Capture the Flag

50.042 Foundations of Cybersecurity 2019

Reverse gnireenignE
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Introduction

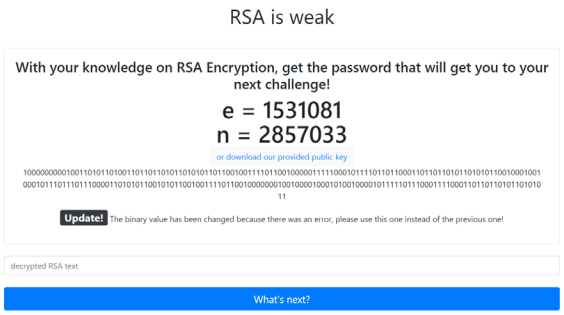
We have compiled our solutions to the 6 challenges that we successfully completed in this report. We have also attached the screenshots included in this report, the codes required and other files in the respective challenge folders.

1. SMTB

http://flask-env.dy2nh6w2mr.ap-southeast-1.elasticbeanstalk.com
Flag:
CTF{thisIsTheFinalFlagThatYouAndYourGroupmatesHaveWorkedHardForToGetForTheLastCoupleOfDays:p}

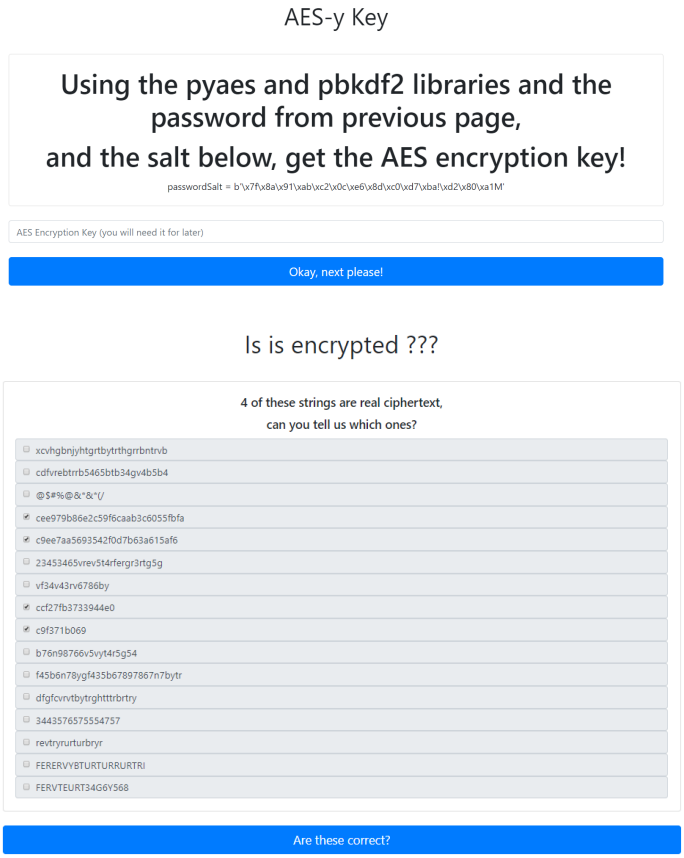
Step 1: SHAttered

From the header, we know that SHA encryption was used.
Given: b7a875fc1ea228b9061041b7cec4bd3c52ab3ce3
Go to : https://hashkiller.co.uk/Cracker/SHA1
Found: letmein
Steb
Firstly, we went to www.factordb.com and using n, we found p and q. We are now able to derive the private key using mod inverse method. The decrypted RSA text is 's3cr3t*c0d3'.



Step 3.1: AES Key Derivation

Next, we had to use pyaes and pdkdf2 to derive our AES encryption key, which is b'c531048c47c13a7092d6ad8b36c0cc86bcef6fd4b8063acb7831c4fd2b523d68'.



Step 3.2: Read the bytes

Once solved, we selected the 4 strings that were the real ciphertext.

Once you have selected correctly, you will be redirected to the next page to decrypt the 4 ciphertexts. The plaintexts are - ‘transpositional’,’substitutional’,’vigenere’ and ‘shift’ respectively.

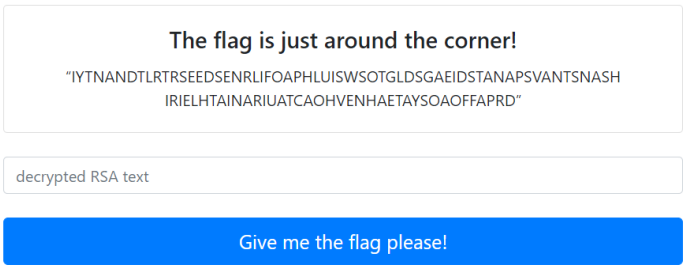
Step 4: AES Decryption (CTR Block Mode)

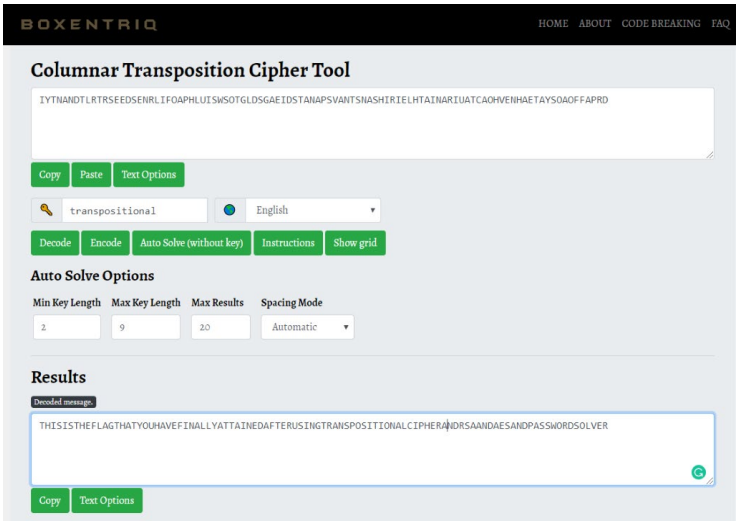
Based on the way ‘CIPHER’ is being arranged, we can derive that transposition cipher was used. We guessed that ‘transpositional’ was the key used. We used an online tool. It is cap sensitve and the decrypted RSA text is ‘Thisistheflagthatyouhavefinallyattainedafterusingtranspositionalcipherandrsaandaesandpasswordsolver’.

C I

PH

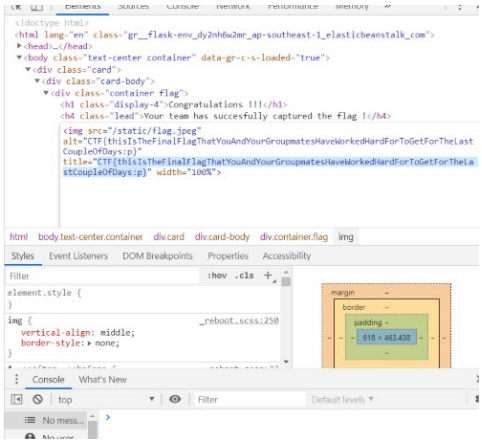
E R





https://www.boxentriq.com/code-breaking/columnar-transposition-cipher

Finally, the flag is within the image and we do an inspect to retrieve it. The flag is CTF{thisIsTheFinalFlagThatYouAndYourGroupmatesHaveWorkedHardForToGetForTheLastCoupleOfDays:p}.



2. Sartech

Flag: CTF{indicatory}

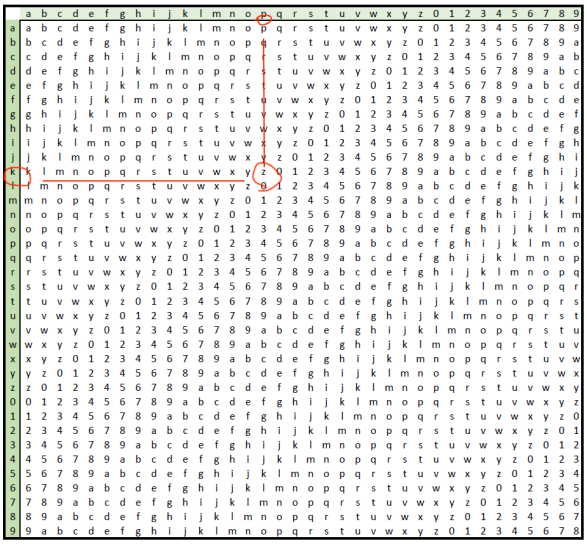
Step 1: Finding Keys

After the last round of hints, Sartech group revealed the key in the poem is KILL & DICT and that the ciphertext is PHIB3FB8DKGEE.

Title: **PHIBFB8DKGEE**
Death is not the end we see**k**
It is the beginning, for **I**
Cannot help but knee**l**
To the collosal hades' wil**l**.

Step 2: Substitution Cipher with KILL

In my first attempt using their special substitution table I derived the wrong text because I was encrypting and not working backwards as shown below in the picture.



On my second attempt I derived:

PHIBFB8DKGEE

KILLKILLKILL

F97053x2a833

Step 3: Transpositional Cipher with DICT

Realising that I would have to decrypt here too, I separated **F97053x2a833** into 4 columns.

C D I T

F 0 x 8

9 5 2 3

7 3 a 3

Then I joined the characters starting from DICT (given the clue 0x is the first two and alphabetically), **Key: 0XF852933A73**.

Step 4: Decrypting Images

We were given 7 images that were encrypted with ECB. After getting the hex key, I used the given ecb.py code to decrypted each image.

```
nonchalantcocoa$ python3.7 ecb.py -i random-1.png -o rd1.jpeg -k 0XF852933A73 -m d
nonchalantcocoa$ python3.7 ecb.py -i random-2.png -o rd2.jpeg -k 0XF852933A73 -m d
nonchalantcocoa$ python3.7 ecb.py -i random-3.png -o rd3.jpeg -k 0XF852933A73 -m d
nonchalantcocoa$  python3.7 ecb.py -i random-4.png -o rd4.jpeg -k 0XF852933A73 -m d
nonchalantcocoa$  python3.7 ecb.py -i random-5.png -o rd5.jpeg -k 0XF852933A73 -m d
nonchalantcocoa$  python3.7 ecb.py -i random-6.png -o rd6.jpeg -k 0XF852933A73 -m d
nonchalantcocoa$  python3.7 ecb.py -i random-7.png -o rd7.jpeg -k 0XF852933A73 -m d
nonchalantcocoa$
```

The results were 7 images of hashes.

c337b66e9655a710d5a292bbe8365946

5578f65081824f19e2f253e59c91671f

2ed074586ca648092321eb284101350b

ae7bc1462aec26b6eb44514af9041c76

9b76f2b398575b43d292063423931bb2

ee052027e2fded28c0e6acb12e2409cd

7100de6fd95ea13a2b32872371deeda7

Step 5: Cracking Hash

Using the online hash cracker hashkiller.co.uk/Cracker/MD5, we found the message.

```
c337b66e9655a710d5a292bbe8365946 MD5 2a535 or osCommerce 2a:535
5578f65081824f19e2f253e59c91671f MD5 15dic or osCommerce 15:dic
2ed074586ca648092321eb284101350b MD5 49i37 or osCommerce 49:i37
ae7bc1462aec26b6eb44514af9041c76 MD5 524n9 or osCommerce 52:4n9
9b76f2b398575b43d292063423931bb2 MD5 o4258
ee052027e2fded28c0e6acb12e2409cd MD5 ry560
7100de6fd95ea13a2b32872371deeda7 MD5 363t9 or osCommerce 36:3t9
```

As their hint indicated the flag only contained alphabets, we found the word dictionary in the above: adicinoryt -> dictionary. However, the flag CTF{dictionary} didn't work. Hence we tried to form other words using the jumbled letters and got the word indicatory, which was successful!

3. Caesar Salad

Flag: CTF{SUTD_lib_2100h}

Step 1

We had to figure out with pubKey encrypts which ciphertext. pubKey1 -> ct2 and vice versa.

Step 2

We used an online tool to find p and q for pubKey1 and pubKey2.

For pubKey1:

13117501291271825080659230487342628208640000000001

Result:
number
1311750129...01<51> = 293049347 · 44762090158391736940670372786541743116868 3<42>

For pubKey2:

```
12435706044156680700266886323532507764867727360000000000001
```

Result:

$_{3>} = 52750358975649354449407_{<23>} \cdot 23574637757246841069594107658796543_{<3}$

Step 3

Use b64decode when reading the ciphertexts

This is the output derived:

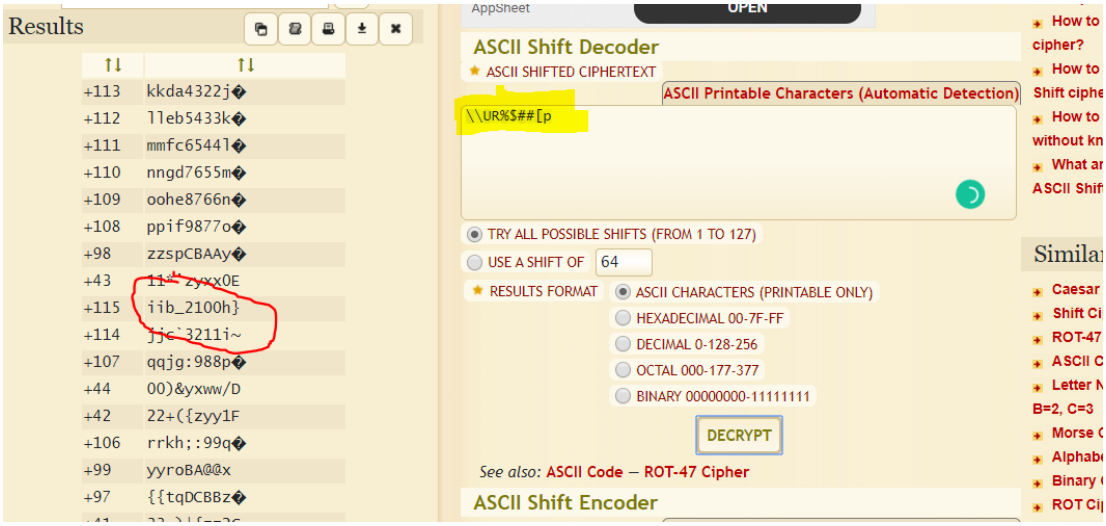
```
Finding private key 1 (t):
t: 715500067991440086669136011636668477568994231538O3
ct1: 113264822024947893022000910723816575818390378749238
dec_ct1: bytearray(b'\\UR%$##[p')

Finding private key 2 (t):
t: 97322916867313153306434656690777750365722586923364180751 9
ct2: 426067942678669650384389884991364363010626560442555009417
dec_ct2: bytearray(b'6G9nFHG7R_')
```

Step 4

We used an online tool to do an ascii shift cipher for each dec_ct(x).

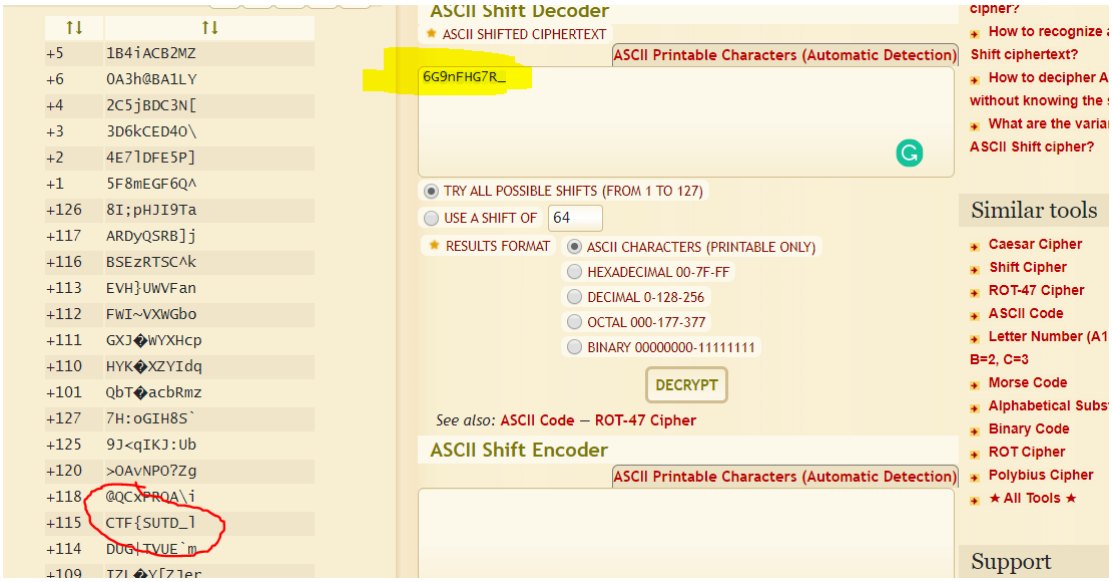
For dec_ct1:

The output is iib_2100h}



For dec_ct2:

The output is CTF{SUTD_I



Step 6

We combined the 2 outputs to get CTF{SUTD_liib_2100h}, how ever there seems to be a typo so we removed the extra ‘i’. The final flag is CTF{SUTD_lib_2100h}.

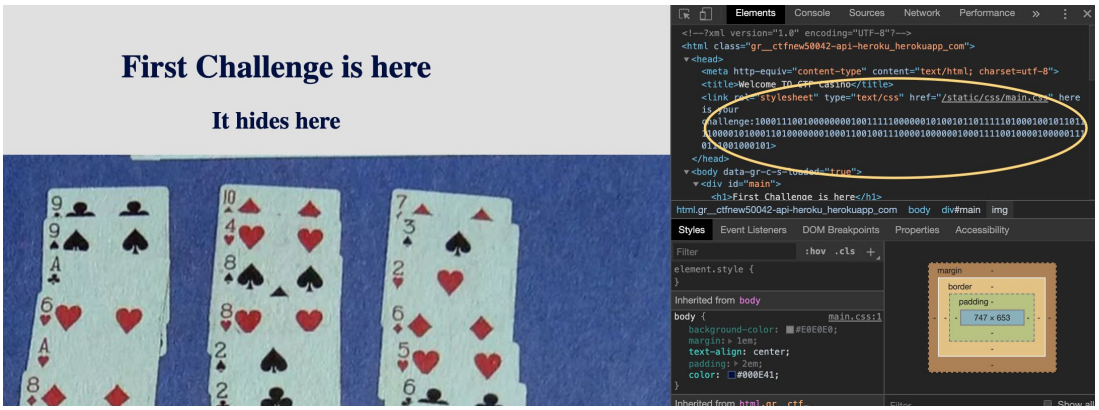
4. Pinky Pinky Unicorn

Flag: CTF{Yas you got it HAHAHA+WellDone+XOR_ECB_FLAG_112715}

Challenge 1: The Card Dealing

Step 1: Finding the cipher

The cipher was hidden in the HTML code.of the webpage provided.



After obtaining the cipher we got the hint that we need to use the word deal as a key to stream cipher with the cipher. However, it was important that we deal the bits like cards in the picture, which is to separate into 3 columns. We had some confusion on separating the cards as there are multiple ways for that. We tried both. (A & B)

```
A1: 10110011  10000111  10011100  01000011  10000011  10001100  1
A2: 01000001  10011111  01111001  00001000  10100010  00001100  0
A3: 01000001  00100010  00001010  11000100  10001010  01010110  1

B1: 11110001  00100111  00011110  11000001  10001011  00000110  1
B2: 01000001  10011111  01111001  00001000  10100010  00001100  0
B3: 00000101  10000010  10001000  01000110  10000010  11011100  1
```

Step 2: Stream cipher

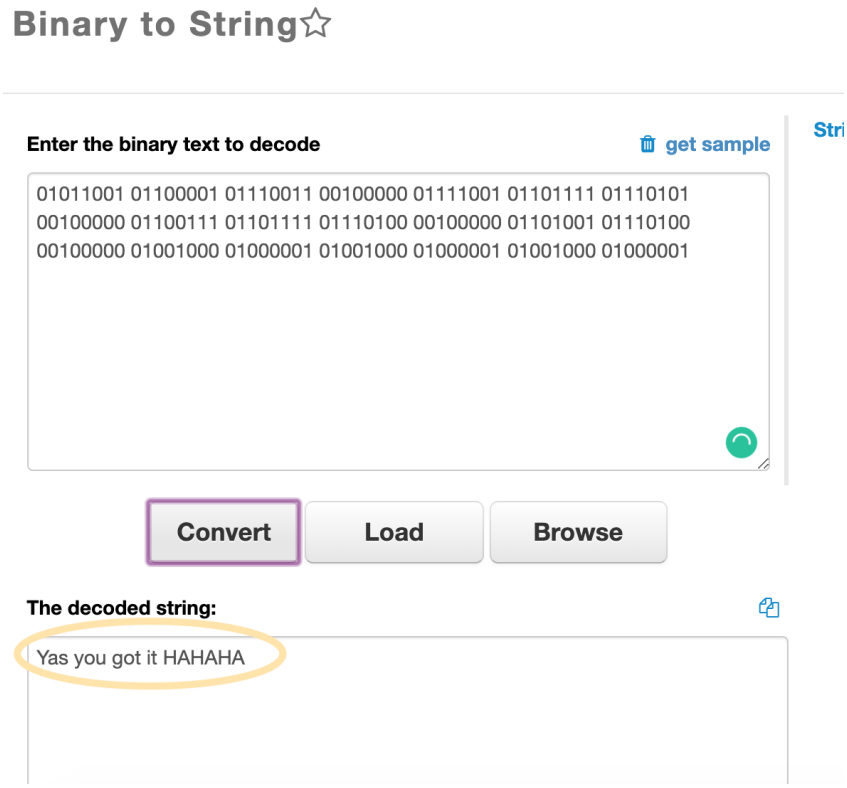
Attempt 1: We did not get a coherent word when we decoded both A and B result after XORing with Deal binary using base64.

```
Deal:00000000 00000000 00110010 00110010 10110000 10110110 0

AX1: 10110011 10000111 10101110 01110001 00110011 00111010 1
AX2: 01000001 10011111 01001011 00111010 00010010 10111010 0
AX3: 01000001 00100010 00111000 11110110 00111010 11100000 1

BX1: 11110001 00100111 00101100 11110011 00111011 10110000 1
BX2: 01000001 10011111 01001011 00111010 00010010 10111010 0
BX3: 00000101 10000010 10111010 01110100 00110010 01101010 1
```

Hence we asked for help and checked with other groups who helped us, saying our binary of DEAL was wrong. We then removed the 0 of each 8 bit of character hence deal: 28 bits instead of 32 bits and hence it was 21 zeros padding + 28 deal bits.

```
Deal:0000000 0000000 0000000 1100100 1100101 1100001 1101100

AX1: 1011001 1100001 1110011 0100000 1111001 1101111 1110101
AX2: 0100000 1100111 1101111 1110100 0100000 1101001 1110100
AX3: 0100000 1001000 1000001 1001000 1000001 1001000 1000001
```

In Attempt 2, after we XORed A with the new Deal, we decoded the binary to string using online application and got the below result.



ANS1: Yas you got it HAHAHA

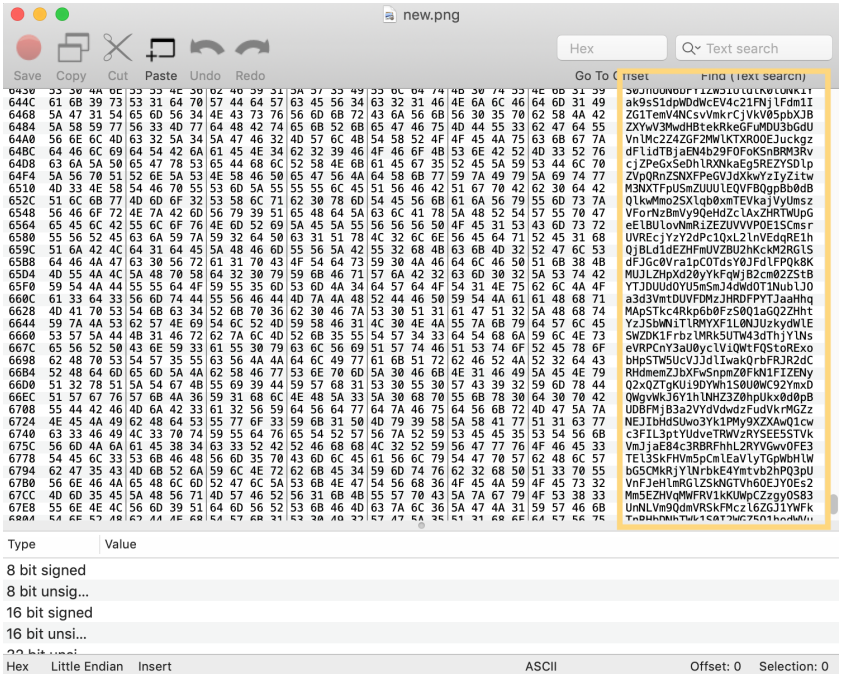
Challenge 2: Image Steganography

Step1: Encrypted.txt

Adding the extension /encrypted.txt to the link provided automatically started a downloaded for encrypted.txt. Now we had to find the key to decrypt this.

Step 2: Finding w hat's in the image

After downloading the image of the ace card from the webpage I opened it using a Hec Editor. At the end we found something that stood out.



Decoding this using an online website with base64 we got:

The Base64 Decode:

```
-----BEGIN RSA PRIVATE KEY-----
MIICWwIBAAKBgQCzlV5enHRWm+KT6MXjOlKWiX7VpExsmE69EvmHdmSzex4+/
Vi+
5dWNimrAev0Ws0tpmzDdxan057lgTVyLsfxdav1iJMtN8BnrH3tYbu0chCxooE8Z
JpQ3tor6OxlRx8eEsdhH9DFXH9ieZPFvR5qOxeluy0c22f+p3sWLZTJfTQIDAQAB
AoGABY02j6lyjoLfLEdj5rRk3TZ+70fW/PxwYrP1dtSYJFxlARZ/6dbdFTUUO8MR
k+QTDr63cgOsT1/igTGjDMaB0KwWDdqfQVAShJrC6DiRtRFsEkkZB97lcBEvQOBO
1BKdzWwm2bAjZ0vrm6e+Aa2CQGNaNfJbxugNOSnnRNkwwVkCQQC32GD1Oa2
Zhxj0
RNG8FJzoAsKD5hd6dxmc2RmcbNTLaqu/CIS92uiDIfC+Qko9LFNTMn7u8cbSlyTQ
```

Step 3: Decrypting Encrypted.txt

Since it was clear this was a private key for RSA, we used a simple decrypt rsa code similar to Lab and decrypted the encrypted.txt.

```python
from Crypto.PublicKey import RSA
from Crypto.Cipher import PKCS1_OAEP

def decrypt(prikey, cipher):
    f = open(prikey, 'r').read()
    key = RSA.importKey(f)
    rsa = PKCS1_OAEP.new(key)
    answer = rsa.decrypt(cipher)
    return answer

#rsakey=RSA.importKey(key)
f = open('encrypted.txt','rb').read()

print(decrypt("key.ppm",f).decode())
```

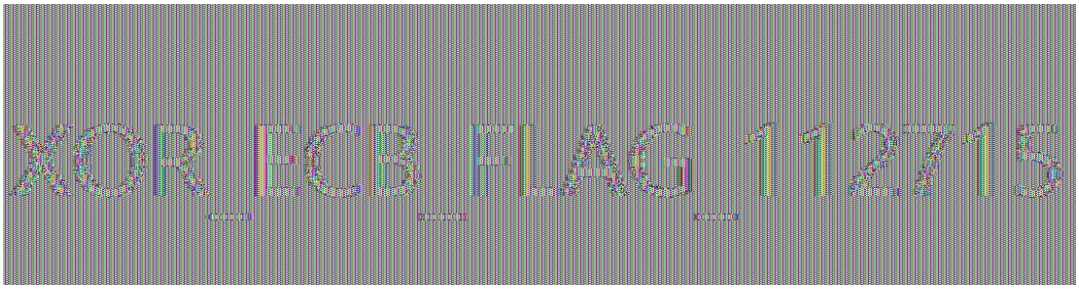
The ANS2 was:

```
Abinayas-MacBook-Pro:PINKY nonchalantcocoa$ python3.7 py.py
WellDone
Abinayas-MacBook-Pro:PINKY nonchalantcocoa$
```

Challenge 3: The Xor Challenge

The hint revealed that it involved some XOR operation. Looking at the encryption code shows that they inserted a random 16 byte nonce at the start, we call this B0. B0 then XORS with B1 to get B1'. B1' then XOR with B2 to get B2 '. This goes on to the last block. Hence to decrypt, we start from the end and XOR the previous block to get the current block. We append all the blocks together and we get the answer. Studying the encryption code also shows that they left the header out f rom the encryption

ANS3 is



Joining ANS1+ANS2+ANS3 we obtained the final flag: CTF{Yas you got it HAHAHA+WellDone+XOR_ECB_FLAG_112715}

5. GFCS

FLAG: CTF{DISCRETIONWILLPROTECTYOUANDUNDERSTANDINGWILLGUARDYOU}

Step 1:

Given n,e and a ciphertext, we did a reverse RSA to get the plaintext 'solomonrocks'.

```
t: 120289586017590607051332131169873371866538956589145395752559909761609773968 33
ct1: 769573650571304960186440656234761222596953190975323619978510288716949487160 71
dec_ct1: bytearray(b'solomonrocks')
```

Step 2:

Reading up on the PDF format will help:

https://resources.infosecinstitute.com/pdf -file-format -basic-structure/#gref

https://amccormack.net/2012 -01-22-anatomy -of-a-pdf-document.html

http://lotabout.me/orgwiki/pdf.html

Initially, the pdf was blank. By removing the '%' from /Contents and /Resources, we were able to load the contents of the pdf.

Before:

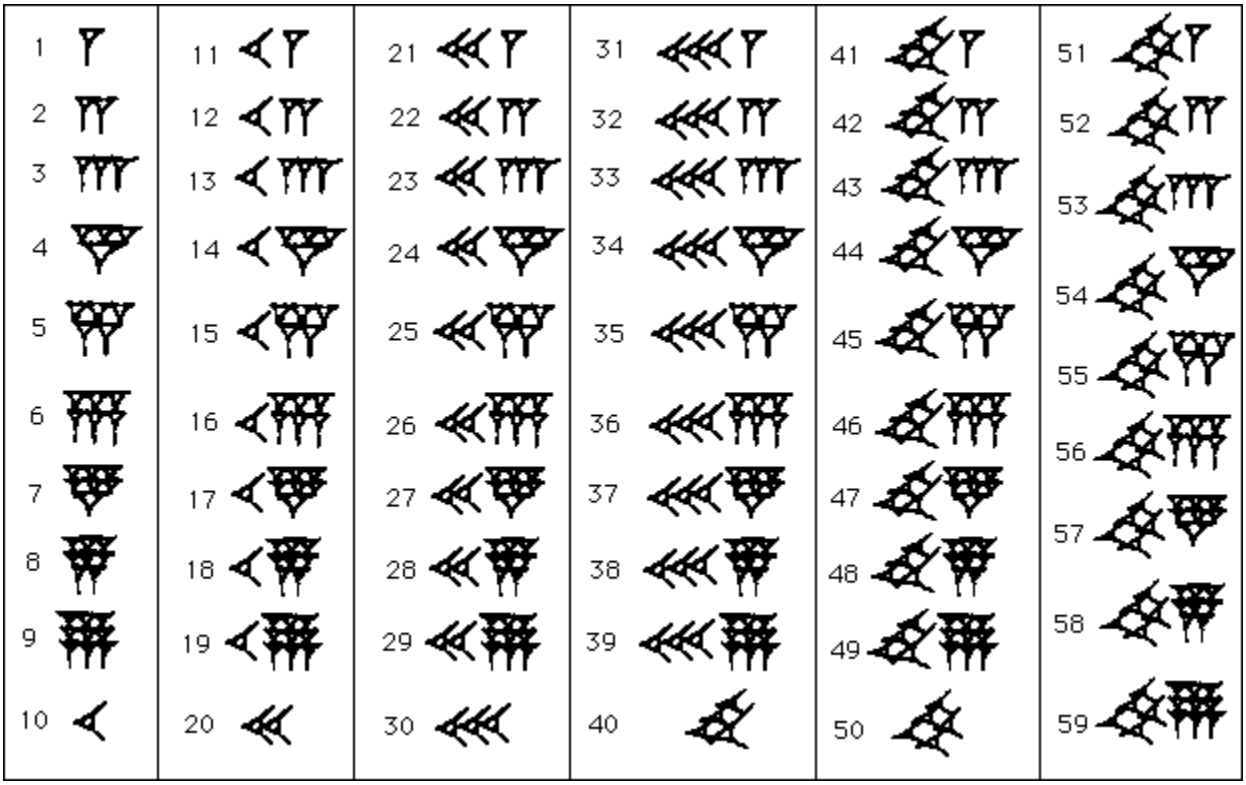
```
%% Page 1
%% Original object ID: 4 0
4 0 obj
<<
  %/Contents 5 0 R
  /MediaBox [
    0
    0
    595
    842
  ]
  /Parent 3 0 R
  %/Resources <<
    /ProcSet [
      /PDF
      /Text
      /ImageB
      /ImageC
      /ImageI
    ]
    /XObject <<
      /XOb4 7 0 R
    >>
  >>
  /Type /Page
>>
endobj
```

After:

```
%% Page 1
%% Original object ID: 4 0
4 0 obj
<<
  /Contents 5 0 R
  /MediaBox [
    0
    0
    595
    842
  ]
  /Parent 3 0 R
  /Resources <<
    /ProcSet [
      /PDF
      /Text
      /ImageB
      /ImageC
      /ImageI
    ]
    /XObject <<
      /XOb4 7 0 R
    >>
  >>
  /Type /Page
>>
endobj
```

Step 3:

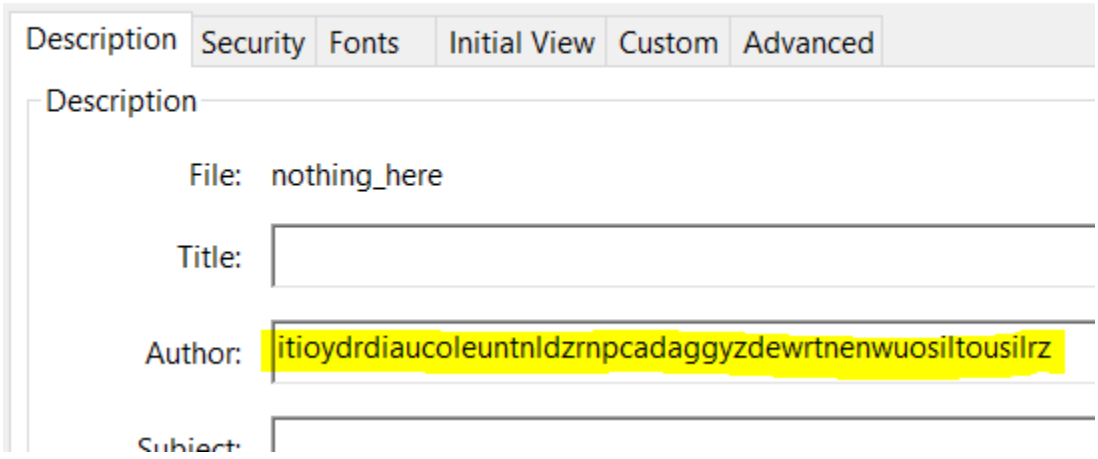
This are the contents in the pdf. Given the hint was Bobby is a paleographer, we went to search up on the ancient handwriting. This are not alphabetic representation but numerics. The fonts were derived from Babylonian number system. From here, we derive ‘53651’.



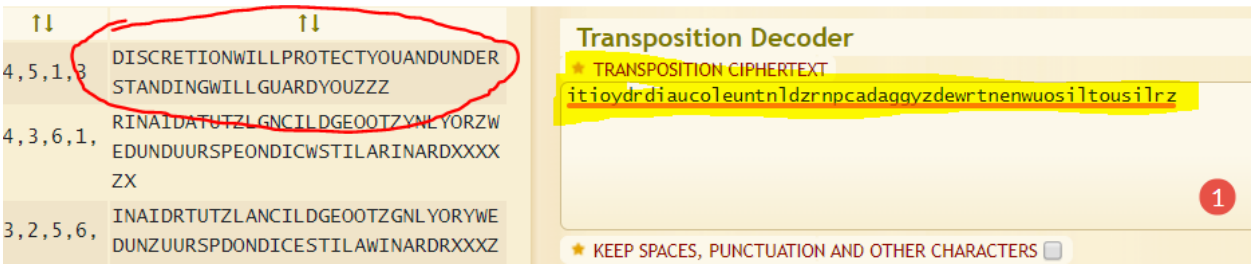
Step 4:

Lastly, under document properties, the final ciphertext to solve was the author's name. Hint was to derive the encryption scheme from week 1 -6. We tried a transposition cipher using an online tool and manage to get the flag. The plaint ext derived had padding, which explains the extra 'Z's at the back. The flag is CTF{DISCRETIONWILLPROTECTYOUANDUNDERSTANDINGWILLGUARDYOU}.

Document Properties



https://www.dcode.fr/transposition_-cipher



↑↓	↑↓
4,5,1,3	DISCRETIONWILLPROTECTYOUANDUNDERSTANDINGWILLGUARDYOUZZZ
4,3,6,1,	RINAIDATUTZLGNCILDGEOOTZYNLYORZWEDUNDUURSPEONDICWSTILARINARDXXXXZX
3,2,5,6,	INAIDRTUTZLANCILDGEOOTZGNLYORYWEDUNZUURSPDONDICESTILAWINARDRXXXZ

6. CIA

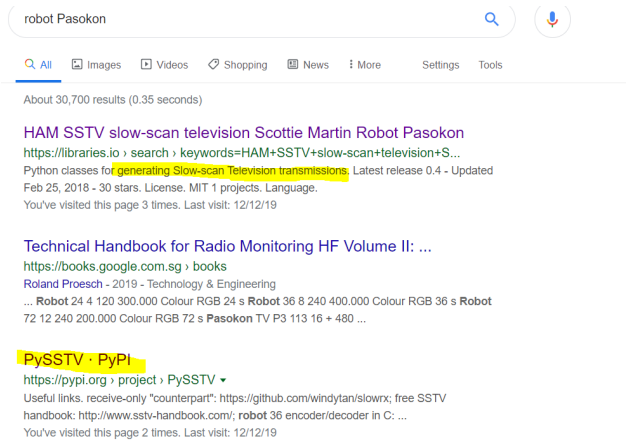
Flag: CTF{THEWORLDHASBEENFOOLEDTHISVIDEOGAMEDOESNOTEXIST}

Step 1: Getting the WAV file

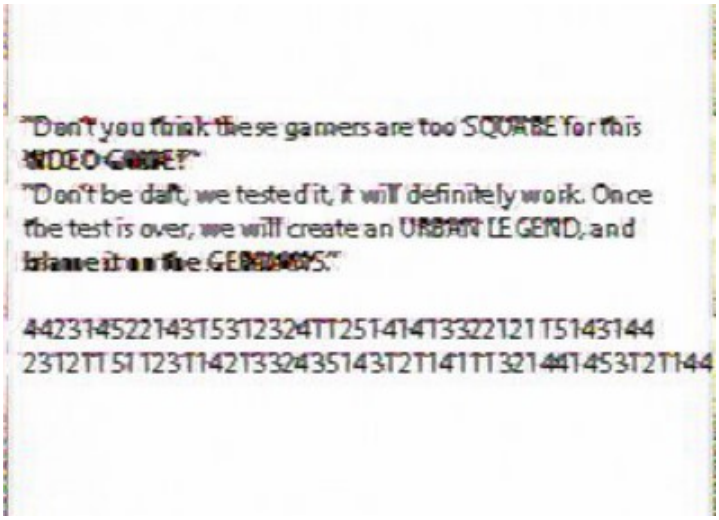
The hint was quite clear to use Lab 1 codes. The also said that the key was their enemy in the hint. From the challenge description, we figured that the key was CIA. Went each letter was represented as a decimal number, we get 391 which is the key for the Caesar Cipher. We then output a wav file

Step 2: Interpreting the WAV file

The hint was to google Robot Pasokon. Based on what we have found, PySSTV was used to convert an image file into WAV file. That inspired us to think of a tool that would be able to decipher the WAV file.



The WAV file given had an awful high frequency which is inaudible. We used a tool called RX-SSTV to help decipher the image from the WAV file.

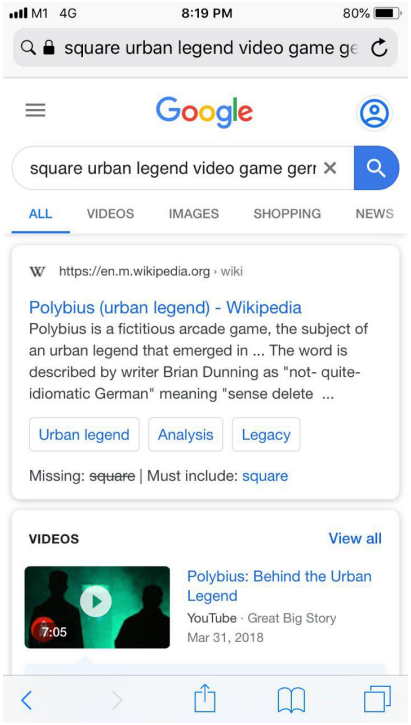


Step 3: Subsequently we got the following

The hint was: There is a relation between the video game and the cipher. the relation is the creator of the game. that relation is the key for the cipher. Please note that for the key AKA the creator, he stands out among the english

The keywords from the previous part was SQUARE, VIDEO GAME, URBAN LEGEND and GERMANS.

We googled all the keywords from STEP 2 and got



Since it was missing square, we searched it and it revealed the Polybius Square Cipher

Googling the German creator revealed that it was Sinneslöschen

- In some versions of this mystery, the players suffered from a series of unpleasant side effects, including amnesia, insomnia, nightmares and night terrors.

  What are the other "versions" of this mystery and what are the sources for them. The quoted material is basically directly from the coinop.org source.

- The supposed creator of Polybius is Ed Rotberg, and the company named in most accounts of the game, Sinneslöschen (German meaning "deletion/erasure of senses, Sense-delete"), often named as either a secret government organization or a codename for Atari.

  Who is the source for tying the game to Ed Rotberg? Who is the source tying any of this to Atari? Where are the accounts that do not associate the game with Sinneslöschen?

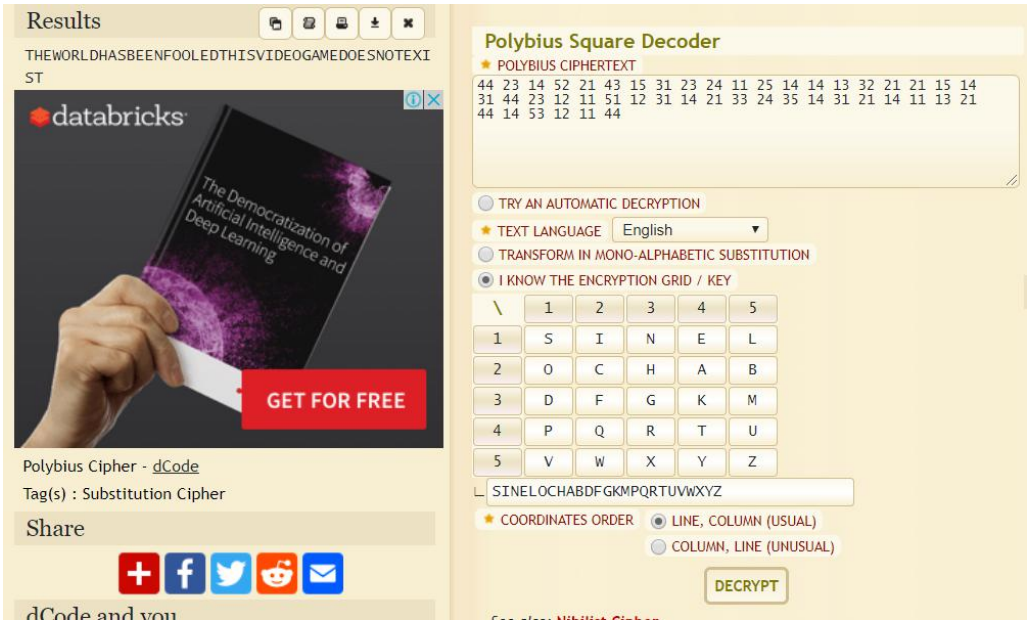
- The gameplay is said to be similar to Tempest (a shoot 'em up game using vector graphics), while the game is said to contain subliminal messages which would influence the action of anyone playing it.

  Where is the source that says the gameplay was similar to Tempest? Where is the source for "vector graphics"? Where the source for "subliminal messages". The sourced description of the game says it was "kind of abstract, fast action with some puzzle elements".

69.198.25.2 (talk) 19:51, 21 January 2014 (UTC)

Step 4: Final Cipher Breaking

We then use an online tool to break the cipher



Insights & Reflection

In general, solving 8 challenges with little CTF experience was extremely challenging, on top of coping with other modules that have project submissions due on the same week as well. With many information being detained from us, it was difficult to deduce what encryption schemes were used and follow the train of thoughts of the creator.

For our RE challenge, many could easily find the plaintext from the hash value and the image. It was deducing the decompiler that was challenging to most groups and getting the correct timestamp. As creators, we felt otherwise. We used a rainbow table to crack our own hash and unscrambled the image, which we found challenging. However, our hash was easily found through online tools and b64decode respectively, to our dismay. We thought the decompiler was the easiest.

Through the challenges, we got to better appreciate and understand the concepts taught in class and how we can apply it to encrypt and decrypt. It would be great if we had a longer period to solve more challenges and have the CTF on an earlier week instead of week 13. It is too close to finals and many project submissions. This gives us insufficient time for revisions and the weightage for each challenge (0.5%) is too much to ask for the amount of time and effort placed into solving them. For an average student with little CTF experience and have many content being cramped in each week, it takes more than 2hrs per challenge. However, despite the aforementioned, we enjoyed doing the challenges, assuming hints were r eadily available. The online server website was also very helpful and informative. The scoreboard encouraged us to take on more challenges and very essential in seeking help from groups who completed similar challenges that we were stuck at.

Overall, our team enjoyed the CTF challenge and we are happy that we achieved more than our set goal of 4. We feel that if the timing of the challenge week was better we could have appreciated the experience more and completed more challenges!