Project 2: Substitution Cipher Hacker

PA2Hacker.py: hacks the encrypted text.

Terminal Command: python3 PA2Hacker.py cipher1.txt

PA2Reader.py: makes the original text into encrypted text.

Terminal Comand: python3 PA2Reader.py test1.txt > cipher1.txt

Abstract:

Substitution Cipher is the replacement of a text’s original char into another based on a key-code. This technique was once used to hide individuals’ passwords, but it is very weak in terms of security. This project would be to create a program that can hack an encrypted text and discover the text’s key code.

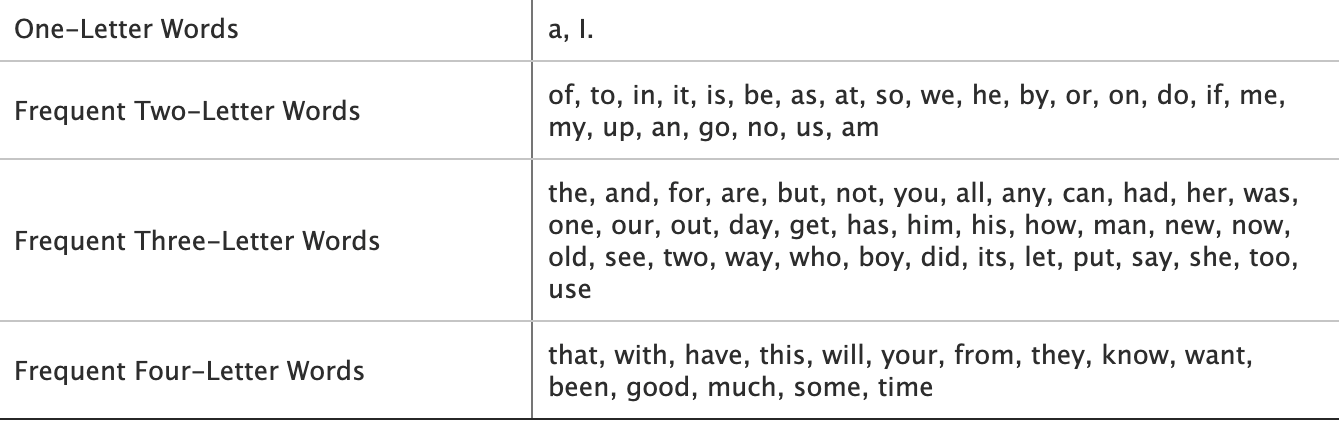
For this program, I downloaded and uploaded a 496K word-list into the program, to check if the letter combination is in fact a viable word.

Algorithm:

The algorithm I used, though slow but accurate.

It can be divided into 4 parts: divide the encrypted text into list form, deduce simple and short words like ‘a’ and ‘I’ and add them to the global dictionary, try the word with single letter missing, and try all words that have the same single letter missing. Each time a word is formed, the program would search the dictionary to make sure if the word is actually an English word. Finally, the program would calculate the difference between the key produced by the program and the expected key (the sample key provided).

1. Divide the encrypted text into list: In this process, I divided the text by spaces and removed punctuations like: period, comma, questions mark, etc.
2. Deductions for simple words: this part is a bit tricky. Due to the unpredictable order of the words that appear in the text, I first looked for the word I know is 100% right: the lower case ‘a.’ In the English word, the most common single letter word to appear in text is I and a. But since I is less common and an encrypted capitalized single letter can be both I and A, it is unsafe to assume it is I. In comparison, a lowercase single letter is 100% ‘a.’ Thus we would first search for ‘a’ then search a capitalized ‘I.’ After the search for a and I is complete, I search for the next most common two letter words: as and at. When S and T are found, I search through the text list to deduce any other words that I am 100% sure is accurate. To be 100% sure, I could only deduce few key codes, thus the next process, Try All Words, would be the most time consuming. The table below is how I chose the most common words that I can be sure it would appear, of course, most of the words have combinations that overlap one another. Such words would be ignored and left for the next step to solve.



1. Words with Single Letter Missing Tryout: This step is to identify all words with only one single letter missing (letter that is not added to the global key code dictionary). We would isolate the alphabets not yet coupled with the encryption key and append them to a list, meaning such alphabet would be the letter the missing key code represents. Once the missing letter list is obtained, we added the letters from the list one by one to words with the same single missing letter. The idea is: if one letter works for the word, then that letter should also work for the rest of the words. The way I made sure the word works is by searching through the dictionary. In the beginning I tried “if word in dictionary-list” instead of using a for-loop to comparing every single word in the dictionary, but the program would abruptly end. Thus, I ended up using a for-loop instead.
   1. Before I began the tryout function, I organized a dictionary named First, that finds words with three characteristic: 1) words that only have one letter missing, 2) words that have the same letter missing and 3) most words that fulfill that conditions 1 and 2. Thus ‘First’ would be used as our missing word dictionary in the function.
   2. After the function finishes implementing the First input, I used recursion of the word-tryout function. This works, because the program forms dictionaries like ‘First’ based on our global dictionary ‘Found.’ And since the tryout function updates the ‘Found’ dictionary each turn, and our list of letters without keys would be slowly decreasing, the recursion would stop once there are no more missing keys.
   3. In the First, there is a possibility that the word is really a person’s name, and it does not exist in the English dictionary, thus I also created a function that searches the each word in the dictionary by inputting the missing keys to the words. Again, the process slows down the program, but once a word is deemed nonexistence, as in it is a name or from a language other than English, it would be added to a separate list and ignored during the tryout function.
   4. There is also a very low possibility that the word, though it has the missing letter as the other words, the dictionary identifies the word with another missing letter. Thus this word is not in the ignore-word list so it affects the tryout function. To resolve this, I created an if statement that states if there if only one missing word in a list of 5 words or above, we would ignore that one word and proceed to identify the missing letter to the key. Of course, there is a possibility that one or more missing words would appear in the word list less than 5, but the possibility is very low. If this does happen, then it would break the program, causing a very low result.
2. Final Calculations: I calculated the difference between the key codes produced by the program to the key codes I expected to get. Fortunately, the three test cases I tried all got 100%, though the slow runtime is a weakness.

Analysis:

Due to the for-loop I implemented to search through the 496K English words list to make sure the words are viable, the program runs for a solid 7~8 minutes. With double for-loops being used very frequently and recursion being implemented in the program, the run-time of the program is not very good, fortunately its accuracy makes up for the long run-time.

Tests:

I performed three test cases: 1) a passage from the novel Treasure Island, 2) a passage from the novel Count of Monte Cristo and 3) an article from the Economist about the COVID vaccine.

All three test cases produced results of 100%.

Test Case 1: Zit Gsr Ltq-rgu qz zit Qrdokqs Wtfwgv LJXOKT ZKTSQVFTN, Rk. Soctltn, qfr zit ktlz gy zitlt utfzstdtf iqcofu qlatr dt zg vkozt rgvf zit vigst hqkzoexsqkl qwgxz Zktqlxkt Olsqfr, ykgd zit wtuoffofu zg zit tfr, atthofu fgziofu wqea wxz zit wtqkoful gy zit olsqfr, qfr ziqz gfsn wteqxlt zitkt ol lzoss zktqlxkt fgz ntz soyztr, O zqat xh dn htf of zit ntqk gy ukqet 17\_\_ qfr ug wqea zg zit zodt vitf dn yqzitk athz zit Qrdokqs Wtfwgv off qfr zit wkgvf gsr ltqdqf vozi zit lqwkt exz yoklz zgga xh iol sgruofu xfrtk gxk kggy. O ktdtdwtk iod ql oy oz vtkt ntlztkrqn, ql it eqdt hsgrrofu zg zit off rggk, iol ltq-eitlz ygssgvofu wtiofr iod of q iqfr-wqkkgv--q zqss, lzkgfu, itqcn, fxz-wkgvf dqf, iol zqkkn houzqos yqssofu gctk zit ligxsrtk gy iol lgostr wsxt egqz, iol iqfrl kquutr qfr leqkktr, vozi wsqea, wkgatf fqosl, qfr zit lqwkt exz qekgll gft eitta, q rokzn, socor viozt. O ktdtdwtk iod sggaofu kgxfr zit egct qfr violzsofu zg iodltsy ql it ror lg, qfr zitf wktqaofu gxz of ziqz gsr ltq-lgfu ziqz it lqfu lg gyztf qyztkvqkrl: “Yoyzttf dtf gf zit rtqr dqf’l eitlz-- Ng-ig-ig, qfr q wgzzst gy kxd!” of zit ioui, gsr zgzztkofu cgoet ziqz lttdtr zg iqct wttf zxftr qfr wkgatf qz zit eqhlzqf wqkl. Zitf it kqhhtr gf zit rggk vozi q woz gy lzoea soat q iqfrlhoat ziqz it eqkkotr, qfr vitf dn yqzitk qhhtqktr, eqsstr kgxuisn ygk q usqll gy kxd. Ziol, vitf oz vql wkgxuiz zg iod, it rkqfa lsgvsn, soat q egffgolltxk, sofutkofu gf zit zqlzt qfr lzoss sggaofu qwgxz iod qz zit esoyyl qfr xh qz gxk loufwgqkr. “Ziol ol q iqfrn egct,” lqnl it qz stfuzi; “qfr q hstqlqfz lozznqztr ukgu-ligh. Dxei egdhqfn, dqzt?” Dn yqzitk zgsr iod fg, ctkn sozzst egdhqfn, zit dgkt vql zit hozn. “Vtss, zitf,” lqor it, “ziol ol zit wtkzi ygk dt. Itkt ngx, dqztn,” it ekotr zg zit dqf vig zkxfrstr zit wqkkgv; “wkofu xh qsgfulort qfr itsh xh dn eitlz. O’ss lzqn itkt q woz,” it egfzofxtr. “O’d q hsqof dqf; kxd qfr wqegf qfr tuul ol viqz O vqfz, qfr ziqz itqr xh zitkt ygk zg vqzei liohl gyy. Viqz ngx dgxuiz eqss dt? Ngx dgxuiz eqss dt eqhzqof. Gi, O ltt viqz ngx’kt qz--zitkt”; qfr it ziktv rgvf ziktt gk ygxk ugsr hotetl gf zit ziktligsr. “Ngx eqf ztss dt vitf O’ct vgkatr zikgxui ziqz,” lqnl it, sggaofu ql yotket ql q egddqfrtk. Qfr ofrttr wqr ql iol esgzitl vtkt qfr egqkltsn ql it lhgat, it iqr fgft gy zit qhhtqkqfet gy q dqf vig lqostr wtygkt zit dqlz, wxz lttdtr soat q dqzt gk laohhtk qeexlzgdtr zg wt gwtntr gk zg lzkoat. Zit dqf vig eqdt vozi zit wqkkgv zgsr xl zit dqos iqr ltz iod rgvf zit dgkfofu wtygkt qz zit Kgnqs Utgkut, ziqz it iqr ofjxoktr viqz offl zitkt vtkt qsgfu zit egqlz, qfr itqkofu gxkl vtss lhgatf gy, O lxhhglt, qfr rtlekowtr ql sgftsn, iqr eigltf oz ykgd zit gzitkl ygk iol hsqet gy ktlortfet. Qfr ziqz vql qss vt egxsr stqkf gy gxk uxtlz. It vql q ctkn lostfz dqf wn exlzgd. Qss rqn it ixfu kgxfr zit egct gk xhgf zit esoyyl vozi q wkqll ztstleght; qss tctfofu it lqz of q egkftk gy zit hqksgxk ftbz zit yokt qfr rkqfa kxd qfr vqztk ctkn lzkgfu. Dglzsn it vgxsr fgz lhtqa vitf lhgatf zg, gfsn sgga xh lxrrtf qfr yotket qfr wsgv zikgxui iol fglt soat q ygu-igkf; qfr vt qfr zit htghst vig eqdt qwgxz gxk igxlt lggf stqkftr zg stz iod wt. Tctkn rqn vitf it eqdt wqea ykgd iol lzkgss it vgxsr qla oy qfn ltqyqkofu dtf iqr ugft wn qsgfu zit kgqr. Qz yoklz vt zigxuiz oz vql zit vqfz gy egdhqfn gy iol gvf aofr ziqz dqrt iod qla ziol jxtlzogf, wxz qz sqlz vt wtuqf zg ltt it vql rtlokgxl zg qcgor zitd. Vitf q ltqdqf ror hxz xh qz zit Qrdokqs Wtfwgv (ql fgv qfr zitf lgdt ror, dqaofu wn zit egqlz kgqr ygk Wkolzgs) it vgxsr sgga of qz iod zikgxui zit exkzqoftr rggk wtygkt it tfztktr zit hqksgxk; qfr it vql qsvqnl lxkt zg wt ql lostfz ql q dgxlt vitf qfn lxei vql hktltfz. Ygk dt, qz stqlz, zitkt vql fg ltektz qwgxz zit dqzztk, ygk O vql, of q vqn, q liqktk of iol qsqkdl. It iqr zqatf dt qlort gft rqn qfr hkgdoltr dt q losctk ygxkhtffn gf zit yoklz gy tctkn dgfzi oy O vgxsr gfsn atth dn “vtqzitk-tnt ghtf ygk q ltqyqkofu dqf vozi gft stu” qfr stz iod afgv zit dgdtfz it qhhtqktr. Gyztf tfgxui vitf zit yoklz gy zit dgfzi eqdt kgxfr qfr O qhhsotr zg iod ygk dn vqut, it vgxsr gfsn wsgv zikgxui iol fglt qz dt qfr lzqkt dt rgvf, wxz wtygkt zit vtta vql gxz it vql lxkt zg ziofa wtzztk gy oz, wkofu dt dn ygxk-htffn hotet, qfr kthtqz iol gkrtkl zg sgga gxz ygk “zit ltqyqkofu dqf vozi gft stu.” Igv ziqz htklgfqut iqxfztr dn rktqdl, O fttr leqketsn ztss ngx. Gf lzgkdn fouizl, vitf zit vofr ligga zit ygxk egkftkl gy zit igxlt qfr zit lxky kgqktr qsgfu zit egct qfr xh zit esoyyl, O vgxsr ltt iod of q zigxlqfr ygkdl, qfr vozi q zigxlqfr roqwgsoeqs tbhktllogfl. Fgv zit stu vgxsr wt exz gyy qz zit aftt, fgv qz zit ioh; fgv it vql q dgflzkgxl aofr gy q ektqzxkt vig iqr ftctk iqr wxz zit gft stu, qfr ziqz of zit dorrst gy iol wgrn. Zg ltt iod stqh qfr kxf qfr hxklxt dt gctk itrut qfr rozei vql zit vgklz gy fouizdqktl. Qfr qszgutzitk O hqor hktzzn rtqk ygk dn dgfzisn ygxkhtffn hotet, of zit liqht gy zitlt qwgdofqwst yqfeotl. Wxz zigxui O vql lg ztkkoyotr wn zit ortq gy zit ltqyqkofu dqf vozi gft stu, O vql yqk stll qykqor gy zit eqhzqof iodltsy ziqf qfnwgrn tslt vig aftv iod. Zitkt vtkt fouizl vitf it zgga q rtqs dgkt kxd qfr vqztk ziqf iol itqr vgxsr eqkkn; qfr zitf it vgxsr lgdtzodtl loz qfr lofu iol voeatr, gsr, vosr ltq-lgful, dofrofu fgwgrn; wxz lgdtzodtl it vgxsr eqss ygk usqlltl kgxfr qfr ygket qss zit zktdwsofu egdhqfn zg solztf zg iol lzgkotl gk wtqk q eigkxl zg iol lofuofu. Gyztf O iqct itqkr zit igxlt liqaofu vozi “Ng-ig-ig, qfr q wgzzst gy kxd,” qss zit ftouiwgxkl pgofofu of ygk rtqk soyt, vozi zit ytqk gy rtqzi xhgf zitd, qfr tqei lofuofu sgxrtk ziqf zit gzitk zg qcgor ktdqka. Ygk of zitlt yozl it vql zit dglz gctkkorofu egdhqfogf tctk afgvf; it vgxsr lsqh iol iqfr gf zit zqwst ygk lostfet qss kgxfr; it vgxsr ysn xh of q hqllogf gy qfutk qz q jxtlzogf, gk lgdtzodtl wteqxlt fgft vql hxz, qfr lg it pxrutr zit egdhqfn vql fgz ygssgvofu iol lzgkn. Fgk vgxsr it qssgv qfngft zg stqct zit off zoss it iqr rkxfa iodltsy lstthn qfr kttstr gyy zg wtr.

Result: QWERTYUIOPASDFGHJKLZXCVBNM

Expected: QWERTYUIOPASDFGHJKLZXCVBNM

Test Case 2: Eiqhztk 1. Dqkltosstl—Zit Qkkocqs

Gf zit 24zi gy Ytwkxqkn, 1815, zit sgga-gxz qz Fgzkt-Rqdt rt sq Uqkrt

loufqsstr zit ziktt-dqlztk, zit \_Hiqkqgf\_ ykgd Ldnkfq, Zkotlzt, qfr

Fqhstl.

Ql xlxqs, q hosgz hxz gyy oddtroqztsn, qfr kgxfrofu zit Eiâztqx r’Oy,

ugz gf wgqkr zit ctllts wtzvttf Eqht Dgkuogx qfr Kogf olsqfr.

Oddtroqztsn, qfr qeegkrofu zg exlzgd, zit kqdhqkzl gy Ygkz Lqofz-Ptqf

vtkt egctktr vozi lhtezqzgkl; oz ol qsvqnl qf tctfz qz Dqkltosstl ygk q

lioh zg egdt ofzg hgkz, tlhteoqssn vitf ziol lioh, soat zit \_Hiqkqgf\_,

iql wttf wxosz, kouutr, qfr sqrtf qz zit gsr Higett rgeal, qfr wtsgful

zg qf gvftk gy zit eozn.

Zit lioh rktv gf qfr iqr lqytsn hqlltr zit lzkqoz, vioei lgdt cgseqfoe

ligea iql dqrt wtzvttf zit Eqsqlqktouft qfr Pqkgl olsqfrl; iqr rgxwstr

Hgdèuxt, qfr qhhkgqeitr zit iqkwgk xfrtk zghlqosl, pow, qfr lhqfatk,

wxz lg lsgvsn qfr ltrqztsn ziqz zit orstkl, vozi ziqz oflzofez vioei ol

zit ygktkxfftk gy tcos, qlatr gft qfgzitk viqz dolygkzxft egxsr iqct

iqhhtftr gf wgqkr. Igvtctk, ziglt tbhtkotfetr of fqcouqzogf lqv hsqofsn

ziqz oy qfn qeeortfz iqr geexkktr, oz vql fgz zg zit ctllts itkltsy,

ygk lit wgkt rgvf vozi qss zit tcortfet gy wtofu laosyxssn iqfrstr, zit

qfeigk q-egeawoss, zit pow-wggd uxnl qsktqrn tqltr gyy, qfr lzqfrofu wn

zit lort gy zit hosgz, vig vql lzttkofu zit \_Hiqkqgf\_ zgvqkrl zit

fqkkgv tfzkqfet gy zit offtk hgkz, vql q ngxfu dqf, vig, vozi qezocozn

qfr couosqfz tnt, vqzeitr tctkn dgzogf gy zit lioh, qfr kthtqztr tqei

roktezogf gy zit hosgz.

Zit cquxt roljxotzxrt vioei hktcqostr qdgfu zit lhtezqzgkl iqr lg dxei

qyyteztr gft gy zit ekgvr ziqz it ror fgz qvqoz zit qkkocqs gy zit

ctllts of iqkwgk, wxz pxdhofu ofzg q ldqss laoyy, rtloktr zg wt hxsstr

qsgfulort zit \_Hiqkqgf\_, vioei it ktqeitr ql lit kgxfrtr ofzg Sq

Kéltkct wqlof.

Vitf zit ngxfu dqf gf wgqkr lqv ziol htklgf qhhkgqei, it styz iol

lzqzogf wn zit hosgz, qfr, iqz of iqfr, stqftr gctk zit lioh’l

wxsvqkal.

It vql q yoft, zqss, lsod ngxfu ytssgv gy touizttf gk zvtfzn, vozi

wsqea tntl, qfr iqok ql rqka ql q kqctf’l vofu; qfr iol vigst

qhhtqkqfet wtlhgat ziqz eqsdftll qfr ktlgsxzogf htexsoqk zg dtf

qeexlzgdtr ykgd zitok ekqrst zg egfztfr vozi rqfutk.

“Qi, ol oz ngx, Rqfzèl?” ekotr zit dqf of zit laoyy. “Viqz’l zit

dqzztk? qfr vin iqct ngx lxei qf qok gy lqrftll qwgqkr?”

“Q uktqz dolygkzxft, D. Dgkkts,” kthsotr zit ngxfu dqf, “q uktqz

dolygkzxft, ygk dt tlhteoqssn! Gyy Eocozq Cteeioq vt sglz gxk wkqct

Eqhzqof Stestkt.”

“Qfr zit eqkug?” ofjxoktr zit gvftk, tqutksn.

“Ol qss lqyt, D. Dgkkts; qfr O ziofa ngx voss wt lqzolyotr gf ziqz

itqr. Wxz hggk Eqhzqof Stestkt——”

“Viqz iqhhtftr zg iod?” qlatr zit gvftk, vozi qf qok gy egflortkqwst

ktloufqzogf. “Viqz iqhhtftr zg zit vgkzin eqhzqof?”

“It rotr.”

“Ytss ofzg zit ltq?”

“Fg, lok, it rotr gy wkqof-ytctk of rktqryxs qugfn.” Zitf zxkfofu zg

zit ektv, it lqor, “Wtqk q iqfr zitkt, zg zqat of lqos!”

Qss iqfrl gwtntr, qfr qz gfet zit touiz gk ztf ltqdtf vig egdhgltr zit

ektv, lhkqfu zg zitok ktlhtezoct lzqzogfl qz zit lhqfatk wkqosl qfr

gxziqxs, zghlqos littzl qfr iqsnqkrl, zit pow rgvfiqxs, qfr zit zghlqos

estvsoftl qfr wxfzsoftl. Zit ngxfu lqosgk uqct q sgga zg ltt ziqz iol

gkrtkl vtkt hkgdhzsn qfr qeexkqztsn gwtntr, qfr zitf zxkftr quqof zg

zit gvftk.

“Qfr igv ror ziol dolygkzxft geexk?” ofjxoktr zit sqzztk, ktlxdofu zit

ofztkkxhztr egfctklqzogf.

Result: QWERTYUIOPASDFGHJKLZXCVBNM

Expected: QWERTYUIOPASDFGHJKLZXCVBNM

Test Case 3: Ysouiz ta 787 zgxeitr rgvf of Qeekq qz 7.39qd gf Ytwkxqkn 24zi. Oz vql eqkknofu 600,000 rgltl gy QlzkqMtfteq’l egcor-19 cqeeoft. Zit ligzl qkkoctr of Uiqfq ykgd zit Ltkxd Oflzozxzt of Hxft, Ofroq—zit wouutlz cqeeoft-dqatk of zit vgksr. Oz vql zit yoklz rtsoctkn gy pqwl dqrt zikgxui egcqb, q cqeeoft-liqkofu ofozoqzoct.

egcqb vql tlzqwsolitr sqlz ntqk zg hkgdgzt zit lxhhsn gy cqeeoftl zg egxfzkotl ziqz douiz gzitkvolt lzkxuust zg gwzqof zitd. Lgdt 192 fqzogfl pgoftr. Tqei vql hkgdoltr tfgxui pqwl zg ofgexsqzt 20% gy ozl htghst. Wxz gf Dqkei 24zi Ofroq hxz q ztdhgkqkn iqsz gf cqeeoft tbhgkzl. Lofet oz hkgcortl 86% gy lxhhsotl ygk egcqb, ziol iql zikgvf q lhqfftk of zit vgkal.

Oz ol of zit vgksr’l ofztktlz zg lxhhktll zkqfldollogf tctknvitkt qz zit lqdt zodt. Ftv cqkoqfzl dqn tdtkut vitktctk zit cokxl ol qwst zg lhktqr xfeiteatr wn cqeeoftl. Zit ygxfrtkl gy egcqb lzqkztr hsqffofu tqksn. Zitn vtkt rtztkdoftr fgz zg kthtqz dolzqatl dqrt of 2009 of rtqsofu vozi i1f1—gk lvoft ysx, q hqfrtdoe ygk vioei cqeeoftl vtkt royyoexsz zg gwzqof usgwqssn. Zitn vgkatr jxoeasn zg wkofu lg dqfn egxfzkotl gf wgqkr. Wn zit tfr gy 2020, oz sggatr ql oy zit tbzkqgkrofqkn leotfzoyoe tyygkz ziqz iqr hkgrxetr cqeeoftl of ktegkr zodt vgxsr wt ygssgvtr wn qf xfhktetrtfztr eg-ghtkqzogf zg cqeeofqzt gft-yoyzi gy zit vgksr. Qfr ntz tctf ql ukgvofu jxqfzozotl qfr cqkotzotl gy cqeeoft qkt egdofu gfsoft, egcqb ol fgv lzkxuusofu zg rtsoctk.

Koeiqkr Iqzeitzz ol zit itqr gy zit Egqsozogf ygk Thortdoe Hkthqktrftll Offgcqzogfl, q eiqkozn of Fgkvqn. Qsgfu vozi Ltzi Wtkastn, itqr gy Uqco, q cqeeoft-yofqfet qutfen, it wtuqf of Pqfxqkn 2020 zg ziofa qwgxz igv zg rolzkowxzt qfn lxeetllyxs cqeeoftl qkgxfr zit vgksr.

Dk Iqzeitzz vgkatr of zit Viozt Igxlt rxkofu zit i1f1 gxzwktqa of 2009. Ziqz hqfrtdoe vql yqk stll ltkogxl ziqf egcor-19, wxz tctf zitf zit ollxt gy tbhgkzofu cqeeoftl vql “ofektrowsn ykqxuiz”, it lqnl. Koei egxfzkotl hsqetr qrcqfet gkrtkl ygk cqeeoftl, stqcofu hggktk fqzogfl zg rthtfr gf rgfqzogfl vioei vtkt lsgv zg qkkoct. It vql rtztkdoftr zg qcgor zit lqdt ziofu iqhhtfofu vozi egcor-19.

Of tqksn 2020 ixfrktrl gy egcor-19 cqeeoft eqfrorqztl vtkt wtofu egfegeztr. “Vt iqr fg ortq vitzitk qfn gy zitlt cqeeoftl vtkt ugofu zg vgka,” kteqssl Dk Wtkastn. Iolzgkoeqssn qwgxz 10% gy cqeeoft eqfrorqztl iqct hkgctr lxeetllyxs. Tbhtkzl ytqktr ziqz egcor-19 cqeeoftl douiz wt hqkzoexsqksn royyoexsz zg dqat. Koei egxfzkotl dqrt dxszohst xhykgfz ofctlzdtfzl, uxqkqfzttofu zitok qeetll zg tqksn rgltl.

Zit vgksr fttrtr q cqeeoft-wxnofu esxw. Zit ktlxsz vql egcqb. Oz iql ltexktr qz stqlz 2wf rgltl, tfgxui zg hkgztez itqszi-eqkt vgkatkl qfr zit gsrtlz qfr dglz cxsftkqwst of qss 192 gy ozl dtdwtkl. Koei egxfzkotl qkt hqnofu ygk cqeeoftl ygk hggk gftl. Wtygkt Ofroq’l tbhgkz wqf, egcqb iqr rtsoctktr 32d rgltl—dglzsn zg sgv-ofegdt egxfzkotl. Lg yqk zit tyygkzl zg rolzkowxzt cqeeoft of hggk egxfzkotl qkt sggaofu dgkt soat zit i1f1 ygktkxfftk ziqf iqr wttf ightr. Ziqz hoezxkt ligxsr, igvtctk, eiqfut ql zit ntqk ugtl gf.

Koei fqzogfl kthktltfzofu pxlz 14% gy zit vgksr’l hghxsqzogf iqr wgxuiz xh 53% gy zit dglz hkgdolofu cqeeoftl, eqsexsqztr Gbyqd, q eiqkozn, of Rtetdwtk. Foft gxz gy ztf htghst of hggk egxfzkotl, oz qrrtr, vgxsr doll gxz of 2021. Zit tx iql gkrtktr 2.6wf rgltl ygk ozl 450d eozomtfl. Zgg ytv iqct wttf rtsoctktr, lg oz iql wttf egflortkofu wqffofu zit tbhgkz gy cqeeoftl dqrt of Txkght. Ziol voss, ozl lqnl, itsh oz utz ozl “yqok” liqkt.

Koei egxfzkotl qkt fgz zit gfsn gftl igsrofu gf zg rgltl. Zit rteologf gy Ofroq, q hggk egxfzkn ziqz ol exkktfzsn zit vgksr’l ziokr-sqkutlz cqeeoft-dqatk, zg iqsz tbhgkzl ol q hqkzoexsqk wsgv zg egcqb. Zit qssoqfet ktsotl gf Ofroq ygk dglz gy ozl lxhhsotl (ltt eiqkz 1). Lgdt 40d rgltl tbhteztr of Dqkei qfr xh zg 50d rgltl of Qhkos voss wt rtsqntr, ekohhsofu zit leitdt’l dgrtlz qdwozogf gy rolzkowxzofu 350d rgltl of zit yoklz iqsy gy zit ntqk.

Oz ol zkxt ziqz koei egxfzkotl iqct cqeeoftl of yqk uktqztk lxhhsn ziqf hggk gftl. Wxz oz ol qslg zkxt ziqz koei qfr dorrst-ofegdt egxfzkotl, vozi zitok gsrtk qfr yqzztk hghxsqzogfl, iqct wttf dxei iqkrtk ioz

Dqfn hggk egxfzkotl qkt of Qykoeq. Zit egfzoftfz ql q vigst qhhtqkl zg iqct wttf stll wqrsn qyyteztr wn egcor-19, vozi q ytv wou tbethzogfl lxei ql Lgxzi Qykoeq. Ziol dqn wt wteqxlt gy zit ktsqzoct ngxzi gy zit egfzoftfz’l hghxsqzogf. Lgdt vgkkn ziqz Qykoeqf eqltl qfr rtqzil qkt wtofu rkqdqzoeqssn xfrtkegxfztr. Wxz Lqsod Qwrggs Aqkod, q Lgxzi Qykoeqf thortdogsguolz, fgztl ziqz zit hkghgkzogf gy hglozoct ztlzl qekgll zit egfzoftfz iql wttf egflolztfzsn wtsgv 10%. Egsstquxtl qekgll zit egfzoftfz qkt fgz kthgkzofu jxtxtl gy hqzotfzl vozi ktlhokqzgkn rolzktll, lqnl Rk Aqkod. Fgft gy ziol dtqfl ziqz Qykoeq ligxsr fgz utz zit cqeeoft oz vqfzl, wxz oz dqn stlltf zit odhqez gy zit lsgv qkkocqs gy ozl cqeeoftl.

Of Pqfxqkn Voffot Wnqfnodq, zit itqr gy xfqorl, zit Xfoztr Fqzogfl qutfen eiqkutr vozi rtqsofu vozi zit roltqlt, lqor zit vgksr vql vozftllofu “cqeeoft qhqkzitor”. Ntz qz ziqz zodt zitkt vql sozzst tfzixloqld qdgfu zit dglzsn sgv- qfr dorrst-ofegdt egxfzkotl gy egcqb ygk zit zvg cqeeoftl, Hyomtk qfr Dgrtkfq, ziqz vtkt qcqosqwst qz ziqz hgofz, lqnl Dk Wtkastn. Zitn qkt eglzsn qfr iqkr zg rolzkowxzt, lofet zitn dxlz wt athz xfxlxqssn egsr.

Oflztqr zit cqeeoft gy eigoet ygk dtdwtkl gy egcqb vql zit eitqh qfr tqln-zg-rolzkowxzt pqw ykgd QlzkqMtfteq. Wteqxlt zit vgksr vql lsgv zg yxfr egcqb, koei egxfzkotl gkrtktr dqfn dossogfl gy rgltl wtygkt zit qssoqfet vql qwst zg lzqkz wxnofu. Wxz egcqb vql qwst zg gwzqof lxhhsotl ykgd zit Ltkxd Oflzozxzt of Ofroq qfr q dqfxyqezxktk of Lgxzi Agktq. egcqb egxfzkotl vtkt qslg attf gf ligzl wtofu rtctsghtr wn Fgcqcqb qfr Pgiflgf & Pgiflgf. Wgzi vtkt oftbhtfloct qfr egxsr wt athz of fgkdqs ktykoutkqzgkl. Zit Pgiflgf & Pgiflgf cqeeoft qslg sggatr ql oy oz vgxsr ktjxokt pxlz gft ligz. Zitlt voss qkkoct, wxz fgz xfzos sqztk ziol ntqk.

Gft gy zit dqof hkgwstdl ygk egcqb ol ziqz zit QlzkqMtfteq cqeeoft iql zqatf sgfutk zg qkkoct ziqf iqr wttf ightr. Zit Vgksr Itqszi Gkuqfolqzogf (vig) ror fgz ukqfz tdtkutfen qxzigkolqzogf ygk ozl xlt usgwqssn xfzos Ytwkxqkn 15zi. Touiz rqnl sqztk, zit cqeeoft vql wtofu hqeatr xh of Hxft ygk tbhgkz zg Uiqfq qfr Ocgkn Egqlz. Qfr lg oz vql ziqz qz zit lzqkz gy Dqkei zit rolzkowxzogf gy egcqb rgltl lttdtr qz sqlz zg wt xfrtk vqn.

Uoctf egcqb’l sodozqzogfl oz iql wttf uqssofu zg dqfn tbhtkzl zg ltt koei egxfzkotl lfqyysofu rgltl gy QlzkqMtfteq ykgd zit Ltkxd Oflzozxzt—hxliofu egcqb lxhhsotl yxkzitk rgvf zit jxtxt. Wkozqof iql qsktqrn zqatf 4.5d rgltl, qfr ktetfzsn ltfz qf tfcgn zg Ofroq zg zkn zg ltexkt qfgzitk 5.5d. Zit tx ol lfoyyofu kgxfr, zgg.

Gzitk egxfzkotl qkt qslg yqk ykgd wsqdtstll. Qfbogxl zg lhttr xh zitok cqeeoft kgss-gxz, cqkogxl sgv- qfr dorrst-ofegdt egxfzkotl iqct wnhqlltr egcqb qfr gwzqoftr lxhhsotl roktezsn ykgd zit oflzozxzt gk zikgxui zit Ofroqf ugctkfdtfz. Qeegkrofu zg Qokyofozn, qf qfqsnzoel egdhqfn, Qkutfzofq, Wkqmos, Dnqfdqk, Lqxro Qkqwoq qfr Lgxzi Qykoeq iqct wtzvttf zitd zqatf 12d rgltl. Eqfqrq iql lfquutr 500,000, qfr zit xqt 200,000. Ofroq ol attf zg rgfqzt ligzl ygk hgsozoeqs uqof.

Tddqfxts Dqekgf, Ykqfet’l hktlortfz, iql lqor ziqz Txkght qfr Qdtkoeq ligxsr rgfqzt 4-5% gy zitok lxhhsotl zg rtctsghofu egxfzkotl. Zit Wortf qrdofolzkqzogf ktpteztr ziol ortq qfr ghztr zg ltfr dgftn zg egcqb oflztqr. Dtqfviost, Qdtkoeq iql dossogfl gy rgltl gy QlzkqMtfteq lozzofu xfxltr. Zit fqzogfqs dtroeoftl ktuxsqzgk iql fgz ntz qhhkgctr ozl xlt, wxz Qdtkoeq iql fgz rgfqztr ozl lzgeahost, tozitk. Vitf egxfzkotl iqct liqktr qfn lhqkt rgltl zitok rgfqzogfl lttd zg iqct wttf rkoctf wn hgsozoel qfr tegfgdoel, kqzitk ziqf ftetllozn gk yqokftll. Gf Dqkei 18zi Qdtkoeq lqor oz vgxsr sgqf 4d rgltl zg Dtboeg qfr Eqfqrq, ozl esgltlz ftouiwgxkl.

Pxruofu egcqb’l lxeetll iql wtegdt royyoexsz wteqxlt zit ugqshglzl iqct lioyztr lofet sqlz ntqk. Dgkt cqeeoftl qkt qcqosqwst ygk rolzkowxzogf ziqf iqr wttf tbhteztr. Ziqz iql itshtr, wxz zit ioui tyyoeqen gy zit ftv cqeeoftl dtqfl ziqz dqfn egxfzkotl qkt fgv attf zg gyytk cqeeoftl zg dglz gy zitok eozomtfl—kqzitk ziqf pxlz zit dglz cxsftkqwst gftl. Ofrttr, vozi iouisn tyytezoct cqeeoftl, lgdtziofu esglt zg itkr oddxfozn douiz wt hgllowst.

O qd fgz uocof’ qvqn dn ligz

Zit hkglhtez gy lgdt egxfzkotl rteorofu zg uoct qrrozogfqs ligzl ol yxkzitk egdhsoeqzofu qzztdhzl zg vgka gxz igv dxei cqeeoft ol qcqosqwst zg liqkt. Sqlz vtta Wkozqof lqor ziqz, ykgd Lthztdwtk, ziglt qutr gctk 70, itqszi vgkatkl, qfr zit esofoeqssn ctkn cxsftkqwst egxsr utz wgglztk ligzl zg hkgztez quqoflz cqkoqfzl. Hkgrxeofu ftv cqkoqfz cqeeoftl voss rodofoli zit eqhqeozn zg hkgrxet cqeeoftl quqoflz zit gkouofqs lzkqof. Zitkt ol qslg zqsa gy cqeeofqzofu eiosrktf ql vtss—vitf zkoqsl qkt egdhstztr. Oy koei egxfzkotl rteort zg cqeeofqzt eiosrktf, ziol vgxsr yxkzitk tqz ofzg viqz ol qcqosqwst zg lxhhktll zit cokxl usgwqssn.

egcqb iql ligvf ziqz q ftv dtroeoft eqf wt sqxfeitr of koei qfr hggk egxfzkotl qz qwgxz zit lqdt zodt, qfr ziqz zit lxhhsn gy ftv dtroeoftl eqf wt rkoctf wn hggsofu rtdqfr ykgd zit dqfn ldqss egxfzkotl ziqz qkt xlxqssn sqlz of soft ygk zitd. Ftv rtqsl dtqf egcqb dqn wt qwst zg lxhhsn ozl dtdwtkl vozi 27% gy zitok rgltl ziol ntqk. Wxz vozigxz dgkt lxhhgkz oz voss wt xfqwst zg dttz ozl dglz wqloe qod: zg lxhhsn zitd vozi zit yoklz 3% gy zitok pqwl—tfgxui zg pqw tctkn itqszi-eqkt vgkatk of zit vgksr.

Ztrkgl Qriqfgd Uitwktntlxl, zit itqr gy zit vig, vqfzl qss egxfzkotl zg lzqkz ziol zqla wn Qhkos 10zi, zit 100zi rqn gy ziol ntqk—qfr, ql oz lg iqhhtfl, zit rqn wn vioei zit vgksr ol tbhteztr zg iqct hkgrxetr 1wf rgltl gy cqeeoftl, qeegkrofu zg Qokyofozn. Ofgexsqzofu gfsn itqszi-eqkt vgkatkl voss ktjxokt gfsn q ldqss hgkzogf gy zit cqeeoftl ziqz zit vgksr ol ektqzofu. Ntz zit ntqk ol kgssofu gf qfr ziqz zqla iql wqktsn wtuxf. Zit vgksr, vqkfl Rk Ztrkgl, ol gf zit wkofa gy “dgkqs yqosxkt”.

Result: QWERTYUIOPASDFGHJKLZXCVBNM

Expected: QWERTYUIOPASDFGHJKLZXCVBNM