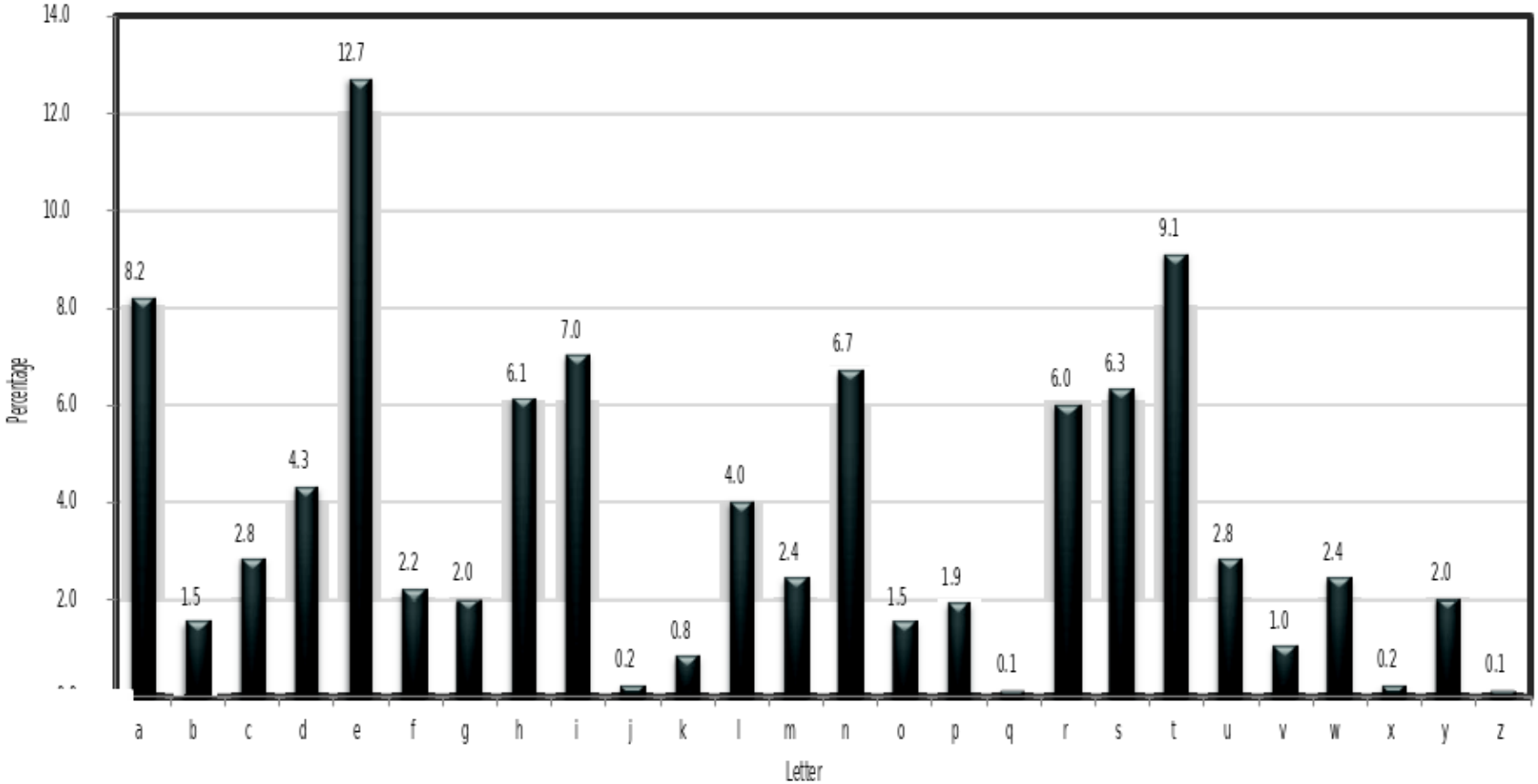
3. You now know all shifts for all positions. Decrypt!

Using Plaintext Letter Frequencies



Vig-Book Cipher

October 25, 2021

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A student said:

Let's use Vig cipher with a book for the key

Is it a good idea? **Discuss**

Vig-Book Cipher

A student said:

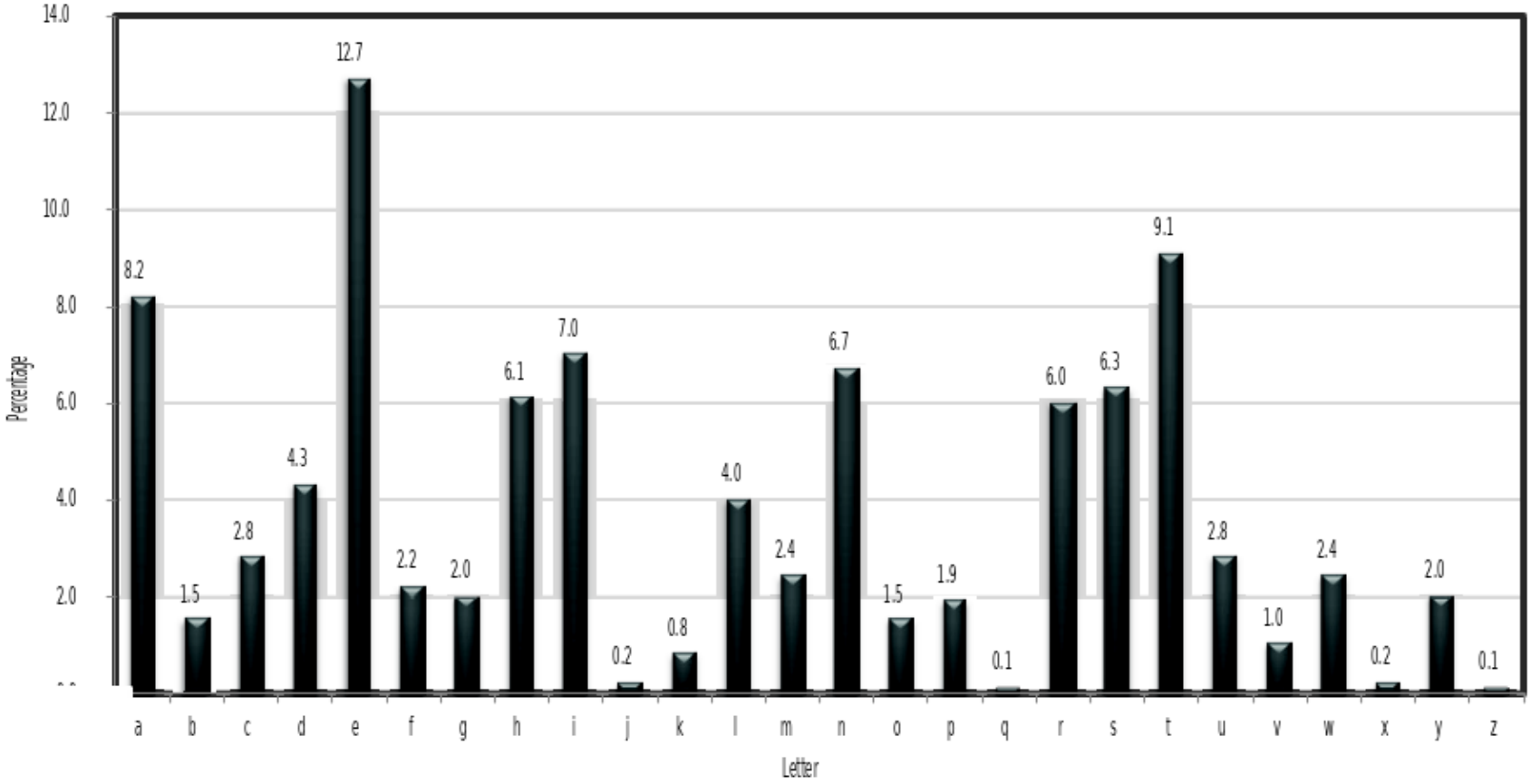
Let's use Vig cipher with a book for the key

Is it a good idea? **Discuss**

1. Before modern computer era: YES.
2. Now. NO.

How to Crack the Vig-Book Cipher

Key: Both Key and Text have the English Lang Frequencies.



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Hence the following are the only possibilities for
(Letter in Key, Letter in Text) are:

(a, d), (z, e), (y, f), (w, g), $\ldots$, (b, c)

Only 26 possibilities. What of it? **Discuss**

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6. Triples. Etc.

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Were these good choices? NO.

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Were these good choices? NO. They are books Eve might guess.

Bill Should Not Use...

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Problems with a Point

Ever notice how civilians (that is non-math people) use math words badly? Ever notice how sometimes you know a math statement is false (or not known) since if it was true you would know it?

Each chapter of this book makes a point like those above and then illustrates the point by doing some real mathematics.

This book gives readers valuable information about how mathematics and theoretical computer science work, while teaching them some actual mathematics and computer science through examples and exercises. Much of the mathematics could be understood by a bright high school student. The points made can be understood by anyone with an interest in math, from the bright high school student to a Field's medal winner.

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Problems with a POINT

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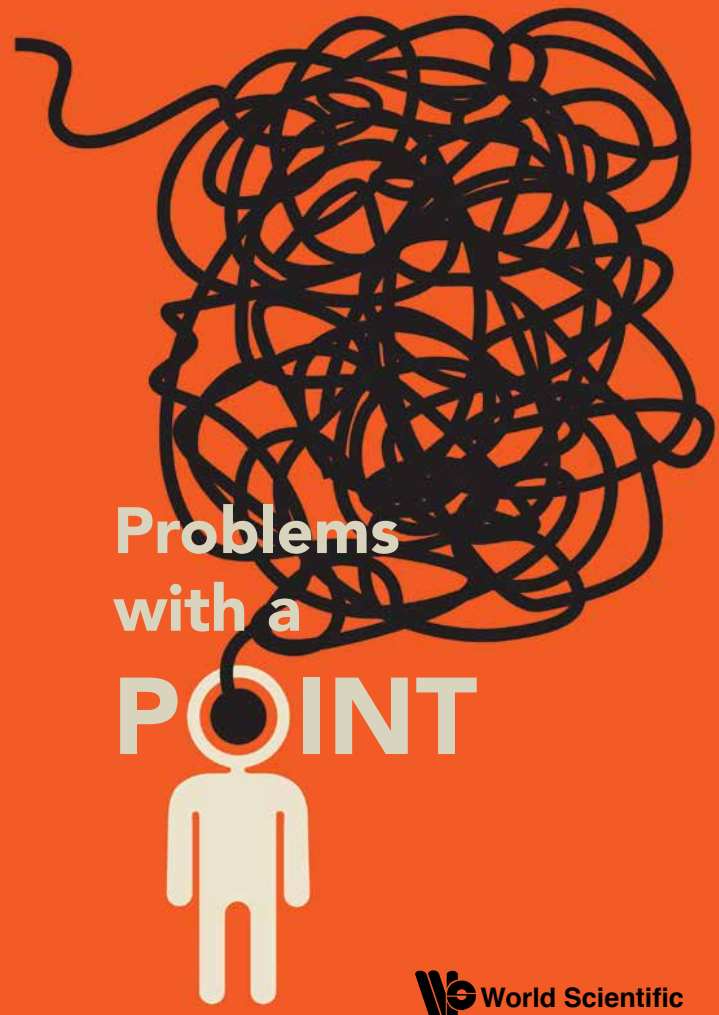
Kruskal

William Gasarch • Clyde Kruskal



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World Scientific

Would make a Good Ugrad Project

Cracking the book cipher would make a good ugrad project.

Vig Cipher with Key Longer Than Message

The Vig-Book Cipher IS Vig Cipher with Key longer than message.

1. **Weakness:** Key is English Phrase, so has freq patterns.
2. How can we strengthen?

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1. **Weakness:** Key is English Phrase, so has freq patterns.
2. How can we strengthen?
3. Make Key Truly Random. This is the one-time pad which we study later.