ЛЕТНЯЯ ШКОЛА
CTF 2021

Разбор задач CryptoCTF 2020

http://10.10.10.19:8080/s/eQK4y9924FlNXgR

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Модульная арифметика

Простое число - натуральное число, имеющее ровно два различных натуральных делителя — единицу и самого себя.

Взятие x по модулю (x % m) – вычисление остатка от деления x на m

a и b **сравнимы** по модулю m, если их остатки при делении на m равны (a ≡ b % m). **Класс вычетов** – множество всех чисел, сравнимых с a по модулю m.

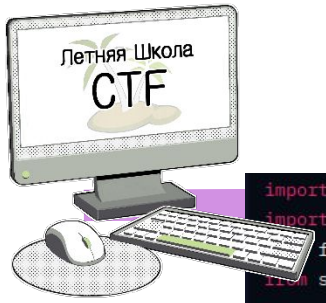
Отношение сравнимости является отношением эквивалентности (симметричным, транзитиным, рефлексивное)

Допустимые операции со сравнениями: $a + m * x \equiv b \% m$; $a - b \equiv 0 \% m$; $a + x \equiv b + x \% m$;
$a * x \equiv b * x \% m$; $a^x \equiv b^x \% m$; $a / k \equiv b / k \% m$ если НОД(k, m)=1

Обратное число по модулю – такое i, что a * i ≡ 1 % m. Существует для всех a, взаимнопростых с m

Теорема Эйлера: $a^{\varphi(n)} \equiv 1 \% m$, φ(m) - функция Эйлера (количество натуральных чисел, не превышающих n и взаимно простых с ним)

Encoding



Abbot

```python
import string
import random
from fractions import Fraction as frac
from secret import flag


def me(msg):
        if len(msg) == 1 :
                return ord(msg)
        msg = msg[::-1]
        reducer = len(msg) - 1
        resultNum, resultDen = frac(ord(msg[0]), reducer).denominator, frac(ord(msg[0]), r
        reducer -= 1
        for i in range(1, len(msg)-1):
                result =  ord(msg[i]) +  frac(resultNum, resultDen)
                resultDen, resultNum  = result.denominator, result.numerator
                resultDen, resultNum =  resultNum, reducer * resultDen
                reducer -= 1
        result = ord(msg[-1]) + frac(resultNum, resultDen)
        resultDen, resultNum  = result.denominator, result.numerator
        return (resultNum, resultDen)

def you(msg):
        if len(msg) == 1 :
                return ord(msg)
        msg = msg[::-1]
        reducer = (-1) ** len(msg)
        result = frac(ord(msg[0]), reducer)
        resultNum, resultDen = result.denominator, result.numerator
        reducer *= -1
        for i in range(1, len(msg)-1):
                result =  ord(msg[i]) +  frac(resultNum, resultDen)
                resultDen, resultNum  = result.denominator, result.numerator
                resultDen, resultNum =  resultNum, reducer * resultDen
                reducer *= -1

        result = ord(msg[-1]) + frac(resultNum, resultDen)
        resultDen, resultNum  = result.denominator, result.numerator
        return (resultNum, resultDen)
```

```python
def us(msg):
        if len(msg) == 1 :
                return ord(msg)
        msg = msg[::-1]
        reducer = (-1) ** int(frac(len(msg), len(msg)**2))
        result = frac(ord(msg[0]), reducer)
        resultNum, resultDen = result.denominator, result.numerator
        reducer **= -1
        reducer = int(reducer)
        for i in range(1, len(msg)-1):
                result =  ord(msg[i]) +  frac(resultNum, resultDen)
                resultDen, resultNum  = result.denominator, result.numerator
                resultDen, resultNum =  resultNum, reducer * resultDen
                reducer **= -1
                reducer = int(reducer)
        result = ord(msg[-1]) + frac(resultNum, resultDen)
        resultDen, resultNum  = result.denominator, result.numerator
        return (resultNum, resultDen)

dict_encrypt = {
        1: me,
        2: you,
        3: us,
        4: you,
        5: me
}
cipher = [[] for _ in range(5)]
S = list(range(1,6))
random.shuffle(S)
print("enc = [")
for i in range(4):
        cipher[i] = dict_encrypt[S[i]](flag[int(i * len(flag) // 5) : int(i * len(flag) //
        print(cipher[i])
        print(", ")
i += 1
cipher[i] = dict_encrypt[S[i]](flag[int(i * len(flag) // 5) : int(i * len(flag) // 5 + len
print(cipher[i])
print( " ]")

enc = [(4874974328610108385835995981839358584964018454799387862L, 7274460867213040421640046
```

Abbot

```python
def us(msg):
    if len(msg) == 1:
        return ord(msg)
    msg = msg[::-1]
    reducer = (-1) ** int(frac(len(msg), len(msg)**2))
    result = frac(ord(msg[0]), reducer)
    resultNum, resultDen = result.denominator, result.numerator
    reducer **= -1
    reducer = int(reducer)
    for i in range(1, len(msg)-1):
        result = ord(msg[i]) + frac(resultNum, resultDen)
        resultDen, resultNum = result.denominator, result.numerator
        resultDen, resultNum = resultNum, reducer * resultDen
        reducer **= -1
        reducer = int(reducer)
    result = ord(msg[-1]) + frac(resultNum, resultDen)

    resultDen, resultNum = result.denominator, result.numerator
    return (resultNum, resultDen)
```

```python
def us_(num, den):

    text_ = ""
    resultDen, resultNum = den, num
    r = int(resultNum / resultDen)
    text_ += chr(r)
    result = frac(resultNum, resultDen) - r
    resultDen, resultNum = result.numerator, result.denominator
    while resultNum != 0 and resultDen != 0:
        r = int(resultNum / resultDen)

        result = (frac(resultNum, resultDen) - r)
        resultDen, resultNum = result.numerator, result.denominator

        if result == 1:
            text_ += chr(r - 1)
        else:
            text_ += chr(r)

    return text_
```

```python
for ct in enc:
    print(us_(ct[0], ct[1]))
    print(me_(ct[0], ct[1]))
    print(you_(ct[0], ct[1]))

    #CCTF{This_13_n0t_Arthur_Who_
    #__ASIS___Crypto_CTF____with_
    # very_m0d3rn_arthur_Enc0d1ng!
    # l0ves_Short_st0ries_This_IS_
    # !_D0_you_Enj0y_IT_as_w311??}


# CCTF{This_13_n0t_Arthur_Who_l0ves_Short_st0ries_This_IS___ASIS___Crypto_CTF____with_very_m0d3rn_arthur_Enc0d1ng!!_D0_you_Enj0y_IT_as_w311??}
```

Amsterdam


```python
def comb(n, k):
    if k > n:
        return 0
    k = min(k, n - k)
    u = reduce(operator.mul, range(n, n - k, -1), 1)
    d = reduce(operator.mul, range(1, k + 1), 1)
    return u // d

def encrypt(msg, n, k):
    msg = bytes_to_long(msg.encode('utf-8'))
    print("msg", msg)
    if msg >= comb(n, k):
        return -1
    m = ['1'] + ['0' for i in range(n - 1)]
    for i in range(1, n + 1):
        if msg >= comb(n - i, k):
            m[i-1]= '1'
            msg -= comb(n - i, k)
            print("sub", comb(n - i, k), n, i, k)
            k -= 1
    m = int(''.join(m), 2)

    print("encryption_res_1", bin(m))
    i, z = 0, [0 for i in range(n - 1)]
    c = 0
    while (m > 0):
        if m % 4 == 1:
            c += 3 ** i
            m -= 1
        elif m % 4 == 3:
            c += 2 * 3 ** i
            m += 1
        m //= 2
        i += 1
    print("enc_res_2", c)
    return c

#enc = encrypt(flag, n, k)
#print('enc =', enc)

enc = 55503328178762801622749998559973784796092358171334382935716776996508868
```

Amsterdam

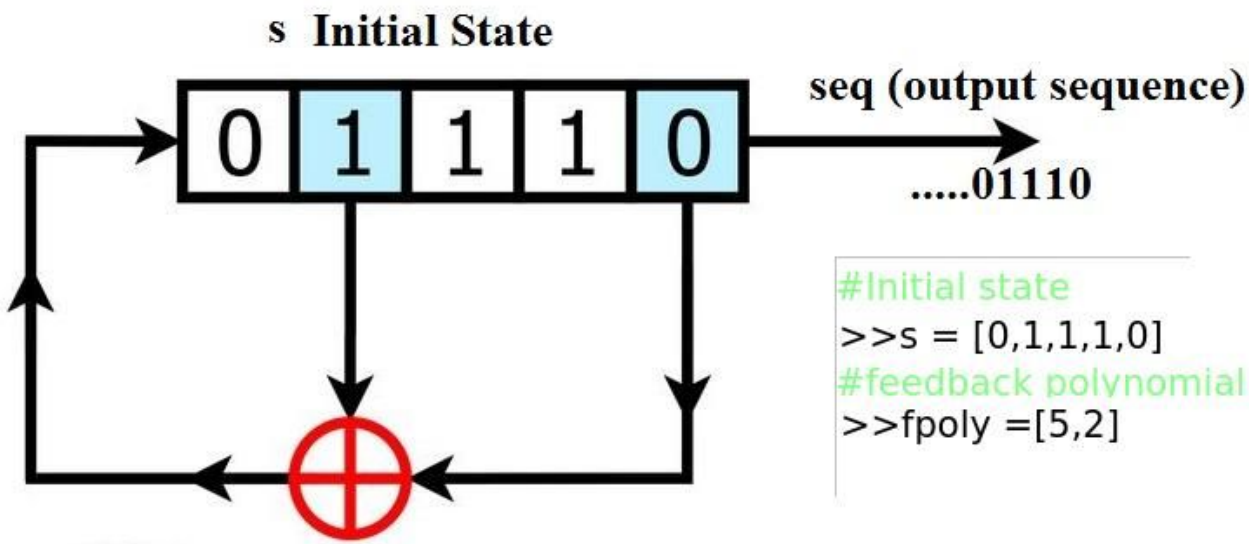

```python
def comb(n, k):
    if k > n:
        return 0
    k = min(k, n - k)
    u = reduce(operator.mul, range(n, n - k, -1), 1)
    d = reduce(operator.mul, range(1, k + 1), 1)
    return u // d

def encrypt(msg, n, k):
    msg = bytes_to_long(msg.encode('utf-8'))
    print("msg", msg)
    if msg >= comb(n, k):
        return -1
    m = ['1'] + ['0' for i in range(n - 1)]
    for i in range(1, n + 1):
        if msg >= comb(n - i, k):
            m[i-1]= '1'
            msg -= comb(n - i, k)
            print("sub", comb(n - i, k), n, i, k)
            k -= 1
    m = int(''.join(m), 2)

    print("encryption_res_1", bin(m))
    i, z = 0, [0 for i in range(n - 1)]
    c = 0
    while (m > 0):
        if m % 4 == 1:
            c += 3 ** i
            m -= 1
        elif m % 4 == 3:
            c += 2 * 3 ** i
            m += 1
        m //= 2
        i += 1
    print("enc_res_2", c)
    return c

#enc = encrypt(flag, n, k)
#print('enc =', enc)

enc = 55503328178762801622749998559973784796092358171334382935716776996508868
```

```python
def dec_(enc):
    arr = []
    i = 0
    while enc > 0:
        m = enc % 3
        arr.append(m)
        enc //= 3
        i += 1
    c = 0

    for m in arr[::-1]:
        c *= 2
        if m == 1:
            c += 1
        elif m == 2:
            c -= 1
    return c

def decrypt(msg, n, k):
    pt = 0

    for i in range(2, n + 1):
        if msg[i-1] == '1':
            pt += comb(n - i, k)
            k -= 1

    return long_to_bytes(pt)


msg_ = dec_(enc)
print(msg_)
msg_ = bin(msg_)[2:]
n = len(msg_)

for k in range(n):
    pt = decrypt(msg_, n, k)
    if b'CCTF{' in pt:
        print(k, pt)
        break

# b'..:: CCTF{With_Re3p3ct_for_Sch4lkwijk_dec3nt_Encoding!} ::..'
```

```python
def decode(c):  ### аналогичная функция из официальных writeups
    c = c.str(base=3)
    m = 0
    for t in c:
        m *= 2
        if t == '1':
            m += 1
        elif t == '2':
            m -= 1
    return m
```

Shift registers

LFSR




```
#Initial state
>>s = [0,1,1,1,0]
#feedback polynomial
>>fpoly =[5,2]
```

Heaven

```python
from bitstring import BitArray
from heaven import seventh_seal, oh, no, new_testament

def matthew_effect(shire, rohan):
    gandalf = ''
    for every, hobbit in enumerate(shire):
        gandalf += oh if ord(hobbit) ^ ord(rohan[every]) == 0 else no
    return gandalf

def born_to_die(isengard):
    luke = 0
    for book in new_testament:
        luke ^= ord(isengard[book])
    lizzy_grant = oh + isengard[:-1] if luke == 0 else no + isengard[:-1]
    return lizzy_grant


david = len(seventh_seal)
elf = seventh_seal
lord = BitArray(bytes=bytes(open('flag.jpg', 'rb').read())).bin
bilbo = len(lord)
matthew = 0
princess_leia = ''
destiny = bilbo // david
apocalypse = bilbo % david
for i in range(32):
    elf = born_to_die(elf)
while matthew < destiny:
    princess_leia += matthew_effect(elf, lord[matthew * david_: (matthew + 1) * david])
    elf = born_to_die(elf)
    matthew += 1
princess_leia += matthew_effect(elf[:apocalypse], lord[matthew * david_:])
res = open('flag.enc', 'wb')
res.write(bytes(int(princess_leia[i_: i + 8], 2) for i in range(0, bilbo, 8)))
```

Heaven

```python
from bitstring import BitArray
from heaven import seventh_seal, oh, no, new_testament

def matthew_effect(shire, rohan):
    gandalf = ''
    for every, hobbit in enumerate(shire):
        gandalf += oh if ord(hobbit) ^ ord(rohan[every]) == 0 else no
    return gandalf

def born_to_die(isengard):
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    return lizzy_grant


david = len(seventh_seal)
elf = seventh_seal
lord = BitArray(bytes=bytes(open('flag.jpg', 'rb').read())).bin
bilbo = len(lord)
matthew = 0
princess_leia = ''
destiny = bilbo // david
apocalypse = bilbo % david
for i in range(32):
    elf = born_to_die(elf)
while matthew < destiny:
    princess_leia += matthew_effect(elf, lord[matthew * david_: (matthew + 1) * david])
    elf = born_to_die(elf)
    matthew += 1
princess_leia += matthew_effect(elf[:apocalypse], lord[matthew * david_:])
res = open('flag.enc', 'wb')
res.write(bytes(int(princess_leia[i_: i + 8], 2) for i in range(0, bilbo, 8)))
```

```python
from bitstring import BitArray
#from heaven import seventh_seal, oh, no, new_testament

oh = '0'
no = '1'

def xor(shire, rohan):
    gandalf = ''
    for every, hobbit in enumerate(shire):
        gandalf += oh if ord(hobbit) ^ ord(rohan[every]) == 0 else no
    return gandalf

def shift(isengard):
    luke = 0
    for book in new_testament:
        luke ^= ord(isengard[book])
    lizzy_grant = oh + isengard[:-1] if luke == 0 else no + isengard[:-1]
    return lizzy_grant

key = ""
key_len = len(key)

msg = BitArray(bytes=bytes(open('flag.jpg', 'rb').read())).bin
msg_len = len(msg)
ctr = 0
ct = ''
for i in range(32):
    key = shift(key)
while ctr < msg_len // key_len:
    ct += xor(key, msg[ctr * key_len_: (ctr + 1) * key_len])
    key = shift(key)
    ctr += 1
ct += xor(key[:msg_len % key_len], msg[ctr * key_len_:])
print(bytes(int(ct[i_: i + 8], 2) for i in range(0, msg_len, 8)))
```

Heaven

1)

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	ASCII
00000000	FF	D8	FF	E0	00	10	4A	46	49	46	00	01	01	01	00	48	яШяа..JFIF.....H
00000010	00	48	00	00	FF	DB	00	43	00	01	01	01	01	01	01	01	.H..яЫ.C.....
00000020	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	.....
00000030	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	.....
00000040	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	.....
00000050	01	01	01	01	01	01	01	01	01	FF	DB	00	43	01	01	01	.....яЫ.C...
00000060	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	.....
00000070	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	.....
00000080	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	.....

```
f = open("flag.enc", "rb")
ct = f.read()
f.close()

k = "FFD8FFE0"
print(xor_(tobit(ct[:4].hex()), tobit(k)))

stream = "11000111001010110000110001110010"

keys = [
    "1100011100101011000"
    "0110001110010"
]
```

```
from bitstring import BitArray
#from heaven import seventh_seal, oh, no, new_testament

oh = '0'
no = '1'

def xor(shire, rohan):
    gandalf = ''
    for every, hobbit in enumerate(shire):
        gandalf += oh if ord(hobbit) ^ ord(rohan[every]) == 0 else no
    return gandalf

def shift(isengard):
    luke = 0
    for book in new_testament:
        luke ^= ord(isengard[book])
    lizzy_grant = oh + isengard[:-1] if luke == 0 else no + isengard[:-1]
    return lizzy_grant

key = ""
key_len = len(key)

msg = BitArray(bytes=bytes(open('flag.jpg', 'rb').read())).bin
msg_len = len(msg)
ctr = 0
ct = ''
for i in range(32):
    key = shift(key)
while ctr < msg_len // key_len:
    ct += xor(key, msg[ctr * key_len_: (ctr + 1) * key_len])
    key = shift(key)
    ctr += 1

ct += xor(key[:msg_len % key_len], msg[ctr * key_len_:])
print(bytes(int(ct[i_: i + 8], 2) for i in range(0, msg_len, 8)))
```

Heaven

2)

JFIF APP0 marker segment

Field	Size (bytes)	Description
APP0 marker	2	`FF E0`
Length	2	Length of segment excluding APP0 marker
Identifier	5	`4A 46 49 46 00` = "JFIF" in ASCII, terminated by a null byte
JFIF version	2	First byte for major version, second byte for minor version (`01 02` for 1.02)
Density units	1	Units for the following pixel density fields • `00` : No units; width:height pixel aspect ratio = Ydensity:Xdensity • `01` : Pixels per inch (2.54 cm) • `02` : Pixels per centimeter

https://asecuritysite.com/information/jpeg?file=new_logo4.jpg

Входящие (24) - otra... Sci-Hub: устраняя пре... CryptoCTF CTFtime.org / otrada WiFi传书 084.pdf () - 393.pdf CPA11.pdf MEPhI (Cryptology & ...

What is Huffman Coding?

Additional scanning signature analysis

Possible: [JPEG files, sig: FFD8FF] Count: 1
Possible: [JPEG files, sig: 4A464946] Count: 1

File hex characters

```
[00000000] FF D8 FF E0 00 10 4A 46 49 46 00 01 01 01 00 48   ......JFIF.....H
[00000016] 00 48 00 00 FF DB 00 43 00 01 01 01 01 01 01 01   .H.....C........
[00000032] 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01   ................
[00000048] 01 01 01 01 01 02 01 01 01 01 01 01 02 02 02 02   ................
[00000064] 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02   ................
[00000080] 02 02 02 02 02 02 02 02 02 FF DB 00 43 01 01 01   ............C...
[00000096] 01 01 01 01 02 02 02 02 02 02 02 02 02 02 02 02   ................
[00000112] 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02   ................
```

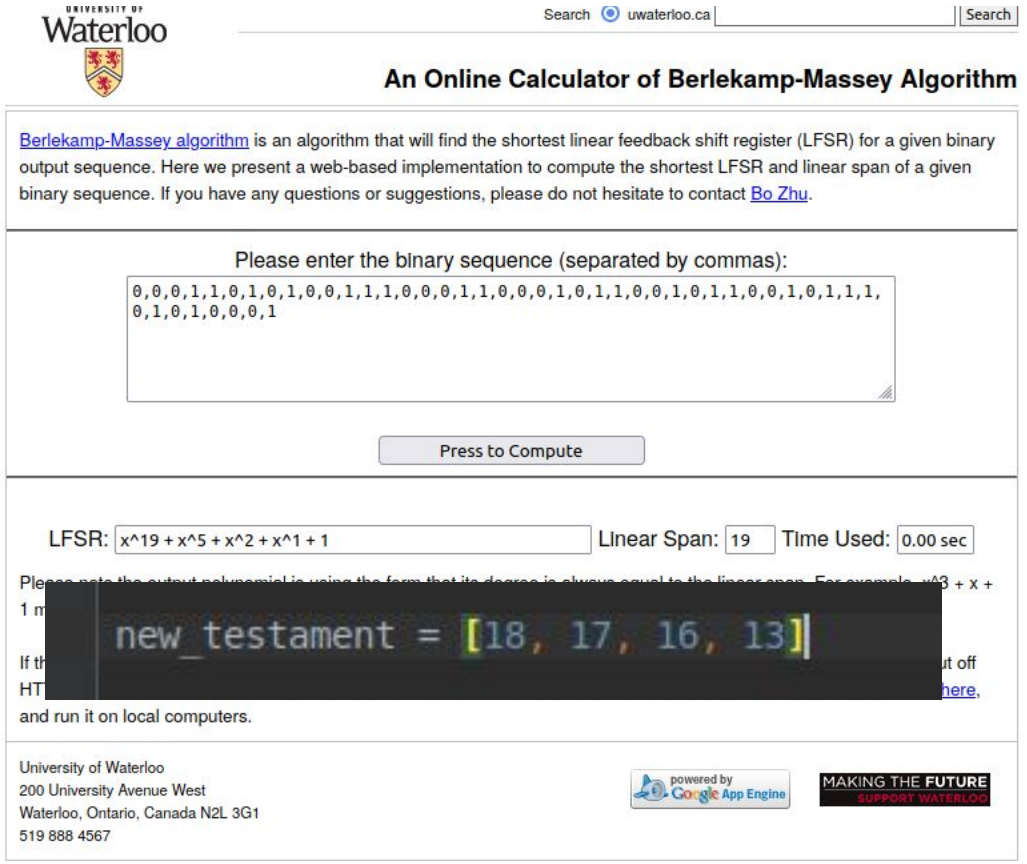
```
key = "1100011100101011000"
key_len = len(key)

ct = BitArray(bytes=bytes(open('flag.enc', 'rb').read())).bin
msg_len = len(ct)
ctr = 0
pt = ''
add = "000101" + "_" * 100000

print(ct)
stream = ""

while ctr < msg_len // key_len:
    pt += xor_(key, ct[ctr * key_len: (ctr + 1) * key_len])
    stream += key
    key = shift_(key, add[0])
    add = add[1:]

    ctr += 1

pt += xor_(key[:msg_len % key_len], ct[ctr * key_len:])

print(stream)
print(pt)
print(tobyte(pt))

k = "FFD8FFE000104a4649460001"

#11110000000001111110010001000011111010011010011010111001000011001111
#1100011100101011000_1100011100101011000_1100011100101011_1100011
#11111111111011000111_11111110000000000_0001000001001010_0110010
#f_f_d_8_f_f_e_0_0_1_0_4_a_6_4

#11110000000001111110010001000011111010011010011010111001000011001111
#1100011100101011000011000111001010110000110001110010101100001100011
#11111111110110001111111111100000000000000001000001001010010001100100
#f_f_d_8_f_f_e_0_0_0_1_0_4_a_4_6_4
```

Heaven

2)

```
100
101 key = "1100011100101011000"
102 key_len = len(key)
103
104 ct = BitArray(bytes=bytes(open('flag.enc', 'rb').read())).bin
105 msg_len = len(ct)
106 ctr = 0
107 pt = ''
108 add = "00010110010110010111010010001" + "_" * 100000
109 #0,0,0,1,1,0,1,0,1,0,0,1,1,1,0,0,0,1,1,0,0,0,1,0,1,1,0,0,1,0,1,1,0,0,1,0,1,1,1,0,1,0,1,0,0,0,1"
110
111 print(ct[400:])
112 stream = ""
113
114 while ctr < msg_len // key_len:
115     pt += xor_(key, ct[ctr * key_len: (ctr + 1) * key_len])
116     stream += key
117     key = shift_(key, add[0])
118     add = add[1:]
119
120     ctr += 1
121
122 pt += xor_(key[:msg_len % key_len], ct[ctr * key_len:])
123
124 print(stream[400:])
125 print(pt[400:])
126 print(tobyte(pt)[400:])
127
128 k = "FFD8FFE000104a4649460001"
129
```

```
CCTF{0Ne_k3y_t0_rU1e_7hem_A11_
      4Nd_7o_d3crYp7_th3_fl4g!}
```



Knapsack

открытый текст	**1 1 1 1 1 0**	**0 0 1 1 0 0**	**0 0 0 0 0 0**	**0 0 0 0 0 1**
вещи в рюкзаке	3 4 6 7 10 11	3 4 6 7 10 11	3 4 6 7 10 11	3 4 6 7 10 11
шифротекст	3 + 4 + 6 + 7 + 10 = 30	6 + 7 = 13	0	11

Namura


```python
def encrypt(pubkey, msg):

    C = 0
    for i in range(n):
        C += pubkey[i] * int(msg[i])
    return C

flag = flag.lstrip('CCTF{').rstrip('}')
bflag = bin(bytes_to_long(flag.encode('utf-8')))[2:]
n = len(bflag)
u = n - 30

pubkey = keygen((n+1) // 3, n, u)

print('pubkey =', pubkey)
enc = encrypt(pubkey, bflag)
print('enc =', enc)

pubkey = [6367304246342826841507875050246368468781925308343013730454
enc = 154657917005376465967753276253676484467260782425419406781078357
```

Namura


```python
def encrypt(pubkey, msg):

    C = 0
    for i in range(n):
        C += pubkey[i] * int(msg[i])
    return C

flag = flag.lstrip('CCTF{').rstrip('}')
bflag = bin(bytes_to_long(flag.encode('utf-8')))[2:]
n = len(bflag)
u = n - 30

pubkey = keygen((n+1) // 3, n, u)

print('pubkey =', pubkey)
enc = encrypt(pubkey, bflag)
print('enc =', enc)

pubkey = [6367304246342826841507875050246368468781925308343013730454
enc = 1546579170053764659677532762536764844672607824254194067810783
```

Knapsack Public-Key Cryptosystem Using Chinese Remainder Theorem

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$$B = \begin{pmatrix} 1 & 0 & \dots & 0 & -\lambda a_1 \\ 0 & 1 & \dots & 0 & -\lambda a_2 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \dots & 1 & -\lambda a_n \\ -1/2 & -1/2 & \dots & -1/2 & \lambda C \end{pmatrix},$$

Namura


```python
def encrypt(pubkey, msg):

    C = 0
    for i in range(n):
        C += pubkey[i] * int(msg[i])
    return C

flag = flag.lstrip('CCTF{').rstrip('}')
bflag = bin(bytes_to_long(flag.encode('utf-8')))[2:]
n = len(bflag)
u = n - 30

pubkey = keygen((n+1) // 3, n, u)

print('pubkey =', pubkey)
enc = encrypt(pubkey, bflag)
print('enc =', enc)

pubkey = [6367304246342826841507875050246368468781925308343013730454
enc = 1546579170053764659677532762536764844672607824254194067810783571
```

```python
def LLL_for_knapsack_problem(vector, w):
    K = 100000000
    def check_01(line):
        for l in line:
            if l not in [0, 1]:
                return False
        return True

    def check_0_1(line):
        for l in line:
            if l not in [0, -1]:
                return False
        return True

    for i in range(len(vector)):
        vector[i] *= K

    l = len(vector)
    A = matrix.identity(l)
    B = zero_matrix(ZZ, l, 1)
    C = matrix([vector])
    D = [[-w * K]]
    M = block_matrix(SR, [[A, B], [C, D]], subdivide=False)
    M = Matrix(ZZ, l + 1, l + 1, M)
    MR = M.T.LLL()
    R = []
    for line in MR:
        if line[-1] == 0 and (check_01(line) or check_0_1(line)):
            R.append(line[:-1])
    return(R)
pubkey = [6367304246342826841507875050246368468781925308343013730454179 41, 4434437
enc = 1546579170053764659677532762536764844672607824254194067810783575 15

print(LLL_for_knapsack_problem(pubkey, enc))
for i in range(10000):
    #print(shuffle(pubkey))
    l = LLL_for_knapsack_problem(pubkey, enc)
    if len(l) > 0:
        print(l)
        print(pubkey)
        break
```

Matrices

$$b_A = \begin{bmatrix} 4 & 1 & 11 & 10 \\ 5 & 5 & 9 & 5 \\ 3 & 9 & 0 & 10 \\ 1 & 3 & 3 & 2 \\ 12 & 7 & 3 & 4 \\ 6 & 5 & 11 & 4 \\ 3 & 3 & 5 & 0 \end{bmatrix} \times \begin{bmatrix} 6 \\ 9 \\ 11 \\ 11 \end{bmatrix} + \begin{bmatrix} 0 \\ -1 \\ 1 \\ 1 \\ 1 \\ 0 \\ -1 \end{bmatrix} \pmod{13} = \begin{bmatrix} 4 \\ 7 \\ 2 \\ 11 \\ 5 \\ 12 \\ 8 \end{bmatrix}$$

Mad hat


```python
import random
#from secret import p, flag

def transpose(x):...

def multiply(A, B):...

def sum_matrix(A, B):...

def keygen(p):
    d = random.randint(1, 2**64)
    if p % 4 == 1:
        Q = []
        for i in range(p):
            q = []
            for j in range(p):
                if i == j:
                    q.append(0)
                elif pow((i-j), int_((p-1) // 2), p) == 1:
                    q.append(1)
                else:
                    q.append(-1)
            Q.append(q)
        H = []
        r = []
        r.append(0)
        r.extend([1 for i in range(p)])
        H.append(r)
        for i in range(1, p + 1):
            r = []
            for j in range(p + 1):
                r.append(1) if j == 0 else r.append(Q[i-1][j-1])
            H.append(r)

        H2 = [[0 for j in range(2*(p+1))] for i in range(2*(p+1))]
        for i in range(0, p+1):
            for j in range(0, p+1):
                if H[i][j] == 0:
                    H2[i*2][j*2] = 1
                    H2[i*2][j*2+1] = -1
                    H2[i*2+1][j*2] = -1
                    H2[i*2+1][j*2+1] = -1
                elif H[i][j] == 1:
                    H2[i*2][j*2] = 1
                    H2[i*2][j*2+1] = 1
                    H2[i*2+1][j*2] = 1
                    H2[i*2+1][j*2+1] = -1
                else:
                    H2[i*2][j*2] = -1
                    H2[i*2][j*2+1] = -1
                    H2[i*2+1][j*2] = -1
                    H2[i*2+1][j*2+1] = +1
        ID = [[(-1)**d if i == j else 0 for i in range(len(H2))] for j in range(len(H2))]
        H2 = multiply(ID, H2)
        return(H2, d)
    else:
        Q = []
        for i in range(p):
            q = []
            for j in range(p):
                if i == j:
                    q.append(0)
                elif pow((i-j), int_((p-1) // 2), p) == 1:
                    q.append(1)
                else:
                    q.append(-1)
            Q.append(q)
        H1 = []
        H1.append([1 for i in range(p+1)])
        for i in range(1, p +1):
            r = []
            for j in range(p +1):
                if j == 0:
                    r.append(-1)
                elif i == j:
                    r.append(1 + Q[i-1][j-1])
                else:
                    r.append(Q[i-1][j-1])
            H1.append(r)
        ID = [[(-1)**d if i == j else 0 for i in range(len(H1))] for j in range(len(H1))]
        H1 = multiply(ID, H1)
        return(H1, d)

def encrypt(msg, key):
    matrix = key[0]
    d = key[1]
    m = [[ord(char) for char in msg_]]
    de = [[-d for i in range(len(msg))]]
    C = multiply(m, matrix)
    cipher = sum_matrix(C, de)
    return cipher

key = keygen(p)
flag = flag + (len(key[0][0]) - len(flag)) * flag[-1]
cipher = encrypt(flag, key)
print('cipher =', cipher)

## 1 x 76
cipher = [-3459749918754130611, -3459749918754138177, -3459749918754137803, -3459749918754138385,
          -3459749918754138025, -3459749918754138097, -3459749918754138073, -3459749918754138245,
          -3459749918754138183, -3459749918754138445, -3459749918754137991, -3459749918754138597,
```

m – искомый вектор

K, d – закрытый ключ
K – матрица, d – натуральное число

c = m * K +
+ [d, d … d]

Mad hat

1) Какие передаваемые или генерируемые в самой функции параметры определяют ключевую матрицу?

```python
import random
#from secret import p, flag

def transpose(x):...

def multiply(A, B):...

def sum_matrix(A, B):...

def keygen(p):
    d = random.randint(1, 2**64)
    if p % 4 == 1:
        Q = []
        for i in range(p):
            q = []
            for j in range(p):
                if i == j:
                    q.append(0)
                elif pow((i-j), int((p-1) // 2), p) == 1:
                    q.append(1)
                else:
                    q.append(-1)
            Q.append(q)
        H = []
        r = []
        r.append(0)
        r.extend([1 for i in range(p)])
        H.append(r)
        for i in range(1, p + 1):
            r = []
            for j in range(p + 1):
                r.append(1) if j == 0 else r.append(Q[i-1][j-1])
            H.append(r)

        H2 = [[0 for j in range(2*(p+1))] for i in range(2*(p+1))]
        for i in range(0, p+1):
            for j in range(0, p+1):
                if H[i][j] == 0:
                    H2[i*2][j*2] = 1
                    H2[i*2][j*2+1] = -1
                    H2[i*2+1][j*2] = -1
                    H2[i*2+1][j*2+1] = -1
                elif H[i][j] == 1:
                    H2[i*2][j*2] = 1
                    H2[i*2][j*2+1] = 1
                    H2[i*2+1][j*2] = 1
                    H2[i*2+1][j*2+1] = -1
                else:
                    H2[i*2][j*2] = -1
                    H2[i*2][j*2+1] = -1
                    H2[i*2+1][j*2] = -1
                    H2[i*2+1][j*2+1] = +1
        ID = [[(-1)**d if i == j else 0 for i in range(len(H2))] for j in range(len(H2))]
        H2 = multiply(ID, H2)
        return(H2, d)
    else:
        Q = []
        for i in range(p):
            q = []
            for j in range(p):
                if i == j:
                    q.append(0)
                elif pow((i-j), int((p-1) // 2), p) == 1:
                    q.append(1)
                else:
                    q.append(-1)
            Q.append(q)
        H1 = []
        H1.append([1 for i in range(p+1)])
        for i in range(1, p +1):
            r = []
            for j in range(p +1):
                if j == 0:
                    r.append(-1)
                elif i == j:
                    r.append(1 + Q[i-1][j-1])
                else:
                    r.append(Q[i-1][j-1])
            H1.append(r)
        ID = [[(-1)**d if i == j else 0 for i in range(len(H1))] for j in range(len(H1))]
        H1 = multiply(ID, H1)
        return(H1, d)

def encrypt(msg, key):
    matrix = key[0]
    d = key[1]
    m = [[ord(char) for char in msg]]
    de = [[-d for i in range(len(msg))]]
    C = multiply(m, matrix)
    cipher = sum_matrix(C, de)
    return cipher

key = keygen(p)
flag = flag + (len(key[0][0]) - len(flag)) * flag[-1]
cipher = encrypt(flag, key)
print('cipher =', cipher)

## 1 x 76
cipher = [-3459749918754130611, -3459749918754138177, -3459749918754137803, -3459749918754138385,
          -3459749918754138025, -3459749918754138097, -3459749918754138073, -3459749918754138245,
          -3459749918754138183, -3459749918754138445, -3459749918754137991, -3459749918754138597,
```

Mad hat

2) как именно они влияют и что нужно для их нахождения

```python
import random
#from secret import p, flag

def transpose(x):...

def multiply(A, B):...

def sum_matrix(A, B):...

def keygen(p):
    d = random.randint(1, 2**64)
    if p % 4 == 1:
        Q = []
        for i in range(p):
            q = []
            for j in range(p):
                if i == j:
                    q.append(0)
                elif pow((i-j), int((p-1) // 2), p) == 1:
                    q.append(1)
                else:
                    q.append(-1)
            Q.append(q)
        H = []
        r = []
        r.append(0)
        r.extend([1 for i in range(p)])
        H.append(r)
        for i in range(1, p + 1):
            r = []
            for j in range(p + 1):
                r.append(1) if j == 0 else r.append(Q[i-1][j-1])
            H.append(r)

        H2 = [[0 for j in range(2*(p+1))] for i in range(2*(p+1))]
        for i in range(0, p+1):
            for j in range(0, p+1):
                if H[i][j] == 0:
                    H2[i*2][j*2] = 1
                    H2[i*2][j*2+1] = -1
                    H2[i*2+1][j*2] = -1
                    H2[i*2+1][j*2+1] = -1
                elif H[i][j] == 1:
                    H2[i*2][j*2] = 1
                    H2[i*2][j*2+1] = 1
                    H2[i*2+1][j*2] = 1
                    H2[i*2+1][j*2+1] = -1
                else:
                    H2[i*2][j*2] = -1
                    H2[i*2][j*2+1] = -1
                    H2[i*2+1][j*2] = -1
                    H2[i*2+1][j*2+1] = +1
        ID = [[(-1)**d if i == j else 0 for i in range(len(H2))] for j in range(len(H2))]
        H2 = multiply(ID, H2)
        return(H2, d)
    else:
        Q = []
        for i in range(p):
            q = []
            for j in range(p):
                if i == j:
                    q.append(0)
                elif pow((i-j), int((p-1) // 2), p) == 1:
                    q.append(1)
                else:
                    q.append(-1)
            Q.append(q)
        H1 = []
        H1.append([1 for i in range(p+1)])
        for i in range(1, p +1):
            r = []
            for j in range(p +1):
                if j == 0:
                    r.append(-1)
                elif i == j:
                    r.append(1 + Q[i-1][j-1])
                else:
                    r.append(Q[i-1][j-1])
            H1.append(r)
        ID = [[(-1)**d if i == j else 0 for i in range(len(H1))] for j in range(len(H1))]
        H1 = multiply(ID, H1)
        return(H1, d)

def encrypt(msg, key):
    matrix = key[0]
    d = key[1]
    m = [[ord(char) for char in msg]]
    de = [[-d for i in range(len(msg))]]
    C = multiply(m, matrix)
    cipher = sum_matrix(C, de)
    return cipher

key = keygen(p)
flag = flag + (len(key[0][0]) - len(flag)) * flag[-1]
cipher = encrypt(flag, key)
print('cipher =', cipher)

## 1 x 76
cipher = [-3459749918754130611, -3459749918754138177, -3459749918754137803, -3459749918754138385,
          -3459749918754138025, -3459749918754138097, -3459749918754138073, -3459749918754138245,
          -3459749918754138183, -3459749918754138445, -3459749918754137991, -3459749918754138597,
```

Для d имеет значение только четность

p можно определить по размерности шифртекста:

$p_1 = 37$

$p_2 = 75$

Mad hat


```python
import numpy as np

p1 = 37
p2 = 75

matrices = [np.matrix(keygen(p1, 1)[0]), np.matrix(keygen(p2, 1)[0]),
            np.matrix(keygen(p1, 2)[0]), np.matrix(keygen(p2, 2)[0])]
inv_matrices = [np.linalg.inv(a) for a in matrices]
d0 = -3459749918754130000


for m in inv_matrices:
    for i in range(10000):
        cipher_ = sum_matrix([cipher], [[-d0 + i] * 76])
        cipher_ = np.matrix(cipher_).dot(m)
        flag = ""
        b = True
        for c in range(76):
            c_ = round(cipher_[0, c])
            if c_ < 0 or c_ >= 256:
                b = False
                break
            flag += chr(c_)
        if b and "CCTF{" in flag:
            print(flag)

#  CCTF{TH13_i3_Hadamard_rip_y0ung_&_bri11iant_Paley!}}}}}}}}}}}}}}}}}}}}
```

```python
import numpy as np
R = IntegerModRing(257)

p1 = 37
p2 = 75

matrices = [Matrix(R, keygen(p1, 1)[0]), Matrix(R, keygen(p2, 1)[0]),
            Matrix(R, keygen(p1, 2)[0]), Matrix(R, keygen(p2, 2)[0])]
inv_matrices = [a.inverse() for a in matrices]
d0 = -3459749918754130000


for m in inv_matrices:
    for i in range(257):
        cipher_ = Matrix(R, [cipher]) + Matrix(R, [[-d0 + i] * 76])
        cipher_ = cipher_ * m
        flag = ""
        b = True
        for c in range(76):
            c_ = cipher_[0, c]
            if c_ < 0 or c_ >= 256:
                b = False
                break
            flag += chr(c_)
        if b and "CCTF{" in flag:
            print(flag)
            #break

```

Algebraic


```
sage: R.<x> = ZZ['x']; A.<Dx> = OreAlgebra(R)

sage: L = (5*x^2+3*x-7)*Dx^2 + (3*x^2+8*x-1)*Dx + (9*x^2-3*x+8)

sage: L.parent()
```

$$\mathbf{Z}[x]\langle \mathrm{Dx} \rangle$$

```
sage: B = OreAlgebra(QQ['x'], 'Dx')

sage: L = B(L)

sage: L.parent()
```

$$\mathbf{Q}[x]\langle \mathrm{Dx} \rangle$$

Gambling

```
nc 05.cr.yp.toc.tf 33371
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+ Hi, there is a strong relation between philosophy and the gambling!  +
+ Gamble as an ancient philosopher and find the flag :)                +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
| Options:
|    [C]ipher flag!
|    [E]ncryption function!
|    [T]ry the encryption
|    [Q]uit
```

```python
def encrypt(m, p, a, b):
    assert m < p and isPrime(p)
    return (m ** 3 + a * m + b) % p
```

p, a, b – не известны

$f(x) \equiv x^3 + ax + b \% p$

f(flag) = c

Мы можем получить f(x) для любого x

Gambling

```
nc 05.cr.yp.toc.tf 33371
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+ Hi, there is a strong relation between philosophy and the gambling!  +
+ Gamble as an ancient philosopher and find the flag :)                +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
| Options:
|    [C]ipher flag!
|    [E]ncryption function!
|    [T]ry the encryption
|    [Q]uit
```

```
def encrypt(m, p, a, b):
    assert m < p and isPrime(p)
    return (m ** 3 + a * m + b) % p
```

p, a, b – не известны
$f(x) \equiv x^3 + ax + b \ \% \ p$
f(flag) = c
Мы можем получить f(x) для любого x

$f(0) \equiv b \ \% \ p$ – получаем b
$f(1) \equiv 1 + a + b \ \% \ p$ – получаем a

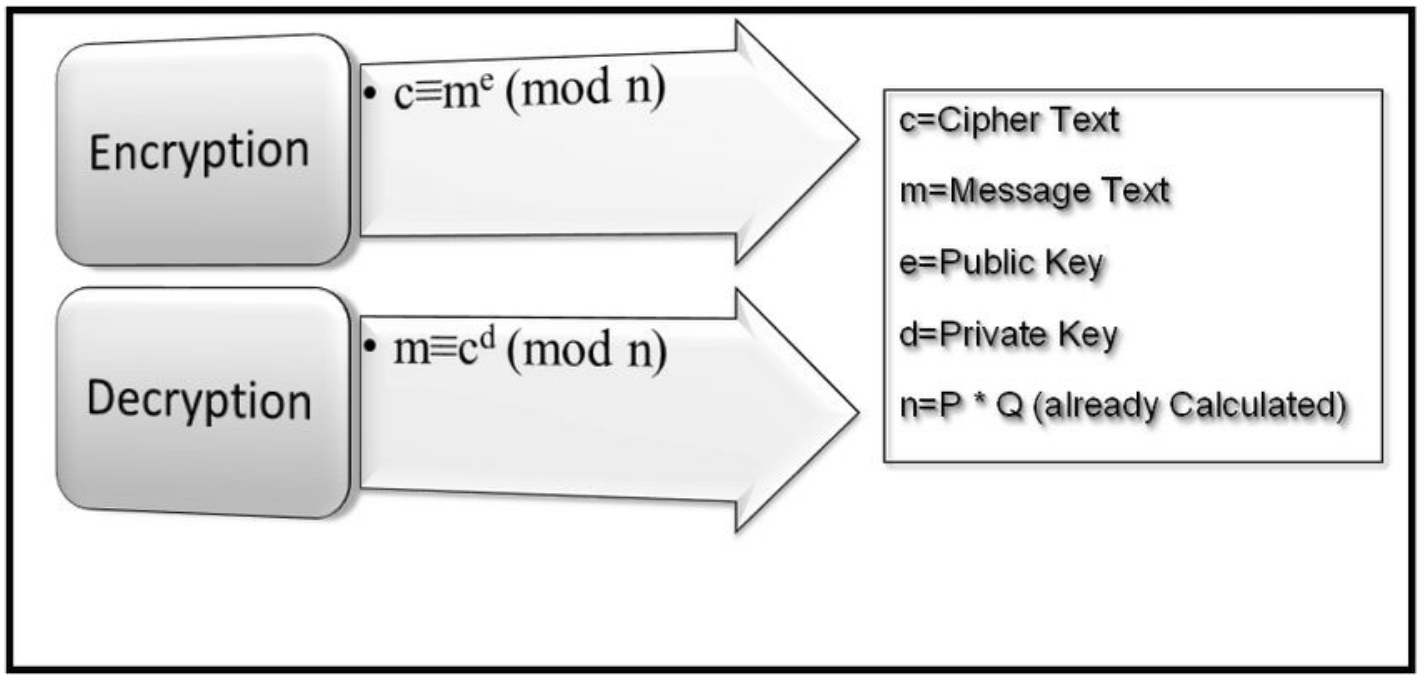
$c_1 = x_1^3 + ax_1 + b = f(x_1) + k_1 p$
$c_2 = x_2^3 + ax_2 + b = f(x_2) + k_2 p$
НОД $(c_1 - f(x_1), c_2 - f(x_2))$ делится на p

Решаем сравнение:
$x^3 + ax + b - c \equiv 0 \ \% \ p$

```
PR.<x> = PolynomialRing(GF(p))
f = x^3 + a * x + b - enc
rts = f.roots()
print(rts)

for root in rts:
    flag = root[0]
    print(long_to_bytes(flag))
```

Algebraic, pow



One line crypto


```python
from Crypto.Util.number import *
from secret import m, n, x, y, flag

p, q = x**(m+1) - (x+1)**m, y**(n+1) - (y+1)**n
assert isPrime(p) and isPrime(q) and p < q < p << 3 and len(bin(p*q)[2:]) == 2048
enc = bytes_to_long(flag)
print(pow(enc, 0x10001, p*q))
```

$p = x^{m+1} - (x+1)^m$
$q = y^{m+1} - (y+1)^m$

One line crypto


```python
from Crypto.Util.number import *
from secret import m, n, x, y, flag

p, q = x**(m+1) - (x+1)**m, y**(n+1) - (y+1)**n
assert isPrime(p) and isPrime(q) and p < q < p << 3 and len(bin(p*q)[2:]) == 2048
enc = bytes_to_long(flag)
print(pow(enc, 0x10001, p*q))
```

$p = x^{m+1} - (x+1)^m$
$q = y^{m+1} - (y+1)^m$

```python
from Crypto.Util.number import *
from gmpy2 import invert

res = 14608474132952352328897080717325464308438322623319847428447933943

def f(p, i):
    return pow(p, i + 1) - pow(p + 1, i)


d13 = pow(2, 1028)
d7 = pow(2, 1021)
primes = []
for i in range(1000):
    for j in range(-1000, 1000):
        fn = f(j, i)
        if fn < d13 and fn > d7 and isPrime(fn):
            print(fn, i, j)
            primes.append(fn)


for i in range(len(primes)):
    for j in range(i, len(primes)):
        n = primes[i]*primes[j]
        if len(bin(n)[2:]) == 2048:
            phi = (primes[i]-1)*(primes[j]-1)
            d = invert(0x10001, phi)
            m = long_to_bytes(pow(res, d, n))
            if b"CCTF{" in m:
                print(m)

# b'CCTF{0N3_1!nE_CrYp7O_iN_202O}'
```

Three ravens

```python
from Crypto.Util.number import *
from flag import flag

def keygen(nbit):
    while True:
        p, q, r = [getPrime(nbit) for _ in range(3)]
        if isPrime(p + q + r):
            pubkey = (p * q * r, p + q + r)
            privkey = (p, q, r)
            return pubkey, privkey

def encrypt(msg, pubkey):
    enc = pow(bytes_to_long(msg.encode('utf-8')), 0x10001, pubkey[0] * pubkey[1])
    return enc

nbit = 512
pubkey, _ = keygen(nbit)
print('pubkey =', pubkey)

enc = encrypt(flag, pubkey)
print('enc =', enc)
```

p, *q*, *r* – *простые (секретный ключ, не известны)*

s = *p* + *q* + *r* - *простое*

n = *p* * *q* * *r* * *s*

s, *n* / *s* – *открытый ключ, известны*

$c = m^e \% n$

m = ?

Three ravens

Короткое сообщение (< длины любого из множителей n)
Известен один из множителей n

$c \equiv m^e \% p*q*r*s$
$c\_ = m^e = k * (p*q*r*s) + c$

$m^e \equiv c \% s$

$d \equiv e^{-1} \% s$
$c^d \equiv m^{ed} \equiv m \% s$

```python
def keygen(nbit):
    while True:
        p, q, r = [getPrime(nbit) for _ in range(3)]
        if isPrime(p + q + r):
            pubkey = (p * q * r, p + q + r)
            privkey = (p, q, r)
            return pubkey, privkey

def encrypt(msg, pubkey):
    enc = pow(bytes_to_long(msg.encode('utf-8')), 0x10001, pubkey[0] * pubkey[1])
    return enc

nbit = 512
pubkey, _ = keygen(nbit)
print('pubkey =', pubkey)


pubkey = (111807355115054176038350676586833428909584921720738342877599212837482603793
enc = 821805228222601189722970390776352121405425478527551188647686132806711749218379

def decrypt(mess, pubkey):
    d = invert(0x10001, pubkey[1] - 1)
    m = pow(mess, d, pubkey[1])
    return long_to_bytes(m)


print(decrypt(enc, pubkey))
# b'CCTF{tH3_thr3E_r4V3n5_ThRe3_cR0w5}'
```

Model

```
nc 04.cr.yp.toc.tf 8001
```

```python
def genkey(nbit):
    while True:
        p, q = getPrime(nbit), getPrime(nbit)
        if gcd((p-1) // 2, (q-1) // 2) == 1:
            P, Q = (q-1) // 2, (p-1) // 2
            r = inverse(Q, P)
            e = 2 * r * Q  - 1
            return(p, q, e)

def encrypt(msg, pubkey):
    e, n = pubkey
    return pow(bytes_to_long(msg), e, n)
```

p, q – простые
P = (q-1) // 2
Q = (p-1) // 2
$r \equiv Q^{-1} \% P$
e = 2 * r * Q - 1

$c \equiv m^e \% p*q$

Model

```
nc 04.cr.yp.toc.tf 8001
```

```python
def genkey(nbit):
    while True:
        p, q = getPrime(nbit), getPrime(nbit)
        if gcd((p-1) // 2, (q-1) // 2) == 1:
            P, Q = (q-1) // 2, (p-1) // 2
            r = inverse(Q, P)
            e = 2 * r * Q  - 1
            return(p, q, e)

def encrypt(msg, pubkey):
    e, n = pubkey
    return pow(bytes_to_long(msg), e, n)
```

p, q – простые
P = (q-1) // 2
Q = (p-1) // 2
$r \equiv Q^{-1} \% P$
e = 2 * r * Q - 1

$c \equiv m^e \% p*q$

$e = 2 * Q^{-1} * Q - 1 = 1 \% P$

1) $e \equiv 1 \% (q-1)$
   $c \equiv m \% q$

1) $e \equiv 1 + P \% (q-1)$
   $c = m^{1+(q-1)/2} \% q$
   $c = m*1^{1/2} \% q$
   $c = \pm m \% q$

$q = gcd(c \pm m, n)$

Butterfly effect

```python
def hq_prng(x, p, g):
    rng = 0
    for _ in range(getRandomNBitInteger(14)):
        x = pow(g, x, p)
    for i in range(nbit):
        x = pow(g, x, p)
        if x < (p-1) // 2:
            rng += 2**i - 1
        elif x > (p-1) // 2:
            rng -= 2**i + 1
        else:
            rng ^= 2**(i + 1)
    if rng <= 0:
        return -rng
    return rng

def keygen(p, g):
    r, s = hq_prng(getRandomNBitInteger(nbit), p, g), hq_prng(getRandomNBitInteger(nbit), p, g)
    u, v = gmpy2.next_prime(r**2 + s**2), gmpy2.next_prime(2*r*s)
    e, n = 0x10001, u * v
    return e, n

def encrypt(msg, e, n):
    return pow(bytes_to_long(msg.encode('utf-8')), e, n)

#encrypt(flag, e, n) = 11766758294702630748270985031821482016596498049541442371160861468107503654695

#(p, g, n) = (68396932999729141946282927360590169590631231980913314894620521363257317833167L, 1114840
```

Butterfly effect

```python
def hq_prng(x, p, g):
    rng = 0
    for _ in range(getRandomNBitInteger(14)):
        x = pow(g, x, p)
    for i in range(nbit):
        x = pow(g, x, p)
        if x < (p-1) // 2:
            rng += 2**i - 1
        elif x > (p-1) // 2:
            rng -= 2**i + 1
        else:
            rng ^= 2**(i + 1)
    if rng <= 0:
        return -rng
    return rng

def keygen(p, g):
    r, s = hq_prng(getRandomNBitInteger(nbit), p, g), hq_prng(getRandomNBitInteger(nbit), p, g)
    u, v = gmpy2.next_prime(r**2 + s**2), gmpy2.next_prime(2*r*s)
    e, n = 0x10001, u * v
    return e, n

def encrypt(msg, e, n):
    return pow(bytes_to_long(msg.encode('utf-8')), e, n)

#encrypt(flag, e, n) = 11766758294702630748270985031821482016596498049541442371160861468107503654695

#(p, g, n) = (68396932999729141946282927360590169590631231980913314894620521363257317833167L, 1114840
```

SageMathCell

Type some Sage code below and press Evaluate.

```
1  Zp = Zmod(68396932999729141946282927360590169590631231980913314894620521363257317833167)
2  a = Zp(11148408907716636563689390048104567047599159688378384611325239859308138541650)
3  print(a.multiplicative_order())
4
```

Evaluate

```
31337
```

Butterfly effect

```python
def hq_prng(x, p, g):
    rng = 0
    for _ in range(getRandomNBitInteger(14)):
        x = pow(g, x, p)
    for i in range(nbit):
        x = pow(g, x, p)
        if x < (p-1) // 2:
            rng += 2**i - 1
        elif x > (p-1) // 2:
            rng -= 2**i + 1
        else:
            rng ^= 2**(i + 1)
    if rng <= 0:
        return -rng
    return rng

def keygen(p, g):
    r, s = hq_prng(getRandomNBitInteger(nbit), p, g),
    u, v = gmpy2.next_prime(r**2 + s**2), gmpy2.next_
    e, n = 0x10001, u * v
    return e, n

def encrypt(msg, e, n):
    return pow(bytes_to_long(msg.encode('utf-8')), e,

#encrypt(flag, e, n) = 1176675829470263074827098503182

#(p, g, n) = (6839693299972914194628292736059016959060
```

```python
import gmpy2
from Crypto.Util.number import bytes_to_long, getRandomNB

nbit = 256
def hq_prng(x, p, g):
    rng = 0
    global gs
    for i in range(nbit):
        x = gs[x % 31337]
        if x < (p-1) // 2:
            rng += 2**i - 1
        elif x > (p-1) // 2:
            rng -= 2**i + 1
        else:
            rng ^= 2**(i + 1)
    if rng <= 0:
        return -rng
    return rng

def keygen(p, g):
    r, s = hq_prng(getRandomNBitInteger(nbit), p, g), hq_
    u, v = gmpy2.next_prime(r**2 + s**2), gmpy2.next_prim
    e, n = 0x10001, u * v
    return e, n

def encrypt(msg, e, n):
    return pow(bytes_to_long(msg.encode('utf-8')), e, n)



# encrypt(flag, e, n) = 1176675829470263074827098503182147

(p, g, n) = (6839693299972914194628292736059016959063123
             1114840890771663656368939004810456704759915
             1744210031238100333817902362218378565157173

print(gmpy2.is_prime(p))

#sage:
```

```python
ord = 31337

gs = [0] * 31337
prns = [0] * 31337
curr = 1
for i in range(31337):
    gs[i] = curr
    curr = curr * g % p
print("done1")
for i in range(0, 31337):
    prns[i] = hq_prng(i, p, g)
print("done2")
prns.sort()


for i in range(0, 31337):
    print(i)
    lef = i+1
    rig = 31336
    mid, best = 0, 0
    while lef <= rig:
        mid = (lef + rig) // 2
        if (prns[i]*prns[i] + prns[mid] * prns[mid]) * 2 * prns[i] * prns[mid] >= n:
            best = mid
            rig = mid - 1
        else:
            lef = mid + 1

    if best == 0:
        continue

    for j in range(best-1, min(best+30, 31337)):
        u = prns[i] * prns[i] + prns[j] * prns[j]
        v = 2 * prns[i] * prns[j]

        u = gmpy2.next_prime(u)
        v = gmpy2.next_prime(v)
        if u * v == n:
            print(u, v)
            exit()
```

https://blog.cryptohack.org/cryptoctf2020

Decent RSA

```
-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEA/Ug8rlEPci1UXMsT
+UDo
y8DfxbTHX/3BK2oU+FPWiJf+EiUBM2x4ep04qZ1SO9Pmqj/WH9skMrF1J/LX
uY3l
fjvJCh0DXa9VUyX2dAJidja9Ior7GpFwwjYdKh+OETNV+2/CcX4RiPvj+8Apm
edW
gn4Fxaeivki+f/UwDa+ws1fTUzmI325v8yvcryHhbgeUWiF85EP6HFAavTsVPl
xb
LikVMAB1fuzDbqqJvW2u138w6b2FH3WrezYF6tbAyZej2HX46phwDm9C7MX
YJ/sU
oS+E8P7S1jMTCWjfwMCOKU3SFGrkWtXuTaoMZ2nZ+HVfJV8xJOjWez1OxQ
5P3F1w
GQIDAQAB
-----END PUBLIC KEY-----
```

Decent RSA

```
-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEA/Ug8rlEPci1UXMsT
+UDo
y8DfxbTHX/3BK2oU+FPWiJf+EiUBM2x4ep04qZ1SO9Pmqj/WH9skMrF1J/LX
uY3l
fjvJCh0DXa9VUyX2dAJidja9Ior7GpFwwjYdKh+OETNV+2/CcX4RiPvj+8Apm
edW
gn4Fxaeivki+f/UwDa+ws1fTUzmI325v8yvcryHhbgeUWiF85EP6HFAavTsVPl
xb
LikVMAB1fuzDbqqJvW2u138w6b2FH3WrezYF6tbAyZej2HX46phwDm9C7MX
YJ/sU
oS+E8P7S1jMTCWjfwMCQKU3SFGrkWtXuTaoMZ2nZ+HVfJV8xJOjWez1OxQ
5P3F1w
GQIDAQAB
-----END PUBLIC KEY-----
```

```python
from Crypto.PublicKey import RSA
from Crypto.Util.number import long_to_bytes, bytes_to_long

flag = bytes_to_long(open("flag.enc","rb").read())
key = RSA.import_key(open("mykey.pem").read())
n = Integer(key.n)

poly = sum(e * x^i for i,e in enumerate(Integer(key.n).digits(11)))
(p, _), (q, _) = poly.factor_list()
p, q = p(x=11), q(x=11)
assert p*q == n

d = inverse_mod(key.e, (p-1)*(q-1))
print(long_to_bytes(pow(flag, d, n)))
```

Official writeups

ЛЕТНЯЯ ШКОЛА CTF 2021

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