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Task 1 – Affine cipher encryptor
First, I build a table of the letter mapping in my code. I define a function called buildTable, that takes two arguments a and b that are used in the affine cipher formula. For every letter in the ascii_uppercase alphabet I apply the formula (a * i + b) mod 26 (sizeOfAlphabet), where i is a letter, so each letter gets mapped to another:

```
def buildTable(a, b):
    cipherTable = {}
    sizeOfAlphabet = len(string.ascii_uppercase)

    for i in range(sizeOfAlphabet):
        plainChar = string.ascii_uppercase[i]
        cipherChar= string.ascii_uppercase[(a*i+b)%sizeOfAlphabet] # apply the
affine cipher formula to map each letter in the alphabet

        cipherTable[plainChar] = cipherChar

    return cipherTable
```

I then define a function called encryptAffine, that encrypts every letter in the string to it's mapped value if it's in the table from buildTable function. If it's not, the letter remains the same:

```
def encryptAffine(plainText, a, b):
    cipherTable = buildTable(a, b)
    cipherText = ""
    for char in plainText:
        if char in cipherTable:
            cipherText += cipherTable[char] # switch characters that are in
the table to its' mapped values
        else:
            cipherText += char  # leave characters that are not in the table
unchanged
    return cipherText
```

Task 2 – Avalanche calculator
In my avalancheCalculator function, I first apply sha256 hashing function to both strings and get their hashed values in hex using hashlib library. Then I convert both hashed values to binary using bin(), because it is easier to compare single bits in binary. Because bin() removes zeros at the start since they don't add any value, I also added a for loop for each binary value to append zeros back at the start, as the hashed value of sha256 function has to be 256 bits long:

```
def avalancheCalculator(string1, string2):
    string1Hex = hashlib.sha256(string1.encode()).hexdigest()
    string2Hex = hashlib.sha256(string2.encode()).hexdigest() # apply sha256
hashing to both strings
    string1Bin = bin(int(string1Hex, 16))[2:] # convert to binary to find the
number of bits that are different between hashed values
    string2Bin = bin(int(string2Hex, 16))[2:] # remove prefix 0b from the
strings with [2:0] (start strings from second char)
    # add zeros to the start of strings' binary values so they are 256 bits
long. They should be 256 bits long because we are using sha256 hash function
```

```
which outputs 256 bit values. bin() function removes zeros from the start as
they don't add any value.
    if len(string1Bin) < 256:
        while len(string1Bin) < 256:
            string1Bin = "0" + string1Bin
    if len(string2Bin) < 256:
            while len(string2Bin) < 256:
                string2Bin = "0" + string2Bin
```

Finally, I add a for loop that compares each bit in the binary values and increments avalanche number if they are different.

```
    avalanceNumber = 0
    for i in range(256):
        if string1Bin[i] != string2Bin[i]: # if bits are different, increment
avalanche number
            avalanceNumber += 1
    return avalanceNumber
```

Task 3 – Diffie Helman

In my Diffie_Hellman function, I first load the dh parameters and peer public key provided to python types that cryptography module understands:

```
dhParameters = serialization.load_pem_parameters(*provided_dh_parameters*)
peerPublicKey = serialization.load_pem_public_key(*provided_peer_public_key*)
```

I then generate my private key X_A and my public key Y_A using dh parameters, so X_A < q and Y_A = α^X_A mod q:

```
myPrivateKey = dhParameters.generate_private_key()
myPublicKey = myPrivateKey.public_key()
```

Then, I generate a shared key (secret) using exchange() with my private key and peer public key and find derived key using the HMAC-based Extract-and-Expand key derivation function with the following setup: SHA256 for the algorithm, length = 32, salt=None and info=b'handshake data':

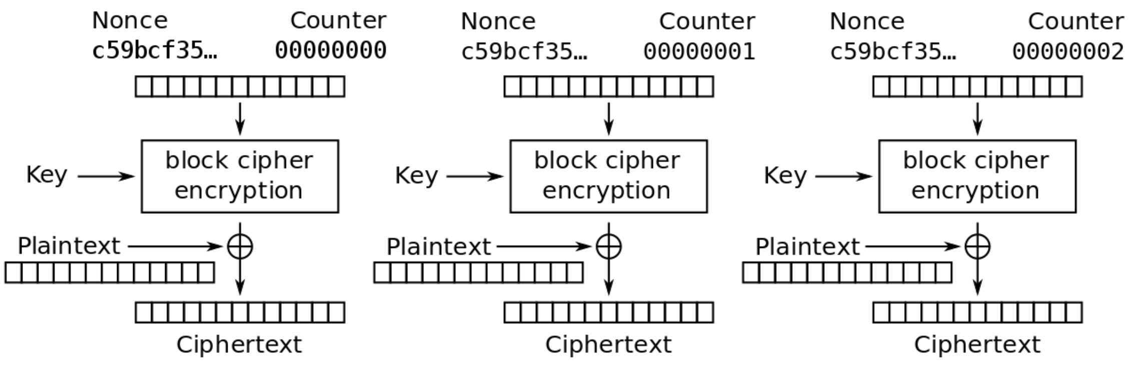
```
sharedKey = myPrivateKey.exchange(peerPublicKey)
    derivedKey = HKDF(
        algorithm=hashes.SHA256(),
        length=32,
        salt=None,
        info=b'handshake data',
    ).derive(sharedKey) # derive key using peer public key and my private key
(Y_A)^(X_B) mod q
```

Finally, I encode my public key to PEM format and return it with the derived key.

```
myPublicKeyPem = myPublicKey.public_bytes(serialization.Encoding.PEM,
format=serialization.PublicFormat.SubjectPublicKeyInfo) # encode my public key
to PEM format
return (myPublicKeyPem, derivedKey)
```

Task 4 – Finding the ciphertext

In the AES-CTR the IV(nonce) is combined or concatenated with the counter. As can be seen on the picture below, this value is then combined with the key and that whole value is then XOR'd with the plaintext to get the cipher text:



Counter (CTR) mode encryption

Therefore, since it is known that the same key and iv values are used to encrypt all subsequent messages, by simply XORing the plaintext with the ciphertext, the combined value of key, IV and counter can be retrieved. After that, this value can be XOR'd with the next message to get its' ciphertext, or even XOR'd with the ciphertext to get the plaintext of the message.

In my code, I define a function xorMessages that uses zip() to get tuples of each byte in the byte strings and then XORs those bytes to get the combined value of key, IV and counter.

```
def xorMessages(message1, message2):
    # xor every byte of message 1 with message 2
    # the byte strings don't have to be the same size because zip function
zips to whatever byte string is the shortest
    return bytes([a ^ b for a, b in zip(message1, message2)])

def findCiphertext():
    keyAndIvValue = xorMessages(messageA, cipherTextA) # xor message a
plaintext and ciphertext to get the added value of key, iv and counter
```

Then I use this function to also XOR this combined key value with the plaintext of message B to get the ciphertext of message B.

```
cipherTextB = xorMessages(messageB, keyAndIvValue) # xor the found value with
message b plaintext to find it's ciphertext
    return cipherTextB #ciphertext of messageB in bytes
```