Assignment 6

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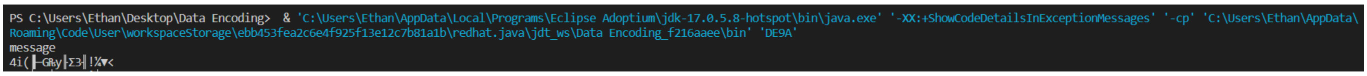
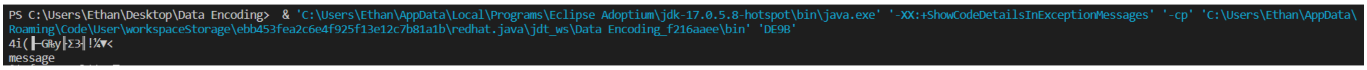
Output

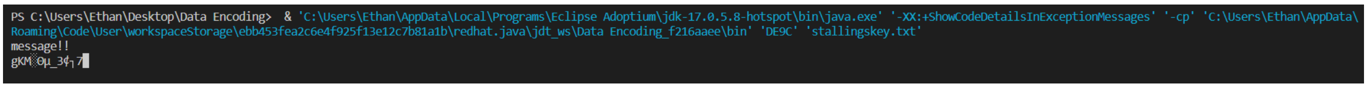
I don't think The test files were properly or consistently readable by my computer or IDE and I am not confident in me having correctly used them.



```
PS C:\Users\Ethan\Desktop\Data Encoding>  & 'C:\Users\Ethan\AppData\Local\Programs\Eclipse Adoptium\jdk-17.0.5.8-hotspot\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\Ethan\AppData\Roaming\Code\User\workspaceStorage\ebb453fea2c6e4f925f13e12c7b81a1b\redhat.java\jdt_ws\Data Encoding_f216aaee\bin' 'DE9A'
message
4i(╟Gπy╟Σ3╢!¼▼<
```



```
PS C:\Users\Ethan\Desktop\Data Encoding>  & 'C:\Users\Ethan\AppData\Local\Programs\Eclipse Adoptium\jdk-17.0.5.8-hotspot\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\Ethan\AppData\Roaming\Code\User\workspaceStorage\ebb453fea2c6e4f925f13e12c7b81a1b\redhat.java\jdt_ws\Data Encoding_f216aaee\bin' 'DE9B'
4i(╟Gπy╟Σ3╢!¼▼<
message
```



```
PS C:\Users\Ethan\Desktop\Data Encoding>  & 'C:\Users\Ethan\AppData\Local\Programs\Eclipse Adoptium\jdk-17.0.5.8-hotspot\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\Ethan\AppData\Roaming\Code\User\workspaceStorage\ebb453fea2c6e4f925f13e12c7b81a1b\redhat.java\jdt_ws\Data Encoding_f216aaee\bin' 'DE9C' 'stallingskey.txt'
message!!
gKM░Θµ_3¢┐7
```

D Output goes here! I could not finish D, providing all other answers.

output

output

Code

DE9A

```
public class DE8A{

  static final int numberOfBits = 8;
  static final int fieldSize = 1 << numberOfBits;
  static final int irreducible = 0x11b;
  static final int logBase = 3;
  static final byte[][] A = new byte[][] {
            {1, 1, 1, 1, 1, 0, 0, 0},
            {0, 1, 1, 1, 1, 1, 0, 0},
        {0, 0, 1, 1, 1, 1, 1, 0},
            {0, 0, 0, 1, 1, 1, 1, 1},
        {1, 0, 0, 0, 1, 1, 1, 1},
            {1, 1, 0, 0, 0, 1, 1, 1},
            {1, 1, 1, 0, 0, 0, 1, 1},
            {1, 1, 1, 1, 0, 0, 0, 1}
    };
  static final byte[] B = new byte[] { 0, 1, 1, 0, 0, 0, 1, 1};
  static final byte[][] G = new byte[][] {
            {2, 1, 1, 3},
            {3, 2, 1, 1},
            {1, 3, 2, 1},
            {1, 1, 3, 2}
        };
  static String hexkey = "0f1571c947d9e8590cb7add6af7f6798";  // Stallings key in "An AES Example"
  int[] alog = new int[fieldSize];
  int[] log = new int[fieldSize];
  int[] S = new int[fieldSize];
  static final int blockSize = 16;
  static final int numberOfRounds = 11;
  int[] state = new int[blockSize];
  int[][] roundKey = new int[numberOfRounds][blockSize];

  int modMultiply(int a, int b, int m){
    int product = 0;
    for (; b > 0; b >>= 1){
      if ((b & 1) > 0) product ^= a;
      a <<= 1;
      if ((a & fieldSize) > 0) a ^= m;
    }
    return product;
  }

  void makeLog(){
    alog[0] = 1;
    for (int i = 1; i < fieldSize; i++)
      alog[i] = modMultiply(logBase, alog[i - 1], irreducible);
    for (int i = 1; i < fieldSize; i++) log[alog[i]] = i;
  }

  int logMultiply(int a, int b){
    return (a == 0 || b == 0) ? 0 : alog[(log[a] + log[b]) % (fieldSize - 1)];
  }

  int multiplicativeInverse(int a){
    return alog[fieldSize - 1 - log[a]];
  }

  void buildS(){
     int[] bitColumn = new int[8];
     for (int i = 0; i < fieldSize; i++){
       int inverse = i < 2 ? i : multiplicativeInverse(i);
       for (int k = 0; k < 8; k++)
           bitColumn[k] = inverse >> (7 - k) & 1;
       S[i] = 0;
       for (int k = 0; k < 8; k++){
          int bit = B[k];
          for (int l = 0; l < 8; l++)
            if (bitColumn[l] == 1) bit ^= A[k][l];
          S[i] ^= bit << 7 - k;
       }
    }
  }

 int readBlock(){
   byte[] data = new byte[blockSize];
```

```
    int len = 0;
    try {
      len = System.in.read(data);
    } catch (IOException e){
      System.err.println(e.getMessage());
      System.exit(1);
    }
    if (len <= 0) return len;
    for (int i = 0; i < len; i++){
      if (data[i] < 0) state[i] = data[i] + fieldSize;
      else state[i] = data[i];
    }
    for (int i = len; i < blockSize; i++) state[i] = 0;
    return len;
  }

   void subBytes(){
     for (int i = 0; i < blockSize; i++)
       state[i] = S[state[i]];
   }

  void shiftRows(){
    int temp = state[2]; state[2] = state[10]; state[10] = temp;
    temp = state[6]; state[6] = state[14]; state[14] = temp;
    temp = state[1]; state[1] = state[5]; state[5] = state[9];
    state[9] = state[13]; state[13] = temp;
    temp = state[3]; state[3] = state[15]; state[15] = state[11];
    state[11] = state[7]; state[7] = temp;
  }

   void mixColumns(){
    int[] temp = new int[4];
    for (int k = 0; k < 4; k++){
     for (int i = 0; i < 4; i++){
       temp[i] = 0;
       for (int j = 0; j < 4; j++)
         temp[i] ^= logMultiply(G[j][i], state[k * 4 + j]);
     }
     for (int i = 0; i < 4; i++) state[k * 4 + i] = temp[i];
    }
   }

  void expandKey(){
    for (int i = 0; i < blockSize; i++) roundKey[0][i] =
      Integer.parseInt(hexkey.substring(i * 2, (i + 1) * 2), 16);
    int rcon = 1;
    for (int i = 1; i < numberOfRounds; i++){
      roundKey[i][0] = S[roundKey[i-1][13]] ^ rcon;
      rcon <<= 1; if (rcon > 0xFF) rcon ^= irreducible;
      roundKey[i][1] = S[roundKey[i-1][14]];
      roundKey[i][2] = S[roundKey[i-1][15]];
      roundKey[i][3] = S[roundKey[i-1][12]];
      for (int k = 0; k < 4; k++)
         roundKey[i][k] ^= roundKey[i-1][k];
      for (int k = 4; k < blockSize; k++)
         roundKey[i][k] = roundKey[i][k-4] ^ roundKey[i-1][k];
    }
  }

  void addRoundKey(int round){
    for (int k = 0; k < blockSize; k++)
       state[k] ^= roundKey[round][k];
  }

   void blockCipher(){
     addRoundKey(0);
     for (int i = 1; i < numberOfRounds; i++){
       subBytes();
       shiftRows();
       if (i < numberOfRounds - 1) mixColumns();
       addRoundKey(i);
     }
   }

  void writeBlock(){
    byte[] data = new byte[blockSize];
    for (int i = 0; i < blockSize; i++)
      data[i] = (byte)(state[i]);
    try {
      System.out.write(data);
    } catch (IOException e){
      System.err.println(e.getMessage());
      System.exit(1);
    }
  }

   void encrypt(){
     while (readBlock() > 0){
       blockCipher();
       writeBlock();
     }
     System.out.flush();
   }


 public static void main(String[] args){
    DE8A de8 = new DE8A();
    de8.makeLog();
    de8.buildS();
    de8.expandKey();
    de8.encrypt();
 }
 }
```

DE9B

```
public class DE9B {

  static final int numberOfBits = 8;
  static final int fieldSize = 1 << numberOfBits;
  static final int irreducible = 0x11b;
  static final int logBase = 3;
  static final byte[][] A = new byte[][] {
            {1, 1, 1, 1, 1, 0, 0, 0},
            {0, 1, 1, 1, 1, 1, 0, 0},
        {0, 0, 1, 1, 1, 1, 1, 0},
            {0, 0, 0, 1, 1, 1, 1, 1},
        {1, 0, 0, 0, 1, 1, 1, 1},
            {1, 1, 0, 0, 0, 1, 1, 1},
            {1, 1, 1, 0, 0, 0, 1, 1},
            {1, 1, 1, 1, 0, 0, 0, 1}
    };
  static final byte[] B = new byte[] { 0, 1, 1, 0, 0, 0, 1, 1};
  static final byte[][] Gi = new byte[][] {
            {14, 9, 13, 11},
            {11, 14, 9, 13},
            {13, 11, 14, 9},
            {9, 13, 11, 14}
        };
  static String hexkey = "0f1571c947d9e8590cb7add6af7f6798";  // Stallings key in "An AES Example"
  int[] alog = new int[fieldSize];
  int[] log = new int[fieldSize];
  int[] S = new int[fieldSize];
  int[] Si = new int[fieldSize];
  static final int blockSize = 16;
  static final int numberOfRounds = 11;
  int[] state = new int[blockSize];
  int[][] roundKey = new int[numberOfRounds][blockSize];

  int modMultiply(int a, int b, int m){
    int product = 0;
    for (; b > 0; b >>= 1){
      if ((b & 1) > 0) product ^= a;
      a <<= 1;
      if ((a & fieldSize) > 0) a ^= m;
    }
    return product;
  }

  void makeLog(){
    alog[0] = 1;
    for (int i = 1; i < fieldSize; i++)
      alog[i] = modMultiply(logBase, alog[i - 1], irreducible);
    for (int i = 1; i < fieldSize; i++) log[alog[i]] = i;
  }

  int logMultiply(int a, int b){
    return (a == 0 || b == 0) ? 0 : alog[(log[a] + log[b]) % (fieldSize - 1)];
```

```
   }

   int multiplicativeInverse(int a){
     return alog[fieldSize - 1 - log[a]];
   }

   void buildS(){
      int[] bitColumn = new int[8];
      for (int i = 0; i < fieldSize; i++){
        int inverse = i < 2 ? i : multiplicativeInverse(i);
        for (int k = 0; k < 8; k++)
            bitColumn[k] = inverse >> (7 - k) & 1;
        S[i] = 0;
        for (int k = 0; k < 8; k++){
           int bit = B[k];
           for (int l = 0; l < 8; l++)
             if (bitColumn[l] == 1) bit ^= A[k][l];
           S[i] ^= bit << 7 - k;
        }
        Si[S[i]] = i;
     }
   }

  int readBlock(){
    byte[] data = new byte[blockSize];
    int len = 0;
    try {
      len = System.in.read(data);
    } catch (IOException e){
      System.err.println(e.getMessage());
      System.exit(1);
    }
    if (len <= 0) return len;
    for (int i = 0; i < len; i++){
      if (data[i] < 0) state[i] = data[i] + fieldSize;
      else state[i] = data[i];
    }
    for (int i = len; i < blockSize; i++) state[i] = 0;
    return len;
  }

   void inverseSubBytes(){
     for (int i = 0; i < blockSize; i++)
       state[i] = Si[state[i]];
   }

  void inverseShiftRows(){
    int temp = state[2]; state[2] = state[10]; state[10] = temp;
    temp = state[6]; state[6] = state[14]; state[14] = temp;
    temp = state[1]; state[1] = state[13]; state[13] = state[9];
    state[9] = state[5]; state[5] = temp;
    temp = state[3]; state[3] = state[7]; state[7] = state[11];
    state[11] = state[15]; state[15] = temp;
  }
```

```
 void inverseMixColumns(){
  int[] temp = new int[4];
  for (int k = 0; k < 4; k++){
   for (int i = 0; i < 4; i++){
     temp[i] = 0;
     for (int j = 0; j < 4; j++)
       temp[i] ^= logMultiply(Gi[j][i], state[k * 4 + j]);
   }
   for (int i = 0; i < 4; i++) state[k * 4 + i] = temp[i];
  }
 }

void expandKey(){
  for (int i = 0; i < blockSize; i++) roundKey[0][i] =
    Integer.parseInt(hexkey.substring(i * 2, (i + 1) * 2), 16);
  int rcon = 1;
  for (int i = 1; i < numberOfRounds; i++){
    roundKey[i][0] = S[roundKey[i-1][13]] ^ rcon;
    rcon <<= 1; if (rcon > 0xFF) rcon ^= irreducible;
    roundKey[i][1] = S[roundKey[i-1][14]];
    roundKey[i][2] = S[roundKey[i-1][15]];
    roundKey[i][3] = S[roundKey[i-1][12]];
    for (int k = 0; k < 4; k++)
       roundKey[i][k] ^= roundKey[i-1][k];
    for (int k = 4; k < blockSize; k++)
       roundKey[i][k] = roundKey[i][k-4] ^ roundKey[i-1][k];
  }
}

void inverseAddRoundKey(int round){  // Your code from DE1B
  for (int k = 0; k < blockSize; k++)
     state[k] ^= roundKey[numberOfRounds - 1 - round][k];
}

 void blockDecipher(){
   inverseAddRoundKey(0);
   for (int i = 1; i < numberOfRounds; i++){
     inverseSubBytes();
     inverseShiftRows();
     inverseAddRoundKey(i);
     if (i < numberOfRounds - 1) inverseMixColumns();
   }
 }

void writeBlock(){
  byte[] data = new byte[blockSize];
  for (int i = 0; i < blockSize; i++)
    data[i] = (byte)(state[i]);
  try {
    System.out.write(data);
  } catch (IOException e){
    System.err.println(e.getMessage());
    System.exit(1);
   }
 }

 void addBlock(int[] destination, int[] source){
   for (int k = 0; k < blockSize; k++)
      destination[k] ^= source[k];
 }

 void copyBlock(int[] destination, int[] source){
   for (int k = 0; k < blockSize; k++)
      destination[k] = source[k];
 }

void decrypt(){  // inverse of DE9A.encrypt()
   int[] previousBlock = new int[blockSize];
   for (int k = 0; k < blockSize; k++) previousBlock[k] = 0;
   int[] currentBlock = new int[blockSize];
   while (readBlock() > 0){
     copyBlock(previousBlock, currentBlock);
     addBlock(state, previousBlock);
     blockDecipher();
     copyBlock(currentBlock, state);
     writeBlock();
   // Your code should be an arrangement of the following five function calls:
   }
   System.out.flush();
 }



public static void main(String[] args){
   DE9B de9 = new DE9B();
   de9.makeLog();
   de9.buildS();
   de9.expandKey();
   de9.decrypt();
}
}
```

DE9C

```
```

DE9D

```
```

DE9E

```
public class DE9E{

  static final int numberOfBits = 8;
  static final int fieldSize = 1 << numberOfBits;
  static final int irreducible = 0x11b;
  static final int logBase = 3;
  static final byte[][] A = new byte[][] {
            {1, 1, 1, 1, 1, 0, 0, 0},
            {0, 1, 1, 1, 1, 1, 0, 0},
        {0, 0, 1, 1, 1, 1, 1, 0},
            {0, 0, 0, 1, 1, 1, 1, 1},
        {1, 0, 0, 0, 1, 1, 1, 1},
            {1, 1, 0, 0, 0, 1, 1, 1},
            {1, 1, 1, 0, 0, 0, 1, 1},
            {1, 1, 1, 1, 0, 0, 0, 1}
    };
  static final byte[] B = new byte[] { 0, 1, 1, 0, 0, 0, 1, 1};
  static final byte[][] G = new byte[][] {
            {2, 1, 1, 3},
            {3, 2, 1, 1},
            {1, 3, 2, 1},
            {1, 1, 3, 2}
        };
  int[] alog = new int[fieldSize];
  int[] log = new int[fieldSize];
  int[] S = new int[fieldSize];
  static final int blockSize = 16;
  static final int numberOfRounds = 11;
  int[] state = new int[blockSize];
  int[] inBlock = new int[blockSize];
  int[] outBlock = new int[blockSize];
  int[][] roundKey = new int[numberOfRounds][blockSize];
  String hexkey = null;

  int modMultiply(int a, int b, int m){
    int product = 0;
    for (; b > 0; b >>= 1){
      if ((b & 1) > 0) product ^= a;
      a <<= 1;
      if ((a & fieldSize) > 0) a ^= m;
    }
    return product;
  }

  void makeLog(){
    alog[0] = 1;
    for (int i = 1; i < fieldSize; i++)
      alog[i] = modMultiply(logBase, alog[i - 1], irreducible);
    for (int i = 1; i < fieldSize; i++) log[alog[i]] = i;
  }

  int logMultiply(int a, int b){
    return (a == 0 || b == 0) ? 0 : alog[(log[a] + log[b]) % (fieldSize - 1)];
  }

  int multiplicativeInverse(int a){
    return alog[fieldSize - 1 - log[a]];
  }

  void buildS(){
     int[] bitColumn = new int[8];
     for (int i = 0; i < fieldSize; i++){
       int inverse = i < 2 ? i : multiplicativeInverse(i);
       for (int k = 0; k < 8; k++)
           bitColumn[k] = inverse >> (7 - k) & 1;
       S[i] = 0;
       for (int k = 0; k < 8; k++){
          int bit = B[k];
          for (int l = 0; l < 8; l++)
            if (bitColumn[l] == 1) bit ^= A[k][l];
          S[i] ^= bit << 7 - k;
       }
    }
  }

 int readBlock(){
   byte[] data = new byte[blockSize];
   int len = 0;
   try {
     len = System.in.read(data);
   } catch (IOException e){
     System.err.println(e.getMessage());
     System.exit(1);
   }
   if (len <= 0) return len;
   for (int i = 0; i < len; i++){
     if (data[i] < 0) inBlock[i] = data[i] + fieldSize;
     else inBlock[i] = data[i];
   }
   return len;
 }

  void subBytes(){
    for (int i = 0; i < blockSize; i++)
      state[i] = S[state[i]];
  }

 void shiftRows(){
   int temp = state[2]; state[2] = state[10]; state[10] = temp;
   temp = state[6]; state[6] = state[14]; state[14] = temp;
   temp = state[1]; state[1] = state[5]; state[5] = state[9];
   state[9] = state[13]; state[13] = temp;
   temp = state[3]; state[3] = state[15]; state[15] = state[11];
   state[11] = state[7]; state[7] = temp;
 }
```

```
 void mixColumns(){
  int[] temp = new int[4];
  for (int k = 0; k < 4; k++){
   for (int i = 0; i < 4; i++){
     temp[i] = 0;
     for (int j = 0; j < 4; j++)
       temp[i] ^= logMultiply(G[j][i], state[k * 4 + j]);
   }
   for (int i = 0; i < 4; i++) state[k * 4 + i] = temp[i];
  }
 }

void readKey(String filename){
  Scanner in = null;
  try {
    in = new Scanner(new File(filename));
  } catch (FileNotFoundException e){
    System.err.println(filename + " not found");
    System.exit(1);
  }
  hexkey = in.nextLine();
  in.close();
}

void expandKey(){
  for (int i = 0; i < blockSize; i++) roundKey[0][i] =
    Integer.parseInt(hexkey.substring(i * 2, (i + 1) * 2), 16);
  int rcon = 1;
  for (int i = 1; i < numberOfRounds; i++){
    roundKey[i][0] = S[roundKey[i-1][13]] ^ rcon;
    rcon <<= 1; if (rcon > 0xFF) rcon ^= irreducible;
    roundKey[i][1] = S[roundKey[i-1][14]];
    roundKey[i][2] = S[roundKey[i-1][15]];
    roundKey[i][3] = S[roundKey[i-1][12]];
    for (int k = 0; k < 4; k++)
       roundKey[i][k] ^= roundKey[i-1][k];
    for (int k = 4; k < blockSize; k++)
       roundKey[i][k] = roundKey[i][k-4] ^ roundKey[i-1][k];
  }
}

void addRoundKey(int round){
  for (int k = 0; k < blockSize; k++)
     state[k] ^= roundKey[round][k];
}

 void blockCipher(){
   addRoundKey(0);
   for (int i = 1; i < numberOfRounds; i++){
     subBytes();
     shiftRows();
     if (i < numberOfRounds - 1) mixColumns();
     addRoundKey(i);
   }
  }

 void writeBlock(int len){
   byte[] data = new byte[blockSize];
   for (int i = 0; i < len; i++)
     data[i] = (byte)(outBlock[i]);
   System.out.write(data, 0, len);
 }

 void readNonce(String filename){
   Scanner in = null;
   try {
     in = new Scanner(new File(filename));
   } catch (FileNotFoundException e){
     System.err.println(filename + " not found");
     System.exit(1);
   }
   hexkey = in.nextLine();
   in.close();
   for (int i = 0; i < blockSize; i++) state[i] =
     Integer.parseInt(hexkey.substring(i * 2, (i + 1) * 2), 16);
 }


 void encrypt(){
   int len = 0;
   while ((len = readBlock()) >= 0){
     blockCipher();
     for (int i = 0; i < len; i++)
       outBlock[i] = inBlock[i] ^ state[i];
     writeBlock(len);
   }
 }

public static void main(String[] args){
   if (args.length < 2){
     System.err.println("Usage: java DE9E key nonce < original > encrypted");
     return;
   }
   DE9E de9 = new DE9E();
   de9.makeLog();
   de9.buildS();
   de9.readKey(args[0]);
   de9.expandKey();
   de9.readNonce(args[1]);
   de9.encrypt();
}
}
```

DE9F

```
public class DE9F{

  static final int numberOfBits = 8;
  static final int fieldSize = 1 << numberOfBits;
  static final int irreducible = 0x11b;
  static final int logBase = 3;
  static final byte[][] A = new byte[][] {
            {1, 1, 1, 1, 1, 0, 0, 0},
            {0, 1, 1, 1, 1, 1, 0, 0},
        {0, 0, 1, 1, 1, 1, 1, 0},
            {0, 0, 0, 1, 1, 1, 1, 1},
        {1, 0, 0, 0, 1, 1, 1, 1},
            {1, 1, 0, 0, 0, 1, 1, 1},
            {1, 1, 1, 0, 0, 0, 1, 1},
            {1, 1, 1, 1, 0, 0, 0, 1}
    };
  static final byte[] B = new byte[] { 0, 1, 1, 0, 0, 0, 1, 1};
  static final byte[][] G = new byte[][] {
            {2, 1, 1, 3},
            {3, 2, 1, 1},
            {1, 3, 2, 1},
            {1, 1, 3, 2}
        };
  int[] alog = new int[fieldSize];
  int[] log = new int[fieldSize];
  int[] S = new int[fieldSize];
  static final int blockSize = 16;
  static final int numberOfRounds = 11;
  int[] state = new int[blockSize];
  int[] counter = new int[blockSize];
  int[] inBlock = new int[blockSize];
  int[][] roundKey = new int[numberOfRounds][blockSize];
  String hexkey = null;

  int modMultiply(int a, int b, int m){
    int product = 0;
    for (; b > 0; b >>= 1){
      if ((b & 1) > 0) product ^= a;
      a <<= 1;
      if ((a & fieldSize) > 0) a ^= m;
    }
    return product;
  }

  void makeLog(){
    alog[0] = 1;
    for (int i = 1; i < fieldSize; i++)
      alog[i] = modMultiply(logBase, alog[i - 1], irreducible);
    for (int i = 1; i < fieldSize; i++) log[alog[i]] = i;
  }

  int logMultiply(int a, int b){
    return (a == 0 || b == 0) ? 0 : alog[(log[a] + log[b]) % (fieldSize - 1)];
```

```
 }

 int multiplicativeInverse(int a){
   return alog[fieldSize - 1 - log[a]];
 }

 void buildS(){
    int[] bitColumn = new int[8];
    for (int i = 0; i < fieldSize; i++){
      int inverse = i < 2 ? i : multiplicativeInverse(i);
      for (int k = 0; k < 8; k++)
          bitColumn[k] = inverse >> (7 - k) & 1;
      S[i] = 0;
      for (int k = 0; k < 8; k++){
         int bit = B[k];
         for (int l = 0; l < 8; l++)
           if (bitColumn[l] == 1) bit ^= A[k][l];
         S[i] ^= bit << 7 - k;
      }
   }
 }

int readBlock(){
  byte[] data = new byte[blockSize];
  int len = 0;
  try {
    len = System.in.read(data);
  } catch (IOException e){
    System.err.println(e.getMessage());
    System.exit(1);
  }
  if (len <= 0) return len;
  for (int i = 0; i < len; i++){
    if (data[i] < 0) inBlock[i] = data[i] + fieldSize;
    else inBlock[i] = data[i];
  }
  return len;
}

 void subBytes(){
   for (int i = 0; i < blockSize; i++)
     state[i] = S[state[i]];
 }

void shiftRows(){
  int temp = state[2]; state[2] = state[10]; state[10] = temp;
  temp = state[6]; state[6] = state[14]; state[14] = temp;
  temp = state[1]; state[1] = state[5]; state[5] = state[9];
  state[9] = state[13]; state[13] = temp;
  temp = state[3]; state[3] = state[15]; state[15] = state[11];
  state[11] = state[7]; state[7] = temp;
}

 void mixColumns(){
  int[] temp = new int[4];
  for (int k = 0; k < 4; k++){
   for (int i = 0; i < 4; i++){
     temp[i] = 0;
     for (int j = 0; j < 4; j++)
       temp[i] ^= logMultiply(G[j][i], state[k * 4 + j]);
   }
   for (int i = 0; i < 4; i++) state[k * 4 + i] = temp[i];
  }
 }

void readKey(String filename){
  Scanner in = null;
  try {
    in = new Scanner(new File(filename));
  } catch (FileNotFoundException e){
    System.err.println(filename + " not found");
    System.exit(1);
  }
  hexkey = in.nextLine();
  in.close();
}

void expandKey(){
  for (int i = 0; i < blockSize; i++) roundKey[0][i] =
    Integer.parseInt(hexkey.substring(i * 2, (i + 1) * 2), 16);
  int rcon = 1;
  for (int i = 1; i < numberOfRounds; i++){
    roundKey[i][0] = S[roundKey[i-1][13]] ^ rcon;
    rcon <<= 1; if (rcon > 0xFF) rcon ^= irreducible;
    roundKey[i][1] = S[roundKey[i-1][14]];
    roundKey[i][2] = S[roundKey[i-1][15]];
    roundKey[i][3] = S[roundKey[i-1][12]];
    for (int k = 0; k < 4; k++)
       roundKey[i][k] ^= roundKey[i-1][k];
    for (int k = 4; k < blockSize; k++)
       roundKey[i][k] = roundKey[i][k-4] ^ roundKey[i-1][k];
  }
}

void addRoundKey(int round){
  for (int k = 0; k < blockSize; k++)
     state[k] ^= roundKey[round][k];
}

 void blockCipher(){
   addRoundKey(0);
   for (int i = 1; i < numberOfRounds; i++){
     subBytes();
     shiftRows();
     if (i < numberOfRounds - 1) mixColumns();
     addRoundKey(i);
   }
 }
void writeBlock(int len){
  byte[] data = new byte[blockSize];
  for (int i = 0; i < len; i++)
    data[i] = (byte)(state[i]);
  System.out.write(data, 0, len);
}

void readNonce(String filename){
  Scanner in = null;
  try {
    in = new Scanner(new File(filename));
  } catch (FileNotFoundException e){
    System.err.println(filename + " not found");
    System.exit(1);
  }
  hexkey = in.nextLine();
  in.close();
  for (int i = 0; i < blockSize; i++) counter[i] =
    Integer.parseInt(hexkey.substring(i * 2, (i + 1) * 2), 16);
}

void incrementCounter(){
  boolean carry = true;
  int k = blockSize - 1;
  while (carry && k >= 0){
    counter[k]++;
    if (counter[k] >= fieldSize) counter[k] = 0;
    else carry = false;
    k--;
  }
  if (carry && k < 0) counter[blockSize - 1] = 1;
}

void addBlock(int[] destination, int[] source){
  for (int k = 0; k < blockSize; k++)
     destination[k] ^= source[k];
}

void copyBlock(int[] destination, int[] source){
  for (int k = 0; k < blockSize; k++)
     destination[k] = source[k];
}

void encrypt(){
  int len = 0;
  while ((len = readBlock()) >= 0){
    copyBlock(state, counter);
    blockCipher();
    addBlock(state, inBlock);
    writeBlock(len);
    incrementCounter();
  }
}
```

```
public static void main(String[] args){
   if (args.length < 2){
     System.err.println("Usage: java DE2eCTR key nonce < original > DE2testCTR.de2");
     return;
   }
   DE9F de9 = new DE9F();
   de9.makeLog();
   de9.buildS();
   de9.readKey(args[0]);
   de9.expandKey();
   de9.readNonce(args[1]);
   de9.encrypt();
}
}
```