Vigenere

June 20, 2025

[63]:
```
Alphabet =␣
 ↪['A','B','C','D','E','F','G','H','I','J','K','L','M','N','O','P','Q','R','S','T','U','V','W

Unscaled = [8.2, 1.5, 2.8, 4.3, 12.7, 2.2, 2.0, 6.1, 7.0, 0.15, 0.77, 4.0, 2.4,␣
 ↪6.7, 7.5, 1.9, 0.095, 6.0, 6.3, 9.1, 2.8, 0.98, 2.4, 0.15, 2.0, 0.074]

EnglishFreqs = [i/100 for i in Unscaled]

def CleanText(Text):   #Removes all characters that are not a space or in the␣
 ↪English alphabet.
    CleanText = ""
    for Char in Text:
        if Char.upper() in Alphabet or Char == " ":
            CleanText = CleanText + Char.upper()
    return(CleanText)

def RemoveSpaces(Text):   #Removes all spaces
    NoSpaceText = ""
    for Char in Text:
        if Char.upper() in Alphabet:
            NoSpaceText = NoSpaceText + Char.upper()
    return(NoSpaceText)

def CharacterCount(Text):   #Counts the number of times each letter appears in␣
 ↪Text.
    CharacterCount = [0] * 26
    for Char in Text:
        if Char.upper() in Alphabet:
            k = Alphabet.index(Char.upper())
            CharacterCount[k] = CharacterCount[k] + 1
    return(CharacterCount)

def Frequencies(Text):   #Gives the frequency of each letter in Text
    LenNoSpaces = len(RemoveSpaces(CleanText(Text)))
    Frequencies = [i/LenNoSpaces for i in CharacterCount(Text)]
    return(Frequencies)
```

```
def CompareFreqs(Freqs1, Freqs2):    #Produces a bar chart comparing two␣
↪frequency distributions.
    Freqs1Spaced = []
    Freqs2Spaced = []
    for i in range(26):
        Freqs1Spaced.append(Freqs1[i])
        Freqs1Spaced.append(0)
        Freqs1Spaced.append(0)
        Freqs2Spaced.append(0)
        Freqs2Spaced.append(Freqs2[i])
        Freqs2Spaced.append(0)
    G=Graphics()
    G += bar_chart(Freqs1Spaced, axes = False, width = 0.8)
    G += bar_chart(Freqs2Spaced, rgbcolor=(1,0,0), axes = False, width = 0.8)
    return(G)

def Grouping(Text, Group):    #Arranges the input text into groups of size Group.
    Count = 0
    GroupedText = ""
    for Char in Text:
        if Char.upper() in Alphabet:
            if Count > 0 and Count % Group == 0:
                GroupedText = GroupedText + " " + Char.upper()
            else:
                GroupedText = GroupedText + Char.upper()
            Count = Count + 1
    return(GroupedText)

def ShiftEncryption(Text, Shift):    #Encrypts Text by shifting each letter by␣
↪the number Shift.
    CryptText = ""
    for Char in Text:
        if Char == " ":
            CryptText = CryptText + " "
        elif Char.upper() in Alphabet:
            CryptText = CryptText + Alphabet[(Alphabet.index(Char.upper()) +␣
↪Shift) % 26]
    return(CryptText)

def ShiftDecryption(Text, Shift):    #Reverses ShiftEncryption
    DecryptText = ShiftEncryption(Text, -Shift)
    return(DecryptText)

def SubEncryption(Text, Permutation):    #Encryption using a substitution cipher
    PermAlphabet = Permutation.action(Alphabet)
    CryptText = ""
    for Char in Text:
        if Char.upper() in Alphabet:
            CryptText = CryptText+PermAlphabet[Alphabet.index(Char)]
        else:
            CryptText = CryptText + Char
    return CryptText

def SubDecryption(Text, Permutation):    #Decryption using a substitution cipher
    return SubEncryption(Text, Permutation.inverse())

def IndexOfCoincidence(Text):
    CharacterCount = [0] * 26   #Initialise a list of 26 copies of 0.
    for Char in Text:
        if Char.upper() in Alphabet:   #Loop over every character in the input␣
 ↪test, exclude non-letters.
            i = Alphabet.index(Char.upper())   #Find the position of the␣
 ↪character in the alphabet.
            CharacterCount[i] = CharacterCount[i] + 1   #Add 1 to the position␣
 ↪of that character.
    Sum = 0
    N = len(RemoveSpaces(CleanText(Text)))   #N is the total number of letters␣
 ↪in the input. We ignore spaces.
    for i in CharacterCount:
        if i > 0:
            Sum = Sum + ( i * (i-1) ) / ( N * (N-1) )
    return(Sum.numerical_approx(digits = 4))

def IndexOfCoincidence(Text):
    CharacterCount = [0] * 26
    for Char in Text:
        if Char.upper() in Alphabet:
            i = Alphabet.index(Char.upper())
            CharacterCount[i] = CharacterCount[i] + 1
    Sum = 0
    N = len(RemoveSpaces(CleanText(Text)))
    for i in CharacterCount:
        if i > 0:
            Sum = Sum + ( i * (i-1) ) / ( N * (N-1) )
    return(Sum.numerical_approx(digits = 4))

def RandomText(Length):   #Generates a text with Length characters, chosen␣
 ↪uniformly at random.
    Text = ""
    Count = 0
    while Count < Length:
        Text = Text + Alphabet[floor(random()*26)]
        Count = Count + 1
    return(Text)
```

```
def VigenereEncryption(Text, Key):   #Encrypts Text using the Vigenere ciper␣
↪with Key as the keyword.
    NumKey = []
    for Char in Key:
        NumKey.append(Alphabet.index(Char.upper()))
    LenKey = len(Key)
    CryptText = ""
    Count = 0
    for i in range(len(Text)):
        Char = Text[i].upper()
        if Char.upper() in Alphabet:
            CryptText = CryptText + Alphabet[(Alphabet.index(Char) +␣
↪NumKey[Count % LenKey]) % 26]
            Count = Count + 1
        else:
            CryptText = CryptText + Char
    return(CryptText)

def VigenereDecryption(Text, Key):   #Decrypts Text using the Vigenere ciper␣
↪with Key as the keyword.
    NumKey = []
    for Char in Key:
        NumKey.append(Alphabet.index(Char.upper()))
    LenKey = len(Key)
    Decrypt = ""
    Count = 0
    for i in range(len(Text)):
        Char = Text[i].upper()
        if Char.upper() in Alphabet:
            Decrypt = Decrypt + Alphabet[(Alphabet.index(Char) - NumKey[Count %␣
↪LenKey]) % 26]
            Count = Count + 1
        else:
            Decrypt = Decrypt + Char
    return(Decrypt)

def PeriodicTexts(Text, Period):   #Extracts every (Period)th letter from Text,␣
↪starting with position 0,1,2,...
    PeriodicTexts = [""] * Period
    NewText = RemoveSpaces(CleanText(Text))
    for i in range(len(NewText)):
        PeriodicTexts[i % Period] = PeriodicTexts[i % Period] + NewText[i]
    return(PeriodicTexts)

def ChiSquared(Text, Period, StartingPosition):
    ExtractedText = PeriodicTexts(Text, Period)[StartingPosition]  ␣
↪#ExtractedText consists of every (Period)th letter, starting with␣
↪StartingPosition
    N = len(ExtractedText)
    Counts = CharacterCount(ExtractedText)   #This counts the number of times␣
↪each letter appears in ExtractedText.
    ChiValues = []
    for Shift in range(26):
        Chi = 0
        for i in range(26):
            ShiftedFreq = EnglishFreqs[(i - Shift) % 26]   #This is the␣
↪frequency of letter i, shifted by Shift positions.
            Chi = Chi + (Counts[i] - ShiftedFreq * N)^2 / (ShiftedFreq * N)
        ChiValues.append(Chi)
    return(bar_chart(ChiValues))
```

[64]:
```
Permutation = Permutations(26).random_element()
```

[65]:
```
Text='RITE OF SPRING'
```

[66]:
```
SubEncryption(Text, Permutation)
```

[66]:
```
'HIRU TB DEHICF'
```

[67]:
```
SubDecryption('CEDY RH PUCEMB', Permutation)
```

[67]:
```
'NPSV TR ZENPBF'
```

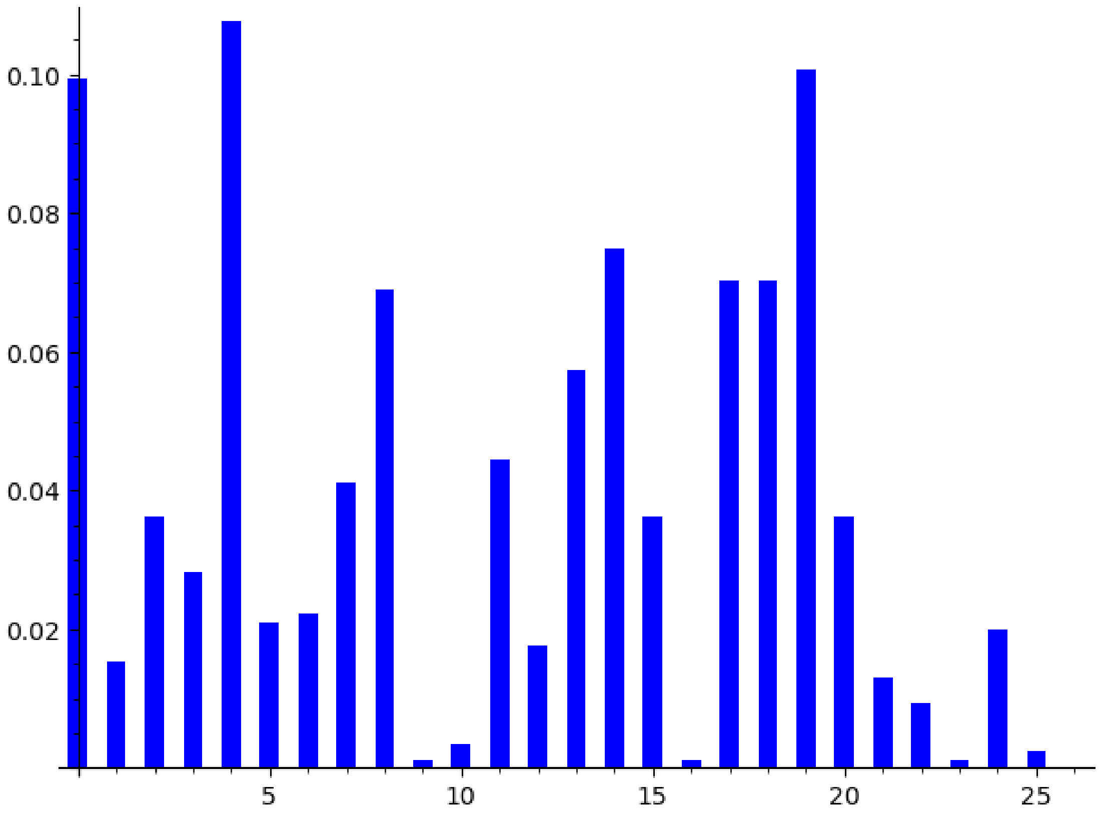
[68]:
```
TestText = CleanText("The various patterns of activity are thought to be mainly␣
↪antipredator adaptations, though some could equally well be predatory␣
↪adaptations.[4] Many predators forage most intensively at night, whereas␣
↪others are active at midday and see best in full sun. The crepuscular habit␣
↪may both reduce predation pressure, increasing the crepuscular populations,␣
↪and offer better foraging opportunities to predators that increasingly focus␣
↪their attention on crepuscular prey until a new balance is struck. Such␣
↪shifting states of balance are often found in ecology. Some predatory␣
↪species adjust their habits in response to competition from other predators.␣
↪For example, the subspecies of short-eared owl that lives on the Galápagos␣
↪Islands is normally active during the day, but on islands like Santa Cruz␣
↪that are home to the Galapagos hawk, the owl is crepuscular.[5][6] Apart␣
↪from the relevance to predation, crepuscular activity in hot regions also␣
↪may be the most effective way of avoiding heat stress while capitalizing on␣
↪available light.")
TestText
```

[68]:
```
'THE VARIOUS PATTERNS OF ACTIVITY ARE THOUGHT TO BE MAINLY ANTIPREDATOR
ADAPTATIONS THOUGH SOME COULD EQUALLY WELL BE PREDATORY ADAPTATIONS MANY
```

```
PREDATORS FORAGE MOST INTENSIVELY AT NIGHT WHEREAS OTHERS ARE ACTIVE AT MIDDAY
AND SEE BEST IN FULL SUN THE CREPUSCULAR HABIT MAY BOTH REDUCE PREDATION
PRESSURE INCREASING THE CREPUSCULAR POPULATIONS AND OFFER BETTER FORAGING
OPPORTUNITIES TO PREDATORS THAT INCREASINGLY FOCUS THEIR ATTENTION ON
CREPUSCULAR PREY UNTIL A NEW BALANCE IS STRUCK SUCH SHIFTING STATES OF BALANCE
ARE OFTEN FOUND IN ECOLOGY SOME PREDATORY SPECIES ADJUST THEIR HABITS IN
RESPONSE TO COMPETITION FROM OTHER PREDATORS FOR EXAMPLE THE SUBSPECIES OF
SHORTEARED OWL THAT LIVES ON THE GALPAGOS ISLANDS IS NORMALLY ACTIVE DURING THE
DAY BUT ON ISLANDS LIKE SANTA CRUZ THAT ARE HOME TO THE GALAPAGOS HAWK THE OWL
IS CREPUSCULAR APART FROM THE RELEVANCE TO PREDATION CREPUSCULAR ACTIVITY IN HOT
REGIONS ALSO MAY BE THE MOST EFFECTIVE WAY OF AVOIDING HEAT STRESS WHILE
CAPITALIZING ON AVAILABLE LIGHT'
```

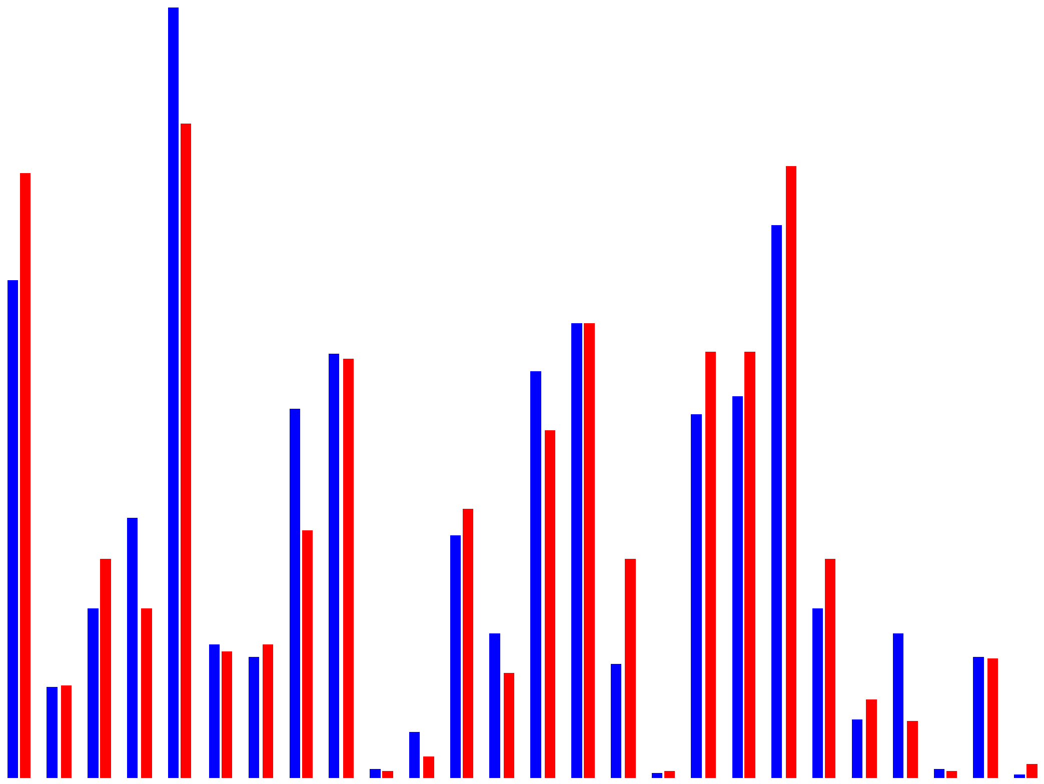
[69]:
```
bar_chart(Frequencies(TestText))
```

[69]:

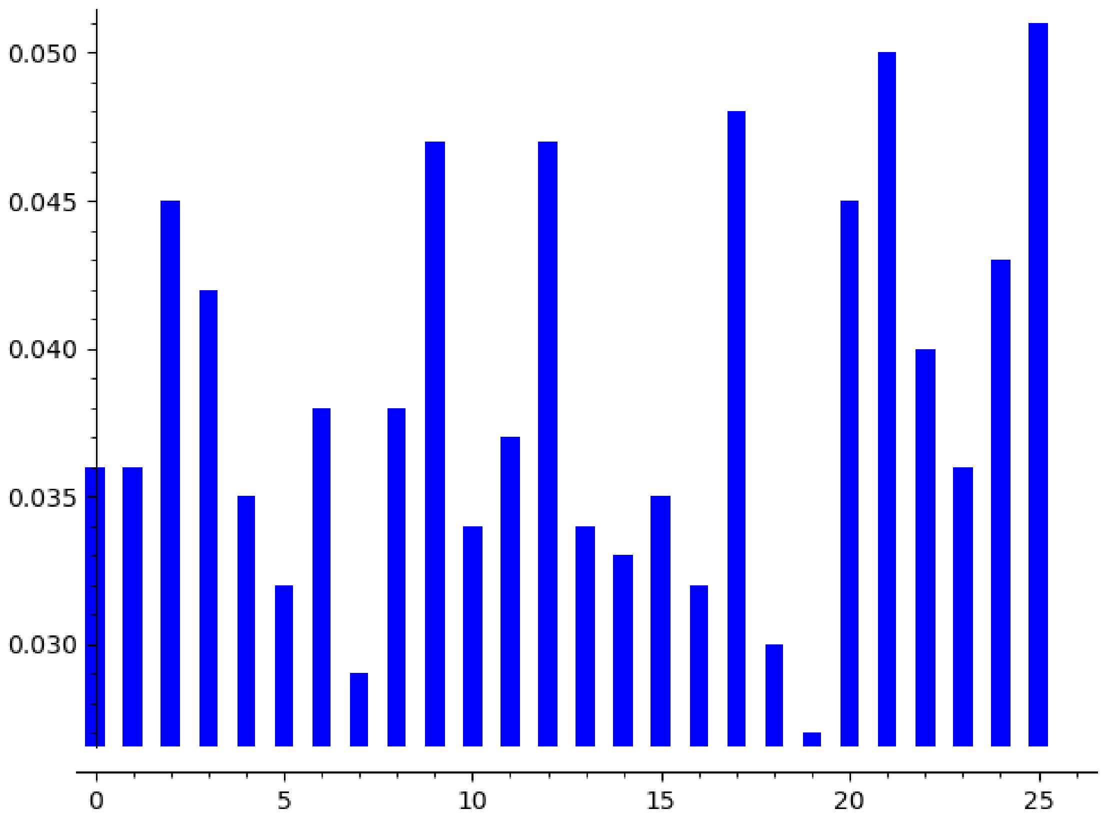


[70]:
```
CompareFreqs(EnglishFreqs, Frequencies(WikiText))
```

[70]:



```
[71]: bar_chart(Frequencies(RandomText(1000)))
[71]:
```



```
[72]: IndexOfCoincidence(RandomText(1000))
```

```
[72]: 0.03902
```

```
[73]: IndexOfCoincidence(TestText)
```

```
[73]: 0.06466
```

```
[78]: PlainText=Grouping(RemoveSpaces(CleanText('History is the systematic study of␣
        ↪the past, focusing primarily on the human past. As an academic discipline,␣
        ↪it analyses and interprets evidence to construct narratives about what␣
        ↪happened and explain why and how it happened. Some theorists categorize␣
        ↪history as a social science, while others see it as part of the humanities␣
        ↪or consider it a hybrid discipline. Similar debates surround the purpose of␣
        ↪history-for example, whether its main aim is theoretical, to uncover the␣
        ↪truth, or practical, to learn lessons from the past. In a more general␣
        ↪sense, the term history refers not to an academic field but to the past␣
        ↪itself, times in the past, or to individual texts about the past.')),5)
      PlainText
```

[78]:
```
'HISTO RYIST HESYS TEMAT ICSTU DYOFT HEPAS TFOCU SINGP RIMAR ILYON THEHU MANPA
STASA NACAD EMICD ISCIP LINEI TANAL YSESA NDINT ERPRE TSEVI DENCE TOCON STRUC
TNARR ATIVE SABOU TWHAT HAPPE NEDAN DEXPL AINWH YANDH OWITH APPEN EDSOM ETHEO
RISTS CATEG ORIZE HISTO RYASA SOCIA LSCIE NCEWH ILEOT HERSS EEITA SPART OFTHE
HUMAN ITIES ORCON SIDER ITAHY BRIDD ISCIP LINES IMILA RDEBA TESSU RROUN DTHEP
URPOS EOFHI STORY FOREX AMPLE WHETH ERITS MAINA IMIST HEORE TICAL TOUNC OVERT
HETRU THORP RACTI CALTO LEARN LESSO NSFRO MTHEP ASTIN AMORE GENER ALSEN SETHE
TERMH ISTOR YREFE RSNOT TOANA CADEM ICFIE LDBUT TOTHE PASTI TSELF TIMES INTHE
PASTO RTOIN DIVID UALTE XTSAB OUTTH EPAST'
```

[81]:
```python
CryptText = VigenereEncryption(PlainText, 'PANIC')
CryptText
```

[81]:
```
'WIFBQ GYVAV WEFGU IEZIV XCFBW SYBNV WECIU IFBKW HIAOR GIZIT XLLWP IHRPW BAAXC
HTNAC CAPIF TMVKF XSPQR AIAMK IAAIN NSRAC CDVVV TRCZG ISRDK SEAKG IOPWP HTECE
INNZT PTVDG HAOWW IWUIV WACXG CEQIP SEKXN PIAEJ NAALJ DWVBJ PPCMP TDFWO TTUMQ
GIFBU RAGMI DRVHG WIFBQ GYNAC HOPQC ASPQG CCREJ XLRWV WEEAU TEVBC HPNZV DFGPG
WUZIP XTVMU DRPWP HIQMT XTNPA QRVLF XSPQR AIAMU XMVTC GDRJC IEFAW GRBCP STUMR
JRCWU TOSPK HTBZA UOEMZ PMCTG LHRBJ TRVBU BAVVC XMVAV WEBZG IIPIN IOHVE DVRZV
WEGZW IHBZR GAPBK RAYBQ AENZP AEFAQ CSSZQ BTUMR PSGQP PMBZG VEAMT PLFMP HEGPG
IEEUJ XSGWT NRRNG GSAWV IONVC RAQMO XCSQG ADOCV IOGPG EAFBK ISRTH IIZMU XNGPG
EAFBQ GTBQP SIIQF JAYBG MTFID DUGBJ TPNAV'
```

[82]:
```python
PeriodicTexts(CryptText, 3)
```

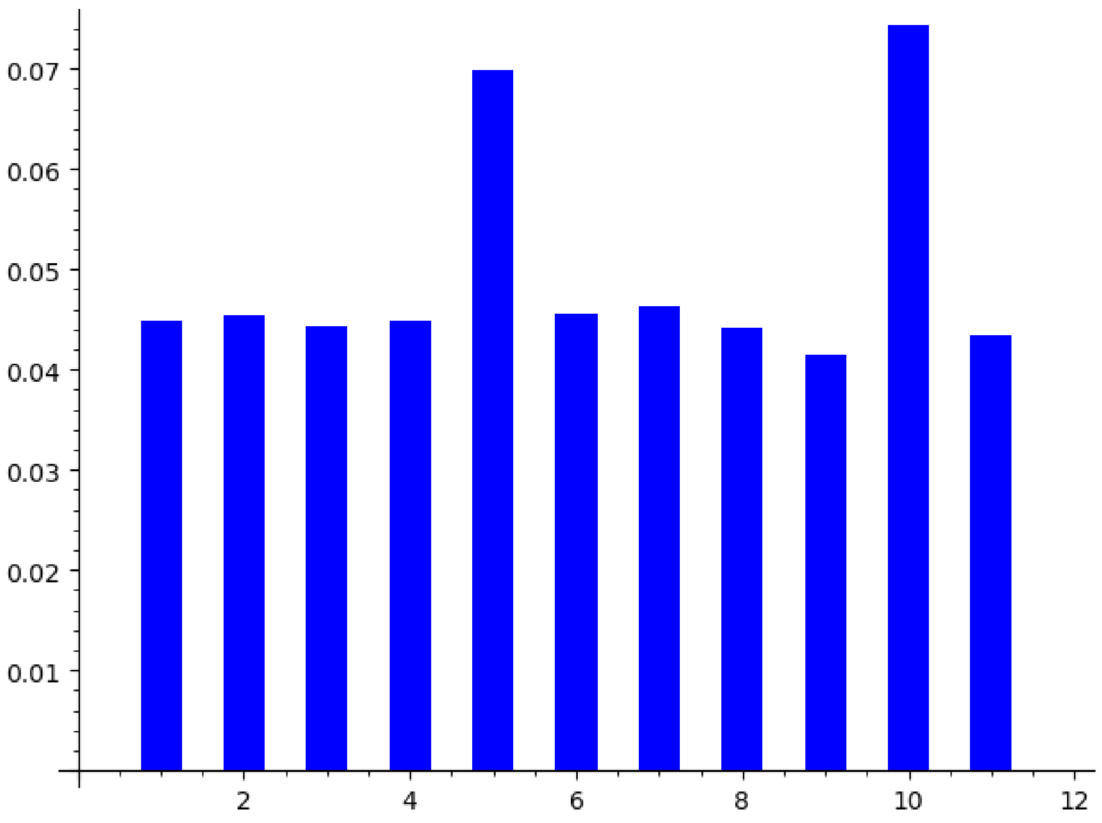
[82]:
```
['WBYVFIICWBWIFWAGILPRBXTCPTKSRAIISCVTZSKAIWTENPDAWUWXEPKPEAJVPMDOUGBAIVWBYCPAQC
JRWAECNDPUPVDWITNQLSRAXTDCFGCTRCTPTAEPTHJVBVMVBIIOERWZHRPRBEPFCZTRGPZETFHPEJGNNS
VNRMCGOIPAKRIMNGFGQIFYMIUJN',
 'IQVWGEVFSNEUBHOITLIPACNCIMFPAMANRCVRGRSKOPEIZTGOIIAGQSXIJADBPPFTMIUGDHIQNHQSGR
XWEUVHZFGZXMRPQXPRFPAMMCRIARPUJWOKBUMMGRTBACVWZINHDZEWBGBAQNAASQUPQMGAPMEGEXWRGA
IVAOSACOGFITIUGEBTPIJBTDGTA',
 'FGAEUZXBYVCIKIRZXWHWAHAAFVXQIKANADVCIDEGPHCNTVHWWVCCIENANLWJCTWTQFRMRGFGAOCPCE
LVETBPVGWITUPHMTAVXQIUVGJEWBSMRUSHZOZCLBRUVXAEGPIVVVGIZAKYAZEQSBMSPBVMLPGIUSTRGW
OCQXQDVGEBSHZXPAQBSQAGFDBPV']
```

[83]:
```python
IndexOfCoincidence(PeriodicTexts(CryptText, 6)[3])
```

[83]:
```
0.04945
```

[84]:
```python
MeanIndices = [0]
for Period in range(1,12):
    PTexts = PeriodicTexts(CryptText, Period)
    Indices = []
    for i in range(Period):
        Indices.append(IndexOfCoincidence(PTexts[i]))
    MeanIndices.append(mean(Indices))
bar_chart(MeanIndices)
```

[84]:

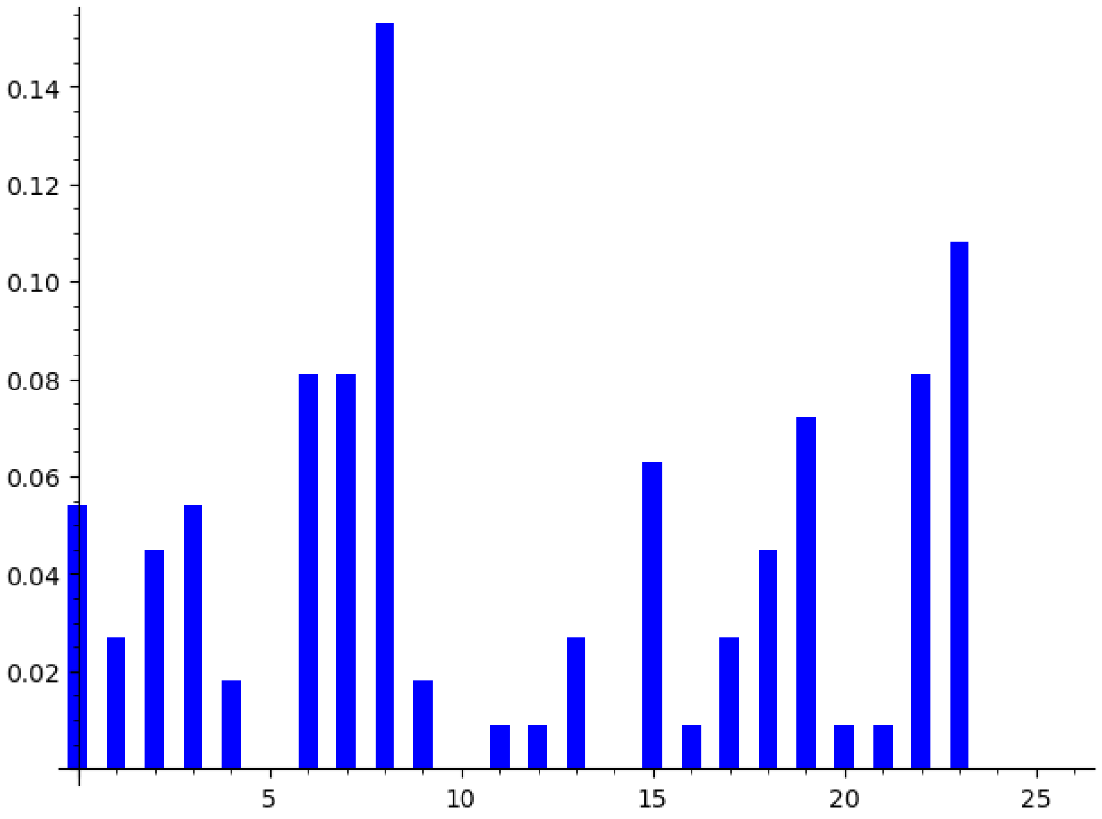


```
[87]: PTexts = PeriodicTexts(CryptText, 5)
      PTexts
```

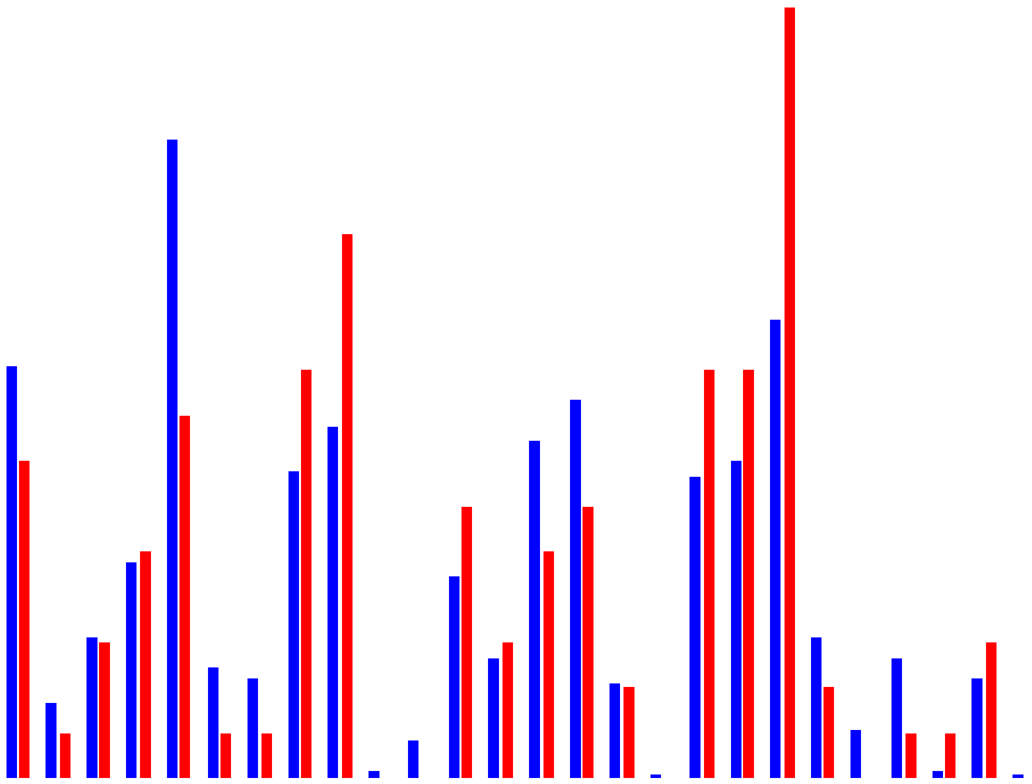
```
[87]: ['WGWIXSWIHGXIBHCTXAINCTISIHIPHIWCSPNDPTTGRDWGHACXWTHDWXDHXQXAXGIGSJTHUPLTBXWIID
      WIGRAACBPPVPHIXNGIRXAIEIIXEGSJMDT',
       'IYEECYEFIILHATAMSIASDRSEOTNTAWAEEIAWPDTIARIYOSCLEEPFUTRITRSIMDERTROTOMHRAMEIOV
      EHAAEESTSMELEESRSOACDOASINATIATUP',
       'FVFZFBCBAZLRANPVPAARVCRAPENVOUCQKAAVCFUFGVFNPPRREVNGZVPQNVPAVRFBUCSBECRVVVBPHR
      GBPYNFSUGBAFGEGRANQSOGFRZGFBIYFGN',
       'BAGIBNIKOIWPXAIKQMIAVZDKWCZDWIXIXELBMWMBMHBAQQEWABZPIMWMPLQMTJACMWPZMTBBVAZIVZ
      ZZBBZAZMQZMMPUWNWVMQCPBTMPBQQBIBA',
       'QVUVWVUWRTPWCCFFRKNCVGKGPETGWVGPNJJJPOQUIGQCCGJVUCVGPUPTAFRUCCWPRUKAZGJUCVGNEV
      WRKQPQQRPGTPGJTGVCOGVGKHUGQPFGDJV']
```

```
[90]: bar_chart(Frequencies(PTexts[0]))
```

```
[90]:
```



```
[94]: CompareFreqs(EnglishFreqs, Frequencies(ShiftEncryption(PTexts[0],-15)))
[94]:
```

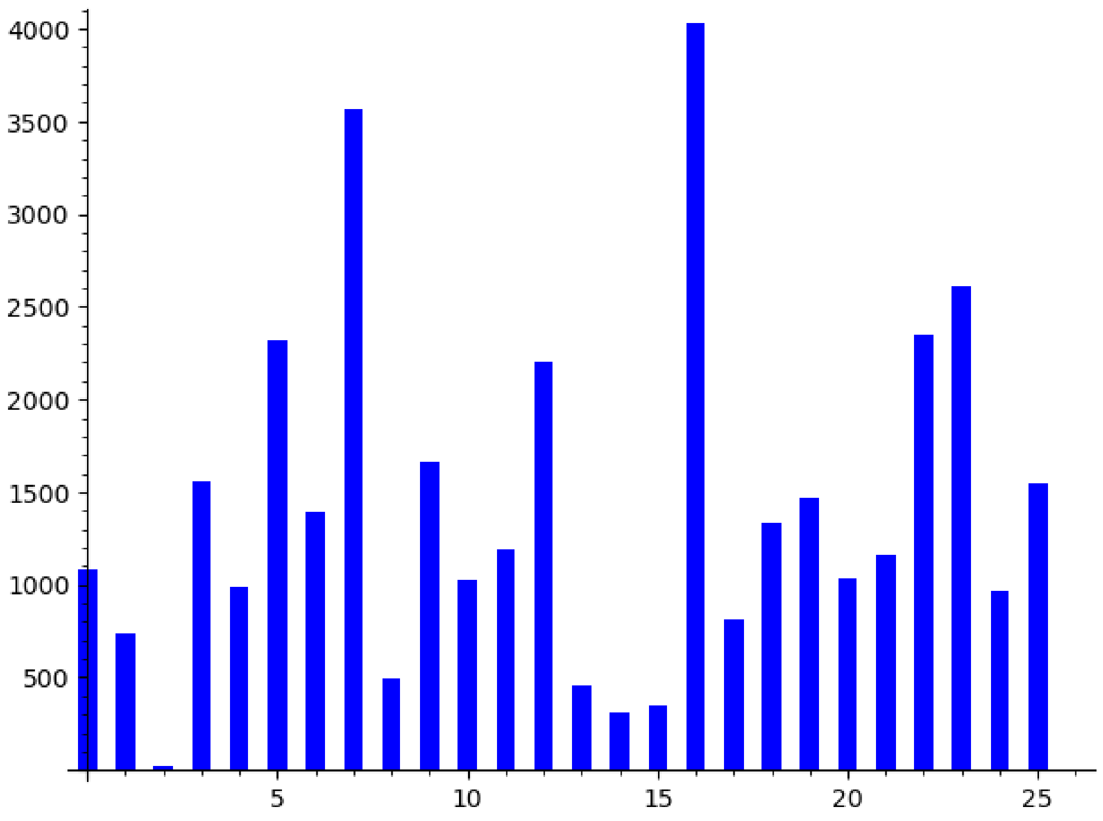


```
[106]: Alphabet[15]
```

```
[106]: 'P'
```

```
[104]: ChiSquared(CryptText, 5, 4)
```

```
[104]:
```



```
[108]: RemoveSpaces(VigenereDecryption(CryptText,'PANIC'))
```

```
[108]: 'HISTORYISTHESYSTEMATICSTUDYOFTHEPASTFOCUSINGPRIMARILYONTHEHUMANPASTASANACADEMIC
       DISCIPLINEITANALYSESANDINTERPRETSEVIDENCETOCONSTRUCTNARRATIVESABOUTWHATHAPPENEDA
       NDEXPLAINWHYANDHOWITHAPPENEDSOMETHEORISTSCATEGORIZEHISTORYASASOCIALSCIENCEWHILEO
       THERSSEEITASPARTOFTHEHUMANITIESORCONSIDERITAHYBRIDDISCIPLINESIMILARDEBATESSURROU
       NDTHEPURPOSEOFHISTORYFOREXAMPLEWHETHERITSMAINAIMISTHEORETICALTOUNCOVERTHETRUTHOR
       PRACTICALTOLEARNLESSONSFROMTHEPASTINAMOREGENERALSENSETHETERMHISTORYREFERSNOTTOAN
       ACADEMICFIELDBUTTOTHEPASTITSELFTIMESINTHEPASTORTOINDIVIDUALTEXTSABOUTTHEPAST'
```

```
[11]: # Can you decode the following crypttext?
```

```
CryptText = "PBLPK GMZAE OBEEG RIGCZ TITBA NLSRW WJFWJ HWGWV ITURL LCMQF VMXBL␣
 ↪RVMPM WFWZG KIYUL CIBRJ WKGMN ULEAI CLITM PRHPC RMEAW VTAXW HYBBU VIHXI␣
 ↪GARIX DRJCG GMZQA KMPZW PGXIA VVCGO RVEVM IPCWC WLVLM QGIYE IVAWQ KEXTQ␣
 ↪YSFNX BBLLG ITNQI TBVPD YFXSA GGMBV TGYVX VREMG LEVLL CWWBJ EPWNV FMUAQ␣
 ↪AYQQO MFWEE AAGSK GAIFS ZCKQR VHGLQ TFGQF XBKIF HNYSV IXWCW RTHWZ KAKMP␣
 ↪ZSRAP ILKJQ KMAWQ KXAGG ERIZB SGJMP RHPCR MEESU MKUST VXZFZ EXXBU WTNTG␣
 ↪RJXCD MPGRV KWYGJ CWQSX ITXVG ULCKI PLITX IPZGJ TZNUX GKJRZ EXXAQ AJHXZ␣
 ↪RFXNR XBKWG LAVFK WGQDM ICUQY AXKXA YAOGW WQYMP ZWEVI HXIGA RIHXC GRGGB␣
 ↪FFSPE MGZEN EGFGQ GVPNJ EEMME KGCGK UGSUX NEGQC LMYWG VBWAG JYXIC GRUHZ␣
 ↪ZSWML BUWPC MBRJS HPPVU LOHLV XMGLB UWMTT JVDMV BMFVI RXVQA RIHVG ZIOTA␣
 ↪XULQL MA"
CryptText
```

```
[11]: 'PBLPK GMZAE OBEEG RIGCZ TITBA NLSRW WJFWJ HWGWV ITURL LCMQF VMXBL RVMPM WFWZG
      KIYUL CIBRJ WKGMN ULEAI CLITM PRHPC RMEAW VTAXW HYBBU VIHXI GARIX DRJCG GMZQA
      KMPZW PGXIA VVCGO RVEVM IPCWC WLVLM QGIYE IVAWQ KEXTQ YSFNX BBLLG ITNQI TBVPD
      YFXSA GGMBV TGYVX VREMG LEVLL CWWBJ EPWNV FMUAQ AYQQO MFWEE AAGSK GAIFS ZCKQR
      VHGLQ TFGQF XBKIF HNYSV IXWCW RTHWZ KAKMP ZSRAP ILKJQ KMAWQ KXAGG ERIZB SGJMP
      RHPCR MEESU MKUST VXZFZ EXXBU WTNTG RJXCD MPGRV KWYGJ CWQSX ITXVG ULCKI PLITX
      IPZGJ TZNUX GKJRZ EXXAQ AJHXZ RFXNR XBKWG LAVFK WGQDM ICUQY AXKXA YAOGW WQYMP
      ZWEVI HXIGA RIHXC GRGGB FFSPE MGZEN EGFGQ GVPNJ EEMME KGCGK UGSUX NEGQC LMYWG
      VBWAG JYXIC GRUHZ ZSWML BUWPC MBRJS HPPVU LOHLV XMGLB UWMTT JVDMV BMFVI RXVQA
      RIHVG ZIOTA XULQL MA'
```