Exercise 02

Cryptography / `ex-crypto`

Log into your VM (`user` / `1234`), open a terminal and type in `infosec pull ex-crypto`.

- When prompted, enter your username and password
- Once the command completes, your exercise should be ready at `/home/user/ex-crypto/`

When you finish solving the assignment, submit your exercise with `infosec push ex-crypto`.

Question 1 (70 pt)

In this exercise you will focus on a simple stream cipher called **Repeated Key cipher**. A repeated key cipher works by XOR-ing the bytes of the plaintext with the bytes of the key similarly to a one-time pad:

- The first byte of the plaintext is XOR-ed with the first byte of the key
- The second byte of the plaintext is XOR-ed with the second byte of the key
- ...
- **If the plaintext is longer than the key, start using the key again from the beginning** (first it's first byte, then it's second byte, etc.)

Note: To convert the text (which is a string) to bytes, use the `latin-1` encoding

```
text_bytes = text.encode('latin-1')
text = text_bytes.decode('latin-1')
```

Part A (10 pt)
Inside `q1.py`, implement the `encrypt` method in the `RepeatedKeyCipher` class.
Tip: Convert the string to bytes, and then easily XOR each byte in the input. <u>You can safely assume that each char will be represented by a single byte</u>.

Part B (5 pt)
Inside `q1.py`, implement the `decrypt` method in the `RepeatedKeyCipher` class. **Add the <u>smallest amount of code</u> possible** on what you already implemented in the previous part.

Part C (20 pt)

Inside `q1.py`, implement the `plaintext_score` method in the `BreakerAssistant` class. The method should take a string (of any length) and return a numeric score such that a string containing a plausible text in English will receive (with a high probability) a higher score than a random string of the same length.

- For example, it should give this string `"I am a sentence!"` a higher score than `"\xc6\xc9u\xd0v\x14\xe2\xcf\xc5\xf5\x1eZ\x10Yd\xd3"`[1].
- As you will be using this method in the following parts, **we recommend implementing a simple method now and improving it if necessary as you proceed in the next parts**.

Document your solution inside `q1c.txt`.

Note (following repeated questions about this): while your score function can be based on the distribution of letters in the English language (i.e. 'e' is typically one of the most frequent, etc.), **there's really no need to base your function on frequency analysis of different letters**. There are a few much simpler heuristics that will work for the next parts of this question. For reference - our canonical solution is 3 lines of code 😅.

Part D (10 pt)

Inside `q1.py`, implement the `brute_force` method in the `BreakerAssistant` class. The function receives a key length, attempts all possible keys of the given length, evaluates the plaintext possibilities using the `plaintext_score` function you have written, and **returns the "correct"[2] plaintext**.

In `q1d.cipher` we attached a sample encrypted text you can try breaking (it has a short key - 2 bytes long). You can run your code on it with `python3 decrypt.py 1d`. **Your solution must decrypt the attached ciphertext to the correct plaintext[3]**.

Document your solution inside `q1d.txt`.

Part E (25 pt)

The problem with the brute force method is, well, that it's brute force. This means we try many attempts without much thought. Trying to a break a key longer than a few bytes is going to be impractical (as we need $2^{8\cdot(number\ of\ bytes)}$ attempts).

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[1] The notation `\x<2 hex digits>` is used in Python to denote a char by it's hexadecimal code. We mainly use this where writing the char directly would result in binary gibberish or chars we can't read.
[2] While you can't know what is the correct plaintext, we hope that the plaintext with the highest score is indeed the correct one.
[3] Some texts have typos in them, that's a mistake in the source we quoted and not necessarily a problem with your code. If everything looks like English, perhaps with typos, it's OK.

In this part we urge you to try and break the key in a different way - find a way which is much faster, and for example, can break a key of length 10 or higher. For this part, **you may assume the ciphertext is long** (roughly the same length or longer than the attached sample).

Inside `q1.py`, implement the `smarter_break` method in the `BreakerAssistant` class using the technique you devised. As before, the method should receive the key length and return the "correct" plaintext.

In `q1e.cipher` we attached a sample encrypted text you can try breaking (it has a looooong key - 16 bytes long). You can run your code on it with `python3 decrypt.py 1e`. **Your solution must work on this text**.

Document your solution inside `q1e.txt`.
Note that we may test your code by generating more encrypted texts with more keys, so try encrypting and breaking a few more examples before submitting your solution.

Question 2 (45 pt)

In this question you will break several simplistic schemes that are based on RSA. While solving this question, keep in mind the following two points:

1. This exercise assumes you understand the basic **mechanics and math used by RSA**. This is not a cryptography course, so we don't assume deep understanding, but **you will need to understand RSA basics**.

2. The documentation of the Python Crypto library (the library we use for the encryption) is available at https://www.dlitz.net/software/pycrypto/api/current/.
    - The links specific to RSA are here and here.
    - You don't need to read this in advance. This is here for reference if something is unclear in our code.

Overview
Inside `q2_atm.py`, you can find the code for a (hypothetical) ATM. After inserting the credit card, the machine sends both the credit card and the PIN code the user entered, to a remote server for verification. Once the server responds, the ATM verifies the response and it's valid, it gives the user his money.

Part A (15 pt)

When a user enters a 4-digit PIN code, the machine encrypts it with a 2048 bit RSA public key before sending it to the server.

Inside `q2.py`, implement the `extract_PIN` method. The method receives an encrypted PIN (as returned from `encrypt_PIN` in the `ATM` class) and returns the original PIN.

In `q2a-pin.txt` we attached a sample encrypted PIN you can try breaking. You can run your code on it with `python3 decrypt.py 2a`. **Your solution must work on this PIN.**

Document your solution in `q2a.txt`.

Part B (15 pt)

The same ATM machine also sends the encrypted credit card number, a 8-9 digit number[4], to the server. Since the developers of the ATM were paranoid, they encrypted the credit card number with a different 2048 bit RSA key.

Inside `q2.py`, implement the `extract_card` method. The method receives an encrypted credit card (as returned from `encrypt_credit_card` in the `ATM` class) and returns the original card number.

In `q2b-card.txt` we attached a sample encrypted card you can try breaking. You can run your code on it with `python3 decrypt.py 2b`. **Your solution must work on this credit card.**

Document your solution in `q2b.txt`.

Part C (15 pt)

When the central server sends a response to the ATM, it sends a status code (these are detailed in `q2_atm.py`) and a signature. The ATM uses the signature to verify the server response (see `verify_server_approval` in the `ATM` class).

Inside `q2.py`, implement the `forge_signature` method. The method should return a `ServerResponse` object that passes the verification of the `ATM` class. Take a look at the documentation of the sign and verify methods of the RSA class if you need the specifics of how the signature is created/verified.

Document your solution in `q2c.txt`.

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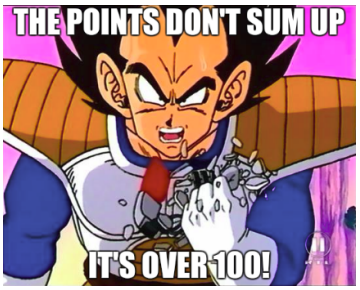
[4] Israeli credit cards are 8-9 digits (unlike the international ones that have at least 11 digits)

Final notes:



- The sum of all points in this exercise is higher than 100.
    - Yes, we know - it's intentional.
- **All answers should run in at most 60 seconds per question**. If anything is running significantly longer than that, your solution is not efficient enough and is probably wrong.
- **Our tests will use long ciphers (> 200 bytes), and we expect them to finish in less than 60 seconds**. Please take that into consideration and take a wide enough security buffer when measuring your own solutions on the supplied ciphers.
- **Document your solutions.**
- Don't use any additional third party libraries that aren't already installed on your machine (i.e. don't install anything).
- If your answer takes an entire page, you probably misunderstood the question.