Advanced Security 1 – DT211-4, DT282-4 and DT228-4

Assignment 2 (10 Mark)

Part A

Write a Java program (or any other programming language you are happy to use) which will test if the given number is a prime number or no. In order to achieve this you have to implement the Miller-Rabin Algorithm as shown below

```
TEST (n)
1. Find integers k, q, with k > 0, q odd, so that
   (n − 1 = 2^k q);
2. Select a random integer a, 1 < a < n − 1;
3. if a^q mod n = 1 then return("inconclusive");
4. for j = 0 to k − 1 do
5. if a^(2^j q) mod n = n − 1 then return("inconclusive");
6. return("composite");
```

Part B

Write a Java program (or any other programming language you are happy to use) to perform the Key Expansion of AES algorithm as shown below. You don't need to implement the whole AES algorithm.

```
KeyExpansion (byte key[16], word w[44])
{
    word temp
    for (i = 0; i < 4; i++)   w[i] = (key[4*i], key[4*i+1],
                                      key[4*i+2],
                                      key[4*i+3]);
     for (i = 4; i < 44; i++)
     {
      temp = w[i - 1];
      if (i mod 4 = 0)   temp = SubWord (RotWord (temp))
                               ⊕ Rcon[i/4];
      w[i] = w[i-4] ⊕ temp
     }
}
```

The input will be 16 byte Key: **0f1571c947d9e8590cb7add6af7f6798**

The output will be **keywords** (w0 to w43) as shown in the table below.

Key Words	Auxiliary Function
w0 = 0f 15 71 c9 w1 = 47 d9 e8 59 w2 = 0c b7 ad d6 w3 = af 7f 67 98	RotWord(w3)= 7f 67 98 af = x1 SubWord(x1)= d2 85 46 79 = y1 Rcon(1)= 01 00 00 00 y1 ⊕ Rcon(1)= d3 85 46 79 = z1
w4 = w0 ⊕ z1 = dc 90 37 b0 w5 = w4 ⊕ w1 = 9b 49 df e9 w6 = w5 ⊕ w2 = 97 fe 72 3f w7 = w6 ⊕ w3 = 38 81 15 a7	RotWord(w7)= 81 15 a7 38 = x2 SubWord(x4)= 0c 59 5c 07 = y2 Rcon(2)= 02 00 00 00 y2 ⊕ Rcon(2)= 0e 59 5c 07 = z2
w8 = w4 ⊕ z2 = d2 c9 6b b7 w9 = w8 ⊕ w5 = 49 80 b4 5e w10 = w9 ⊕ w6 = de 7e c6 61 w11 = w10 ⊕ w7 = e6 ff d3 c6	RotWord(w11)= ff d3 c6 e6 = x3 SubWord(x2)= 16 66 b4 8e = y3 Rcon(3)= 04 00 00 00 y3 ⊕ Rcon(3)= 12 66 b4 8e = z3
w12 = w8 ⊕ z3 = c0 af df 39 w13 = w12 ⊕ w9 = 89 2f 6b 67 w14 = w13 ⊕ w10 = 57 51 ad 06 w15 = w14 ⊕ w11 = b1 ae 7e c0	RotWord(w15)= ae 7e c0 b1 = x4 SubWord(x3)= e4 f3 ba c8 = y4 Rcon(4)= 08 00 00 00 y4 ⊕ Rcon(4)= ec f3 ba c8 = 4
w16 = w12 ⊕ z4 = 2c 5c 65 f1 w17 = w16 ⊕ w13 = a5 73 0e 96 w18 = w17 ⊕ w14 = f2 22 a3 90 w19 = w18 ⊕ w15 = 43 8c dd 50	RotWord(w19)= 8c dd 50 43 = x5 SubWord(x4)= 64 c1 53 1a = y5 Rcon(5)= 10 00 00 00 y5 ⊕ Rcon(5)= 74 c1 53 1a = z5
w20 = w16 ⊕ z5 = 58 9d 36 eb w21 = w20 ⊕ w17 = fd ee 38 7d w22 = w21 ⊕ w18 = 0f cc 9b ed w23 = w22 ⊕ w19 = 4c 40 46 bd	RotWord(w23)= 40 46 bd 4c = x6 SubWord(x5)= 09 5a 7a 29 = y6 Rcon(6)= 20 00 00 00 y6 ⊕ Rcon(6)= 29 5a 7a 29 = z6
w24 = w20 ⊕ z6 = 71 c7 4c c2 w25 = w24 ⊕ w21 = 8c 29 74 bf w26 = w25 ⊕ w22 = 83 e5 ef 52 w27 = w26 ⊕ w23 = cf a5 a9 ef	RotWord(w27)= a5 a9 ef cf = x7 SubWord(x6)= 06 d3 df 8a = y7 Rcon(7)= 40 00 00 00 y7 ⊕ Rcon(7)= 46 d3 df 8a = z7
w28 = w24 ⊕ z7 = 37 14 93 48 w29 = w28 ⊕ w25 = bb 3d e7 f7 w30 = w29 ⊕ w26 = 38 d8 08 a5 w31 = w30 ⊕ w27 = f7 7d a1 4a	RotWord(w31)= 7d a1 4a f7 = x8 SubWord(x7)= ff 32 d6 68 = y8 Rcon(8)= 80 00 00 00 y8 ⊕ Rcon(8)= 7f 32 d6 68 = z8
w32 = w28 ⊕ z8 = 48 26 45 20 w33 = w32 ⊕ w29 = f3 1b a2 d7 w34 = w33 ⊕ w30 = cb c3 aa 72 w35 = w34 ⊕ w32 = 3c be 0b 38	RotWord(w35)= be 0b 38 3c = x9 SubWord(x8)= ae 2b 07 eb = y9 Rcon(9)= 1B 00 00 00 y9 ⊕ Rcon(9)= b5 2b 07 eb = z9
w36 = w32 ⊕ z9 = fd 0d 42 cb w37 = w36 ⊕ w33 = 0e 16 e0 1c w38 = w37 ⊕ w34 = c5 d5 4a 6e w39 = w38 ⊕ w35 = f9 6b 41 56	RotWord(w39)= 6b 41 56 f9 = x10 SubWord(x9)= 7f 83 b1 99 = y10 Rcon(10)= 36 00 00 00 y10 ⊕ Rcon(10)= 49 83 b1 99 = z10
w40 = w36 ⊕ z10 = b4 8e f3 52 w41 = w40 ⊕ w37 = ba 98 13 4e w42 = w41 ⊕ w38 = 7f 4d 59 20 w43 = w42 ⊕ w39 = 86 26 18 76	

Table 5.3 Key Expansion for AES Example

Part C

In this part you have to send an encrypted email or attachment to aneelrahim263@gmail.com. You will have to create your private and public key pair, send your public key to aneelrahim263@gmail.com. Remember that I must have your public key, otherwise, I will not be able to decrypt your email or attachment.

For example, you can install Enigmail (https://enigmail.net/index.php/en/) which is the extension for the mail clients Interlink Mail & News and Postbox, and Mozilla Thunderbird. It allows you to encrypt and digitally sign emails using the OpenPGP standard. User manual for Enigmail is available at https://enigmail.net/index.php/en/user-manual

Part D

Write a Java program (or any other programming language you are happy to use) to perform a letter frequency attack on any monoalphabetic substitution cipher without human intervention. Your software should produce possible plaintexts in rough order of likelihood. It would be good if your user interface allowed the user to specify "give me the top 5 possible plaintexts."

Letters by frequency of appearance in English:

E	12.7 %	T	9.1 %	A	8.2 %
O	7.5 %	I	7.0 %	N	6.7 %
S	6.3 %	H	6.1 %	R	6.0 %
L	4.0 %	D	4.3 %	C	2.8 %
U	2.8 %	M	2.4 %	W	2.4 %
F	2.2 %	G	2.0 %	Y	2.0 %
P	1.9 %	B	1.5 %	V	1.0 %
K	0.8 %	J	0.2 %	X	0.2 %
Q	0.1 %	Z	0.1 %		

Example

Cipher Text = UZQSOVUOHXMOPVGPOZPEVSGZWSZOPFPESXUDBMETSXAIZ VUEPHZHMDZSHZOWSFPAPPDTSVPQUZWYMXUZUHSXEPYEPOPDZSZUFPOMBZ WPFUPZHMDJUDTMOHMQ

Calculate letter frequency

$$\text{Freq} = \frac{\text{number of occurrence}}{\text{Total Element}} \times 100$$

$$J = \frac{1}{120} \times 100 = 0.83$$

$$Y = \frac{2}{120} \times 100 = 1.67$$

P 13.33	H 5.83	F 3.33	B 1.67	C 0.00
Z 11.67	D 5.00	W 3.33	G 1.67	K 0.00
S 8.33	E 5.00	Q 2.50	Y 1.67	L 0.00
U 8.33	V 4.17	T 2.50	I 0.83	N 0.00
O 7.50	X 4.17	A 1.67	J 0.83	R 0.00
M 6.67				

Swap it with the English Frequency and generate five possible plaintext.

Submission Guidelines:

1. Presentation
   a. Create 5 to 8 PowerPoint slides (1 or 2 slides for each part)
   b. Create a video screen recording verballing describing your presentation slides and content of your assignment.
   c. The video should be 5 minute max.

2. Source Code how you implement the above algorithms.