Quiz 3

- Cryptography Engineering

1. Please write a python program to determine keyword length of the encrypted message using I.C. (hint: 3 < the keyword length < 8)

   Ex: keyword = CEISFUN, the output should be “7”

2. Then write a second python program to solve the encryption keyword letters for the message.
3. Finally, break these ciphertext and recover to the plaintext.

Note:

The first two programs will need to read the message from stdin and output the result followed by a newline to stdout.

The answer should be saved in a text file.

Reference https://macs4200.org/chapters/08/5/determining-keyword.html

Encrypted message 1

- ZQQTK PQUWD PGMWD BQTXY LFQWL SHAJB UCIPV KUQEJ RBAAC LRSIZ ZCRWT LDFMT PGYXF ISOSE ASZXN PHTAY HHIIR ADDIJ LBFO E VKUWW VFFLV TCEXG HFFXF ZVGXF BFQEI ZOSEZ UGFGF UJUGK PCZWZ UQQJI VAFLV CSDCX YOPYR SQTEI HQFII VTAYI LRGGR AWAR N LAGWK JCZXZ UIMPC FTAVX LHMRU LAMRT PDMXV VIDWV SJQWW YCYOE VKXIU NSBVV CWAYJ SMMGH BWDIU DSYYJ AGQXR ZWP IF SRZSK PCZWR URQQS YOOIW YSELF USEEE KOEAV SSMVE DSYYJ APQHR PZKYE SSMVE PBSWF TSFLZ UUILZ JVUXY HGOSJ AIERF ZAMP C SONSL YOZHR ULUIK FHAET XIUVV HBPXY PGPMW MWOYC AMMXK HQTIJ PHEIC MAAVV JZAWV SMFSR UOSIZ UKTMT ODDSX YSEW Y HGSEZ USPEJ AFARX HGOIE KSZGP VJQVG YSVYU PQQEE KWZAY PQTTV YGARJ HBPXY PBSWR YSPEP IMPEP MWZHZ UUFLV PFDIR SZQ ZV SWZPZ LIAJK OSUVT VBHIE AWARR SJMPL LHTIJ HAQTI PBOMG SSEAY PQTLR CSEAV WHMAR FHDEU PHUSE HZMFL ZSEEE KKTMT O ODID HYURX YOBMU OOHST HAARX AVQVV CSZYV ZCRWZ USOYI PGFWR UREXI PDBME NHTIK OWZXR DRDCM LWXJI VAMXK YOOXZ C SEYG LFEXZ AWARJ HFQAF YYURX HGMGK PJQPP PBXMK LFMXL YSMWZ UGAGZ LHKXY LQDIU BZUXP VTARV DFUXV YCDXY LDMVK POX MK FCREE VHTII MWZHJ HGBSN LFRYC HHAYT OGFSE LOZHR ZKTSC LGAQV HQTEJ AWEID LBFME AVQLV HZFLP ZQQTK PQUWD VTMXV TDQVR ASOPR ZGAJR UHMKF UWEXJ HGFLV KFQED ZCRGF UGQVM HHUWD VFFLV PABSJ AIDIJ VTBPL YOXMJ AGURV JIDIJ PBFLV JVGVT OVUWK VFKEE KHDEU PHUSE DVQXY LFAJR UQUIE ACDGF TDMVR AWHIC FFQGV UHFMD LGMVV ZINNV JHQHK VJQVP KWRJV YSZXY HBPPZ UURVF THTEK DVUGY AVQME KIXKV UQQSI JFQHL SWFCF MTAVD LFMKV ZQAYC KOXPF DAQVV ZHMXV TSZXJ HFQNV HZAYJ SM IEK JVQHR URFLV TCFMM LGAJK OSIVZ ASDJF YAMWZ TDAVK HBFEE PBSVV KWQRK PBFLV HBMPP ZWESW OWELZ ZHAVP HGFLV MOO XJ OSDIT VFPWG YCNES PZUXP PGMTF DSDJL SOZHK YCGFC LGAQV ASEXR URUXZ ZPKXY PGFVF BPXIJ VAQWK HBPEI KHTEK HZMVX LD AVK PCZSW OWEXF YWOEC LJUHV UQQMJ ZWRXV KQARJ PGFIE JMUWE VZQWJ WSDXZ UOOMF BGMRU LLMGK PBSME PHEHV TOZHJ PBNVZ LTFSN YWFIR OWEXF YMIID BGFOE VKYSI LHTEE TSDIW HQFWY BAMRE HHGVV CWQAV KIZHV YOZME KIOXZ VBAJV EHQRU LRQ BG LFUIE JSUWK OSNIJ AVQPG ACFLV JFUXZ JWEQF MVGQR UVUWK VFKLZ ZHAVZ JOXGY HFMGK LFEGR UCZPP ISQWK PAMXV KPKXY L GFEE KODHN OWOLY BAMRV EDQVZ LBOIN OSFLV YOOXL HZAVK YOPMK PCZEI FVMWW BFZMJ OSPXF MCDQT VFDIT AJUIN ZCRME K WHMU BOXWN LAGWK YSSEI KHTID HGRSI TWZKG HFFWF MOSVV HHILF SSIID BGFQV HGGVV AVQQS FHTIZ YFQPR AWARK VHTID HGE SW ISURX ZPKAY VAFLV FODIJ BFDSL URQHR URURT VBFID WZMXZ UUFLV PBOMU LBFWZ UHTIZ YZUZV ZCDGF URUXZ VBILZ JVFVR KW FMF UVMWY HBPIU KCIRK VIEAV TIEXI HHTII JCZWZ KSDXY LUQRV YOXFV HFURX VTFLV DVAPV UODVR AWHIK OOZXY LFQWG LQFMM LDDSS HPUPZ AMAJZ AGPIK HWXW

Encrypted message 2

- UTCEM KTGHF KJYHF WTFIA GICHN NKMUD PFUAX FXCPL MEMLE GUETB UFDHV GGRXV KJKIH DVADG VVLIP KKFLA CKUTT VGPTL GERZG QNGHY QIRWX OFQII CIRIH UYSIH WICPK UREPB PJRRH PMGRM KFLHB PTCUK QDRWX XVPNZ TRBJT NTFPK CTRTK QWMJK GUSRT VZMCP GDSHM EFLIB PLYAE AWMGZ GKYCW GDYCV KGYIX QLPHX NMCHY TFKZG QNJTW IVNGX XZMJL NPYRJ WZPTW YVKJL VJCIT UZBTH NULDM KFLHT PUCBU TRATY TVQWH PVQPG FRQLX NVYGG YVKJL VSCST KCWJG NVYGG KEEHH OVRWB PXUWB EYGIA CJADL VLQCH UDYAE NRZDN TRLST POGTM AKMPV SLGGX CEBIA KJBXY HZAJE VPYIM CTFTL KKQTE HDMGX ECMHX NPRDT PRETB PNFXV JGPDZ TVQHA CJEPB PVBPL VIMCZ CJATG FVLRR QMCGI TVHJW KTCPG FZLLA KTFEX TJMCL CEBIA KEEHT TVBPR DPBPR HZLSB PXRWX KIPTT NCCKX NZLAB GLMUM JVGGV QETTG VZMCT NMYAN GKFTL CDCEK KEAXI NVQLA KTFWT XVQLX RKYLT AKPPW KKGDG CCYQN UVQPG FNFXV JRPTF CBGCZ TRNXW JRTDV CDMCZ VYCGX XVLJX UFDHB PVAJK KJRHT PUQIK KGNXG IKFTM JZLIT YUPNO GZJUK QDYIM TRAIB XVQJI GIQIB VZMCL CICLH TBGCZ CJYRM KMCAR KEJXM GIYIN TVYHB PJMRB GKWIA GTPTW WCGIR QWMCX YIGIX TFPIA GGYGM KRJXM AFDPG QKFTK HZLSL CJNDP GIDJE CKMJV JJRDG GRLST UNFDE GJMBX CTFPL VZQTF GERXG VYCWX CCRWR UTCEM KTGHF QWYIX OGCGT VVAAT UJMUT PKYVH PZQIL CJRWX FICPF UFDRH PJCGO CKGHF QIRWX KDNDL VLPTL QWNAN TRJXL VJGCX ELPTL KERWX EYSGV JYGHM QIWPG FKPPW KKGDG YYCIA GIMUT PTGTG VFPRH OGYGT VZTTE AICRX PKRXF GJYGX ULZYX EKCSM QMCGR FZDUX TVLIA CEBAB PXDGH OKFPM YYGRA VYCXG FLJVX PTCDK EICSN NZRNH HWMGF GIYVX UTMJE FRJAH YDCGX UKYIX OVLIL CICYX CCMJL NPUPM EYCST PURWX OFRXO GJMUM JVUGB VVPUH TDYHB OGMGM CERPG KEEGX FZCCM KERWX CEYAR UZQDY JZQWB UKMGR CJRWX HRAIL JVPTV QIBHI TFZPU KCGIR KJYEH YVPUN NRLSM TFSQE GJMBX VVQIT PUGIB USWIA KJRGH WSJTL QDCHM CEBPK FKFPM CCYGZ GGMGM KFLDY JZQIH TZAPE GMGSX PTCXL UZDIX FTMCL KJRTG EPGHG QCCHL RVPIB PRAXH WJYCW GOYRM KEEXG KKQSX ORLSL KEZGB GWRDP TZRTT JZQIH TPUTF WJRZG QNKDK GKFPG OVPTY CTRHA WDYCG CKSGX XZCLX FLLSX TRLXG FLAIB QEMUX ZKCCW GUCMI GIGTG EVGHM JVZTL VYCAI VFRWX EIGIB EZQBH HYSBT PYGHM QIWWB UKMGB ERJRA CIYRM GIQRT PFLAR DVCHM KDYIX FSWIA GJRPG FRPSP JZAWA WDYCX ZGCGB GEATP JVRWX TRAIN CCMGM TRBXM KFLPK AYYHY WILXL JVBIH HFPBV QIPTV VMGTP UFDXG FZTXW WRJHP GDSHM TVEPK FKFTF CJDDK OZLVI CIRHH HREGX CKUWH NVUTF WJRBX CJSGX VYCBU AKFTB TICAT VZMCM QKFTF CJQDY DVGCZ USWLA QDRWX ARPTL WIPDN PUCST PUGCV QERTF RCYIB PXRWX KEAXW GERHB PKFTB TCGKX UFPRH PUGIB QEUWB EYRGT FZRXH PYYHA CEBTW FFUCM QLQLX OLQIK CKFTK EFLHB FVPIA GXCCX TRJQX CIGCZ QWRWX YYMAX PRPGT VZTTM JRLIA GICHI GTRXO GGPDU CSGAB VPMUB VJBTM CZJH

Encrypted message 3 **HINT key length could be 5 or 6**

- IVIKDKDQMJGLPWLZGMPFBJIIDBBYSLJDXFGBIWWEHAPHEYSGNCCYOOTSTZABCOBVRTAZEYWVWWAZAIDGAZPETHPVBPWOBVJXGFMD
  OBCGPFKXKSZZAIGCJRPETACJHUTHPVHKJHPZHFPMEVZEQSBYOMHSDVFTASFGZTCOBZCGHFMDOBCWVNVBRVKRGXDBMKFBTGBVGMP
  TBVFMTGBLBMXZWESHGCBYSKDTBYSFWOARQHCJQEQBCUIDCNCHWWGNEDWIHPTKQCZGDKIGDENHPZGIGWVTWIASBFHATQIJSBCD
  WZBMPGQKKTHTQIGMEFMJSGISLKCFTHPVFXLSZVHAGSMGCLHWJCSXMDTRBTIWWEGHUHPVGXRZCJWHCCZZBVPFKVFTIWWECYIVQJU
  XCHTVATCWVRBHJHPFILTCNYWLUOBYSKHAIEGBDBBYSKTKIJHATSFGZTCOBZCGIVIKVXLOAZBAXRQEUYDFITFBBSWIHAPHPVKTHAIUOGS
  HPRHMWSGNWLWSLKCTKCQUOGPGGCIFDFBYOMWSPRRLDAMUWLTOAVKAXQPTONHSLYWLHSOISZPHQFBBRCCCRMWWVBCYCCWKV
  XGOLVENPHMJCEJHQFBLIVMJSMWSVYOWICJVGBUHMUOGSPICOGRSLRUTXBAKSTRVWKVXG

Polyalphabetic cipher

- A polyalphabetic cipher is any cipher based on substitution, using **multiple substitution alphabets**.
- The Vigener cipher is probably the best-known example of a polyalphabetic cipher, though it is a simplified special case.
- The **Enigma machine and** some **electric encryption device are** more complex but is still fundamentally a **polyalphabetic substitution cipher**.

Vigener cipher

k = C R Y P T O C R Y P T O C R Y P T

(+ mod 26)

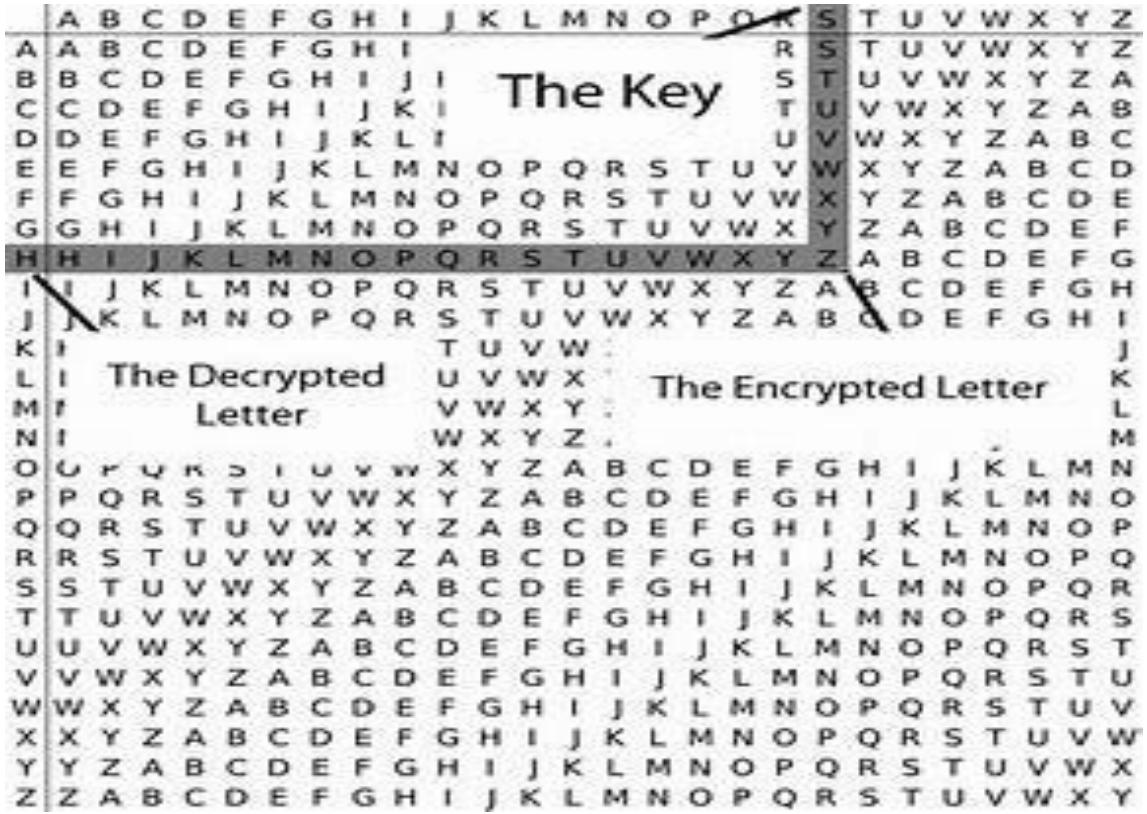
m = W H A T A N I C E D A Y T O D A Y

---

c = Z Z Z J U C | L U D T U N | W G C Q S

suppose most common = “H” ⟹ first letter of key = “H” – “E” = “C”

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
B	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
C	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B
D	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C
E	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D
F	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E
G	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F
H	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G
I	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H
J	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I
K	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J
L	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K
M	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L
N	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M
O	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N
P	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Q	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
R	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
S	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
T	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
U	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
V	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
W	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
X	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Y	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Z	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y



https://pages.mtu.edu/~shene/NSF-4/Tutorial/VIG/Vig-Base.html

Vigener cipher

k = C R Y P T O C R Y P T O C R Y P T

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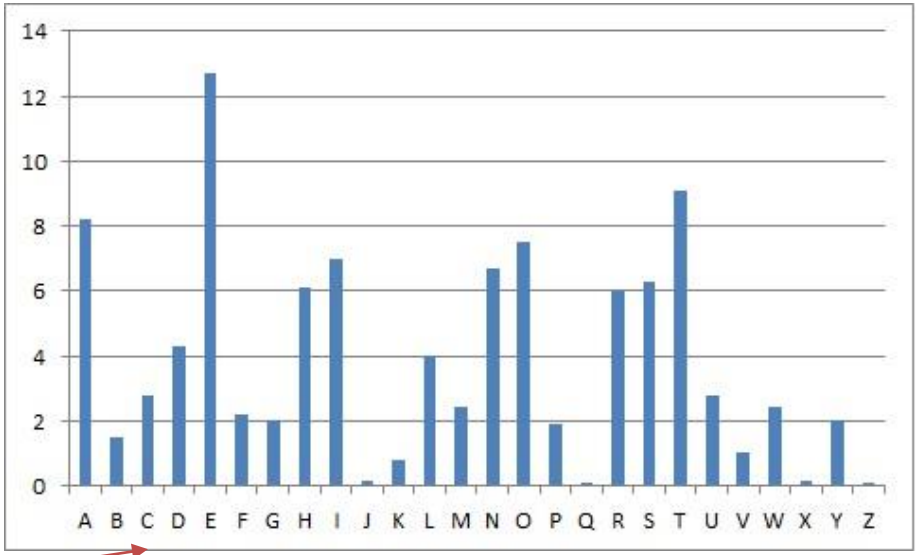


Plaintext m
frequency

M+K=C

key
C=3
Shift 2 times

Shift 2 times

C D E F G HI J K L M N O P Q R S T U V W X Y X Z A B

Ciphertext C
frequency

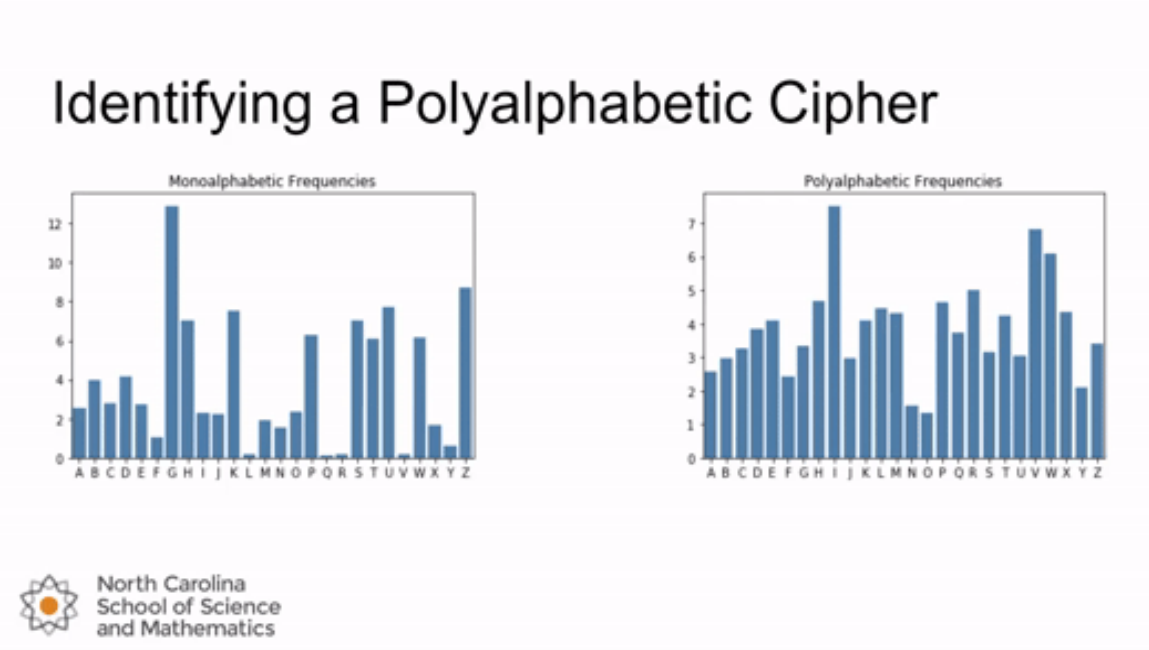
Substitution Cipher

Encryption: Substitution cipher

Similar to Caesar cipher, but you can choose which letters substitute the alphabet

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
MRBGSLOAEFYWDKUQHPCJTZVXIN
```

Identify a Polyalphabetic Cipher



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Calculating Probabilities

For the monoalphabetic ciphertext, the probability of picking two letters at random from the text and having them both be A's (using the distribution above) would be:

$$M_{\text{both A's}} = \frac{73}{1000} \cdot \frac{72}{999} \approx 0.00526$$

The probability of picking two letters at random from the text and having them both be B's

$$M_{\text{both B's}} = \frac{9}{1000} \cdot \frac{8}{999} \approx 0.0000721$$

and in general, where n_i denotes the number of character i and n_{text} denotes the total number of characters in the text:

$$M_{\text{both i's}} = \frac{n_i}{n_{text}} \cdot \frac{n_i - 1}{n_{text} - 1}$$

For long messages, $\frac{n_i}{n_{text}} \approx \frac{n_i - 1}{n_{text} - 1}$, so the formula can be simplified to:

$$M_i^2 \approx \left(\frac{n_i}{n_{text}} \right)^2$$

The sum of all these probabilities, which is equivalent to asking "What's the probability of picking two letters at random from the text, and having them be the same letter?" works out to be:

$$\sum_{i=A}^{Z} M_i^2 \approx 0.066$$

Doing the same calculation on our very evenly distributed polyalphabetic ciphertext yields:

$$\sum_{i=A}^{Z} P_i^2 \approx 0.038$$

This score, calculated by summing the squares of the letter frequencies is called the **Index of Coincidence**. When presented with an unknown ciphertext, it's index of coincidence will suggest if it was enciphered with a polyalphabetic cipher (if the score is close to 0.038) or a monoalphabetic cipher (if the score is close to 0.066). This gives a quick and easy way to determine with a single number the most likely type of cipher used to create a ciphertext.

Identifying a Polyalphabetic Cipher

Monoalphabetic

A	73	J	2	S	63
B	9	K	3	T	93
C	30	L	35	U	130
D	44	M	25	V	13
E	27	N	5	W	16
F	28	O	74	X	78
G	16	P	27	Y	19
H	35	Q	3	Z	1
I	74	R	77	.....	

Polyalphabetic

A	38	J	38	S	39
B	39	K	39	T	38
C	38	L	38	U	39
D	38	M	39	V	39
E	39	N	39	W	38
F	38	O	38	X	38
G	38	P	39	Y	39
H	39	Q	38	Z	38
I	38	R	39	.....	

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Identifying a Polyalphabetic Cipher

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E	27	N	5	W	16
F	28	O	74	X	78
G	16	P	27	Y	19
H	35	Q	3	Z	1
I	74	R	77	.....	

```
character_frequency( message )

[ 0.073, 0.009, 0.030, ..., 0.019, 0.001]
   M_a     M_b     M_c          M_y     M_z
```

$$M_{\text{both i's}} = \frac{n_i}{n_{text}} \cdot \frac{n_i - 1}{n_{text} - 1}$$

So for long messages...

$$M_i^2 \approx \left(\frac{n_i}{n_{text}}\right)^2$$

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Identifying a Polyalphabetic Cipher

Monoalphabetic

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F	28	O	74	X	78
G	16	P	27	Y	19
H	35	Q	3	Z	1
I	74	R	77	.....	

This number is around 0.066 for monoalphabetic ciphertexts

```
character_frequency( message )

[ 0.073, 0.009, 0.030, ..., 0.019, 0.001]
   M_a     M_b     M_c          M_y     M_z
```

Index of Coincidence

$$\sum_{i=A}^{Z} M_i^2 \approx 0.066$$

Probability of picking 2 A OR 2 B OR 2 C ...

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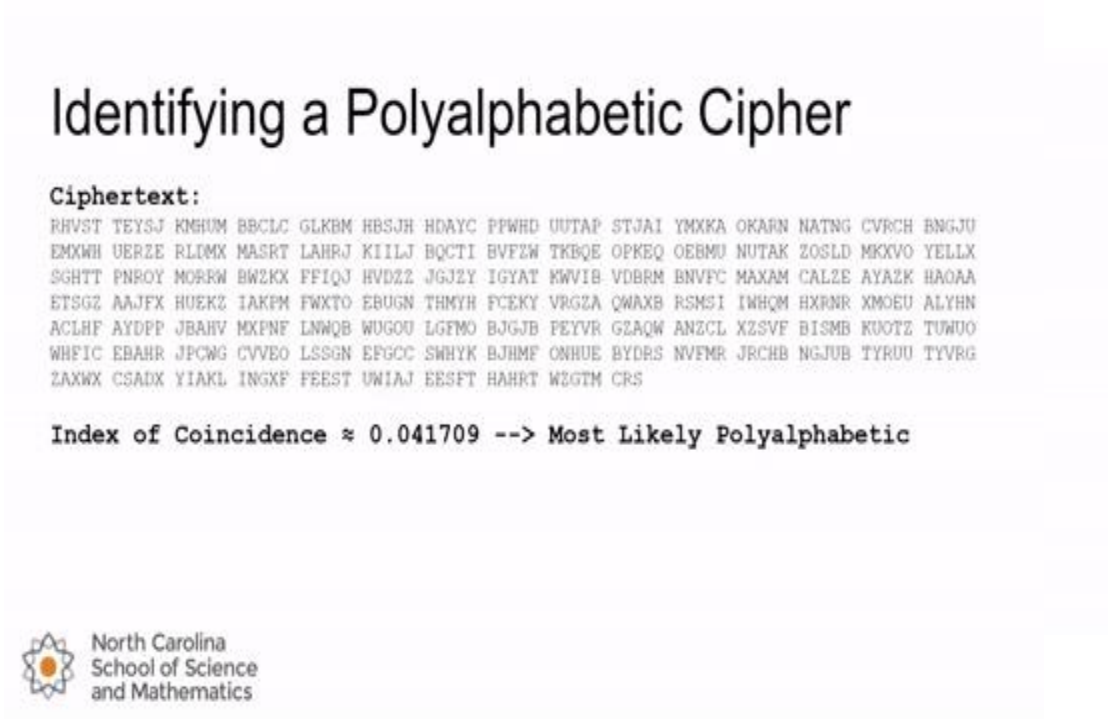
To identify a Polyalphabetic Cipher



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keyword length	Index of Coincidence
1	0.066
2	0.052
5	0.044
10	0.041
large	0.038

Example

```
JAKXQ SWECW MMJBK TQMCM LWCXJ BNEWS XKRBO IAOBI NOMLJ GUIMH
YTACF ICVOE BGOVC WYRCV KXJZV SMRXY VPOVB UBIJH OVCVK RXBOE
ASZVR AOXQS WECVO QJHSG ROXWJ MCXQF OIRGZ VRAOJ RJOMB DBMVS
CIESX MBDBM VSKRM GYFHA KXQSW ECWME UWXHD QDMXB KPUCN HWIWF
NFCKA SKXNF DLJBY RNOBI YFSQN HRIYV IWRQS WCGKC BHRVN SSWYF
SQNTS ZNWCT AWWIB SFIWW CTAWW IWWXI RGKRN LZIAW WIWHK PNFBS
ASVIE SXMBD BMVSK RMGYC NGKPU CNHWI WFNFC KASKX NFDLJ BYRNO
BIYFS QNHRI NBQMW SOVBO IWCVB INWCT AWWIO WFIRG ZVRAO WNJOR
RGZVR AORRB OMBDB MVSOP NJORR GZVRA OXQWB XNSXM BDBMV SPMOH
OIWWC TAWWI
```

Example

```
ABABA BABAB ABABA BABAB ABABA BABAB ABABA BABAB ABABA BABAB
JAKXQ SWECW MMJBK TQMCM LWCXJ BNEWS XKRBO IAOBI NOMLJ GUIMH


Group 1 (A): JKQWCMJKQCLCJNWXROABNMJUM...   I.C. = 0.06060
Group 2 (B): AXSEWMBTMMWXBESKBIOIOLGIH...   I.C. = 0.05624

                                            Avg. = 0.05842
```

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Example

```
ABCAB CABCA BCABC ABCAB CABCA BCABC ABCAB CABCA BCABC ABCAB
JAKXQ SWECW MMJBK TQMCM LWCXJ BNEWS XKRBO IAOBI NOMLJ GUIMH

Group 1 (A): JXWWJTCWJEXBAIMGM...          I.C. = 0.04405
Group 2 (B): AQEMBQMCBWKOONLUH...          I.C. = 0.05108
Group 3 (C): KSCMKMLXNSRIBOJI ...          I.C. = 0.04782

                                           Avg. = 0.04765
```

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Example

Key Length	Average I.C.
2	0.05842
3	0.04765
4	0.08340
5	0.04539
6	0.04539
7	0.04814
8	0.08125

A little higher than expected, but most likely candidate for the correct key length

This is also a likely candidate, but so are lengths of 12, 16, 20, etc. Why does that make sense if the key has length 4?

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The Algorithm

1. Assume key length, *n*, starting with a value of 2
2. Split ciphertext into *n* groups so that characters in the same group would have been enciphered using the same character of the keyword
3. Calculate the index of coincidence of each group
4. Calculate the average index of coincidence of all groups
5. If the average index of coincidence is "close" to the English value of ≈ 0.068 then assume *n* is the correct length
6. If not, increase *n* by 1 and start the process over

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How can we crack a Vigener cipher!!

Ciphertext

```
JAKXQ SWECW MMJBK TQMCM LWCXJ BNEWS XKRBO IAOBI NOMLJ GUIMH
YTACF ICVOE BGOVC WYRCV KXJZV SMRXY VPOVB UBIJH OVCVK RXBOE
ASZVR AOXQS WECVO QJHSG ROXWJ MCXQF OIRGZ VRAOJ RJOMB DBMVS
CIESX MBDBM VSKRM GYFHA KXQSW ECWME UWXHD QDMXB KPUCN HWIWF
NFCKA SKXNF DLJBY RNOBI YFSQN HRIYV IWRQS WCGKC BHRVN SSWYF
SQNTS ZNWCT AWWIB SFIWW CTAWW IWWXI RGKRN LZIAW WIWHK PNFBS
ASVIE SXMBD BMVSK RMGYC NGKPU CNHWI WFNFC KASKX NFDLJ BYRNO
BIYFS QNHRI NBQMW SOVBO IWCVB INWCT AWWIO WFIRG ZVRAO WNJOR
RGZVR AORRB OMBDB MVSOP NJORR GZVRA OXQWB XNSXM BDBMV SPMOH
OIWWC TAWWI
```

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Find out key length is 4 by I.C.

Ciphertext

1234

JAKXQ SWECW MMJBK TQMCM LWCXJ BNEWS XKRBO IAOBI NOMLJ GUIMH
YTACF ICVOE BGOVC WYRCV KXJZV SMRXY VPOVB UBIJH OVCVK RXBOE
ASZVR AOXQS WECVO QJHSG ROXWJ MCXQF OIRGZ VRAOJ RJOMB DBMVS
CIESX MBDBM VSKRM GYFHA KXQSW ECWME UWXHD QDMXB KPUCN HWIWF
NFCKA SKXNF DLJBY RNOBI YFSQN HRIYV IWRQS WCGKC BHRVN SSWYF
SQNTS ZNWCT AWWIB SFIWW CTAWW IWWXI RGKRN LZIAW WIWHK PNFBS
ASVIE SXMBD BMVSK RMGYC NGKPU CNHWI WFNFC KASKX NFDLJ BYRNO
BIYFS QNHRI NBQMW SOVBO IWCVB INWCT AWWIO WFIRG ZVRAO WNJOR
RGZVR AORRB OMBDB MVSOP NJORR GZVRA OXQWB XNSXM BDBMV SPMOH
OIWWC TAWWI

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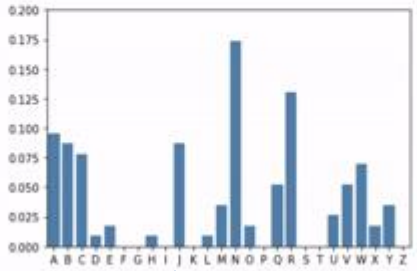
Group 1

JQCJQ LJWRA NJMAC BCCJM VBJCX ARQCJ RJQRR RBVEB VMRQC UDXUW
NANJN YNYRC BNYNN ABWAW RNAWN AEBVM NUWNA NJNYN NWBCN AORRN
RRRBV NRRQN BVOWA



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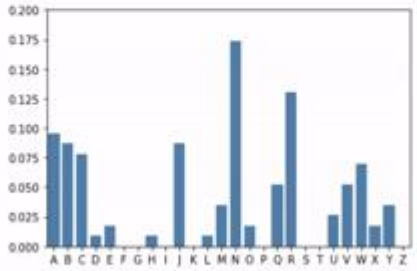
A

Group 1

JQCJQ LJWRA NJMAC BCCJM VBJCX ARQCJ RJQRR RBVEB VMRQC UDXUW
NANJN YNYRC BNYNN ABWAW RNAWN AEBVM NUWNA NJNYN NWBCN AORRN
RRRBV NRRQN BVOWA



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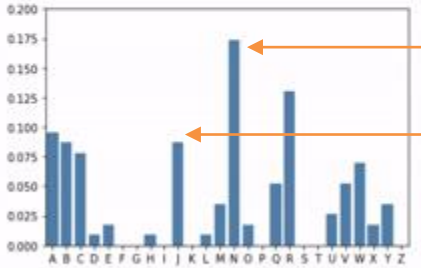
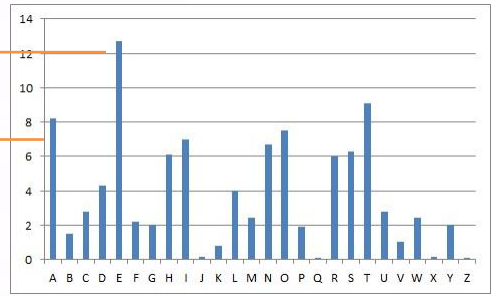
A

Group 1

JQCJQ LJWRA NJMAC BCCJM VBJCX ARQCJ RJQRR RBVEB VMHQC UDXUW
NANJN YNYRC BNYNN ABWAW RNAWN AEBVM NUWNA NJNYN NWBCN AORRN
RRRBV NRRQN BVOWA





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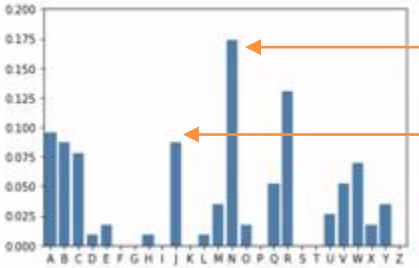
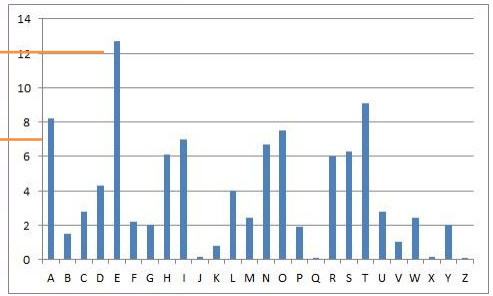
Shit 9 like a Caesar cipher

How can we find out the right shift

Group 1

JQCJQ LJWRA NJMAC BCCJM VBJCX ARQCJ RJQRR RBVEB VMHQC UDXUW
NANJN YNYRC BNYNN ABWAW RNAWN AEBVM NUWNA NJNYN NWBCN AORRN
RRRBV NRRQN BVOWA





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Shift 9 like a Caser cipher

$$\text{I.C.} = \frac{\sum_{i=A}^{i=Z}(f_i+f_{i+k'})(f_i+f_{i+k'}-1)}{(N+N')(N+N'-1)} \; where \; 0 \leq k < 26$$

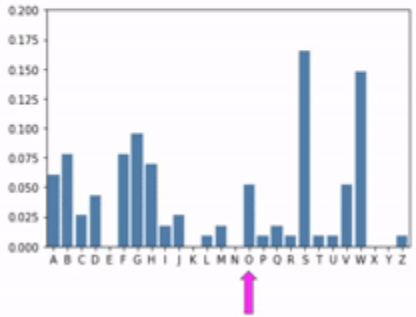
$$\sum_{i=A}^{i=Z}\left(f_i^2 + f_i'^2 + 2f_i\, f'_{i+k} - f_i - f_{i+k}'\right)$$

$$= \sum_{i=A}^{i=Z} f_i^2 + \sum_{i=A}^{i=Z} f_{i+k}'^2 + \mathbf{2}\sum_{\boldsymbol{i=A}}^{\boldsymbol{i=Z}} \boldsymbol{f_i f'_{i+k}} - \sum_{i=A}^{i=Z} f_i - \sum_{i=A}^{i=Z} f'_{i+k}$$

$$\sum_{i=A}^{i=Z} f_i f'_{i+k} = 3(2) + 4(2) + 5(1) + \cdots + 0(2) + 5(6)$$

Group 2

ASWBM WBSBO OGHCV GWVZR PUHVB SASVH OMFGA JDSSD SGASW WQBCI
FSFBO FHVQG HSFTW WSWWW GLWHF SSDSG GCIFS FBOFH BSOVW WWGAJ
GABDS JGAWS DSHWW



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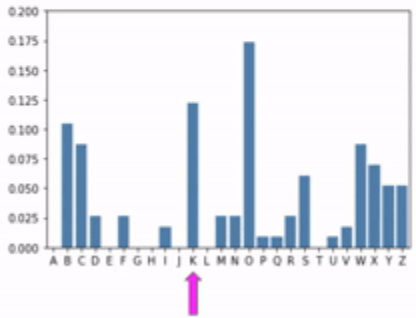
```
 0 (A):   325.7668
 1 (B):   883.3711
 2 (C):  4317.3209
 3 (D):   611.5731
 4 (E):   893.7738
 5 (F):   751.9344
 6 (G):  3896.8727
 7 (H):  1589.9641
 8 (I):  1479.7620
 9 (J):  2843.9011
10 (K):  1107.8685
11 (L):   991.7172
12 (M):   751.9465
13 (N):  2039.9947
14 (O):    50.3009
15 (P):  1265.0717
16 (Q):  1414.7607
17 (R):  1465.7353
18 (S):   553.8066
19 (T):  4314.7729
20 (U):   459.8573
21 (V):  2343.4717
22 (W):  1096.8136
23 (X):  4275.2646
24 (Y):  1108.1107
25 (Z):  1788.0592
```

A

Group 3

KWMKC CNXOB MUYFO OYKVX OBOKO ZOWOS XCOZO OBCXB KYKWM XDKNW
CKDYB SRISK RSSSC WFCWX KZWKB VXBKY KNWCK DYBSR QOIBC WFZOO
ZOOBO OZOBX BPOCW



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```
 0 (A):  1046.2090
 1 (B):  1561.0377
 2 (C):  2470.9050
 3 (D):  1353.3253
 4 (E):  1357.3504
 5 (F):  2957.6687
 6 (G):  1232.2920
 7 (H):   797.8171
 8 (I):   705.6488
 9 (J):   886.3809
10 (K):    58.9651
11 (L):  3622.6714
12 (M):  1265.4848
13 (N):  2159.6061
14 (O):   552.4254
15 (P):  5049.3125
16 (Q):   549.0219
17 (R):  2475.0480
18 (S):  1151.4112
19 (T):  1490.7523
20 (U):  2040.6587
21 (V):   491.1330
22 (W):   340.3210
23 (X):  1335.5712
24 (Y):  4497.8480
25 (Z):  1250.2771
```

A

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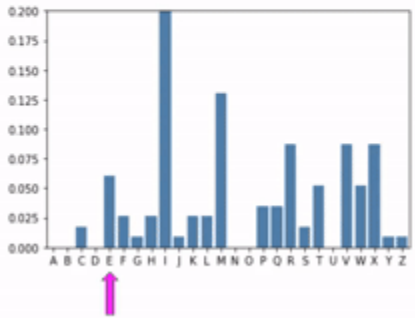
Group 4

XEMTM XEKII LITIE VRXSY VIVRE VXEQG WXIVJ MMIMM RFXEE HMPHF
KXLRI QIWWC VWQZT IITII RIIPS IMMRC PHFKX LRIQI MVWIT IIVWR
VRMMP RVXXM MMITI



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```
 0 (A):   921.3981
 1 (B):  1117.8622
 2 (C):   549.3962
 3 (D):  1852.3085
 4 (E):    38.6190
 5 (F):  1604.6688
 6 (G):   844.3241
 7 (H):  1705.8365
 8 (I):   789.9132
 9 (J):  6101.7858
10 (K):   579.6742
11 (L):  3365.3096
12 (M):   917.9620
13 (N):  3284.8424
14 (O):  1296.2255
15 (P):  1477.7176
16 (Q):   391.4905
17 (R):   536.4596
18 (S):  6139.4866
19 (T):   439.6708
20 (U):  1199.8803
21 (V):   525.0241
22 (W):  3700.5745
23 (X):   638.0083
24 (Y):  2118.7299
25 (Z):  3423.9338
```

A

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Ciphertext: Keyword = JOKE

```
JAKXQ SWECW MMJBK TQMCM LWCXJ BNEWS XKRBO IAOBI NOMLJ GUIMH
YTACF ICVOE BGOVC WYRCV KXJZV SMRXY VPOVB UBIJH OVCVK RXBOE
ASZVR AOXQS WECVO QJHSG ROXWJ MCXQF OIRGZ VRAOJ RJOMB DBMVS
CIESX MBDBM VSKRM GYFHA KXQSW ECWME UWXHD QDMXB KPUCN HWIWF
NFCKA SKXNF DLJBY RNOBI YFSQN HRIYV IWRQS WCGKC BHRVN SSWYF
SQNTS ZNWCT AWWIB SFIWW CTAWW IWWXI RGKRN LZIAW WIWHK PNFBS
ASVIE SXMBD BMVSK RMGYC NGKPU CNHWI WFNFC KASKX NFDLJ BYRNO
BIYFS QNHRI NBQMW SOVBO IWCVB INWCT AWWIO WFIRG ZVRAO WNJOR
RGZVR AORRB OMBDB MVSOP NJORR GZVRA OXQWB XNSXM BDBMV SPMOH
OIWWC TAWWI
```

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Plaintext

amath emati ciana physi cista ndane ngine erare eacha skedt
oprov ethea ssert ionth atall oddnu mbers great ertha nonea
repri methe mathe matic iansa ysthr eeisp rimef iveis prime
seven ispri meand sobym athem atica lindu ction allod dnumb
ersgr eater thano neare prime theph ysici stsay sthre eispr
imefi veisp rimes eveni sprim enine isane xperi menta lerro
relev enisp rimea ndsoy esall oddnu mbers great ertha nonea
repri methe engin eersa ysthr eeisp rimef iveis prime seven
ispri menin eispr imeel eveni sprim ethir teeni sprim efift
eenis prime

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