# Midterm: Part I

## Note

This is a closed-book exam. Part I contains five problems, each accounting for 10 points.

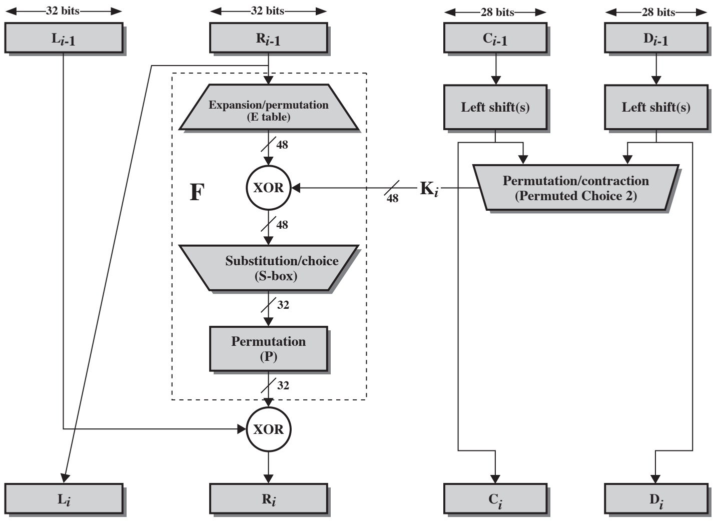
## Problems

1. Answer the following questions concerning basic concepts in information security.
   - (a) What are the four general services, aside from *access control* and *availability*, that encompass the various functions required of an information security facility? Please briefly explain.
   - (b) Name and describe two types of passive attack and three types of active attack.
2. Answer the following questions concerning DES.
   - (a) Why in DES the round function (**F**) need not be invertible?
   - (b) How does three-key triple DES achieve backward compatibility with DES? Please describe all alternatives.
3. Consider the AES algorithm, where the irreducible polynomial modulus is $x^8+x^4+x^3+x+1$.
   - (a) What is the result of (0111 1001) $\cdot$ (0000 0101)? Show the steps of your calculation.
   - (b) What is the value of $(0100\ 0111)^{-1}$? Show the steps of your calculation.
4. Answer the following questions concerning the various block cipher modes of operation.
   - (a) How do the Cipher Feedback Mode and the Output Feedback Mode compare (in terms of strengths and weaknesses)?
   - (b) What is the main weakness of the Counter Mode?
5. Consider pseudorandom number generation with the OFB mode of operation using 128-bit encryption. Suppose, as an observer (not knowing the seed value), you have observed so far $n$ *different* blocks $C_1, C_2, \ldots, C_n$ of pseudorandom bits on the output.
   - (a) If the next block $C_{n+1}$ would be equal to any of the previous blocks, it must be $C_1$. Why?
   - (b) What is the probability that the stream of blocks will start to repeat itself from $C_{n+1}$?

   Please justify your answers.

## Appendix

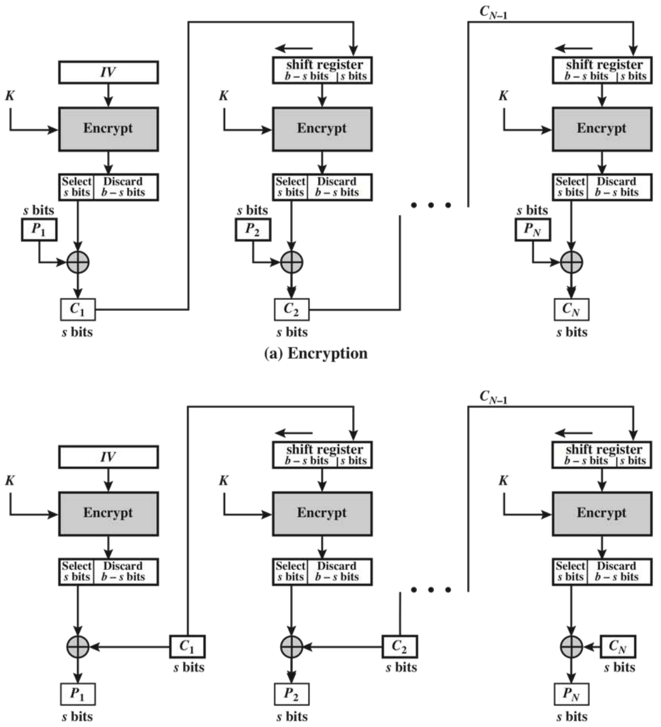
- Single round of the DES Algorithm:



- Extended Euclid's algorithm for polynomials:

```
    $EXTENDED\ EUCLID(a(x), b(x)):$
1.  $[V_1(x), W_1(x), R_1(x)] \leftarrow [1, 0, a(x)]; [V_2(x), W_2(x), R_2(x)] \leftarrow [0, 1, b(x)]$
2.  if $R_2(x) = 0$ then return $R_1(x) = \gcd(a(x), b(x))$; no inverse
3.  if $R_2(x) = 1$ then return $R_2(x) = \gcd(a(x), b(x)); W_2(x) = b^{-1}(x) \pmod{a(x)}$
4.  $Q(x) =$ the quotient of $R_1(x)/R_2(x)$
5.  $[V(x), W(x), R(x)]$
    $\leftarrow [V_1(x) - Q(x)V_2(x), W_1(x) - Q(x)W_2(x), R_1(x) - Q(x)R_2(x)]$
6.  $[V_1(x), W_1(x), R_1(x)] \leftarrow [V_2(x), W_2(x), R_2(x)]$
7.  $[V_2(x), W_2(x), R_2(x)] \leftarrow [V(x), W(x), R(x)]$
8.  goto 2
```

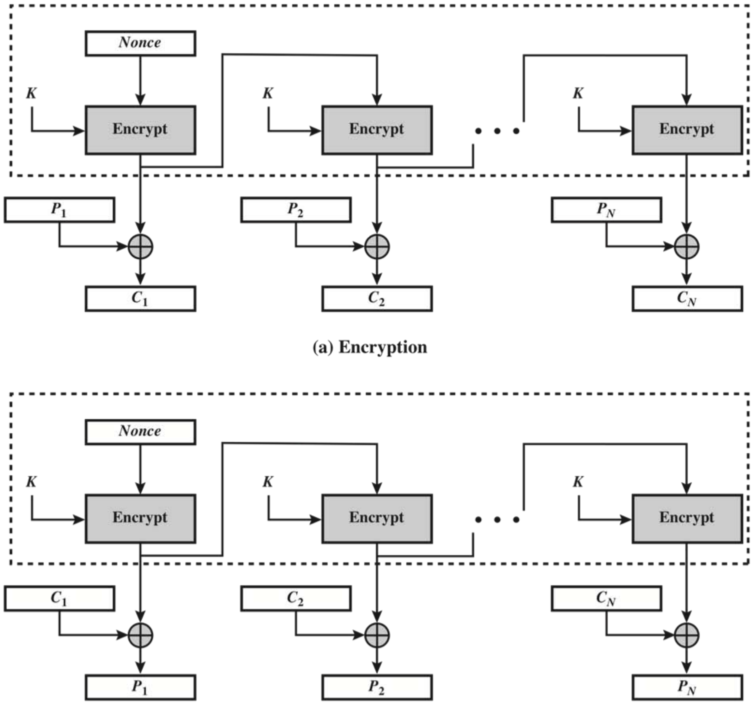
- The Cipher Feedback (CFB) Mode of Operation:



**(a) Encryption**

**(b) Decryption**

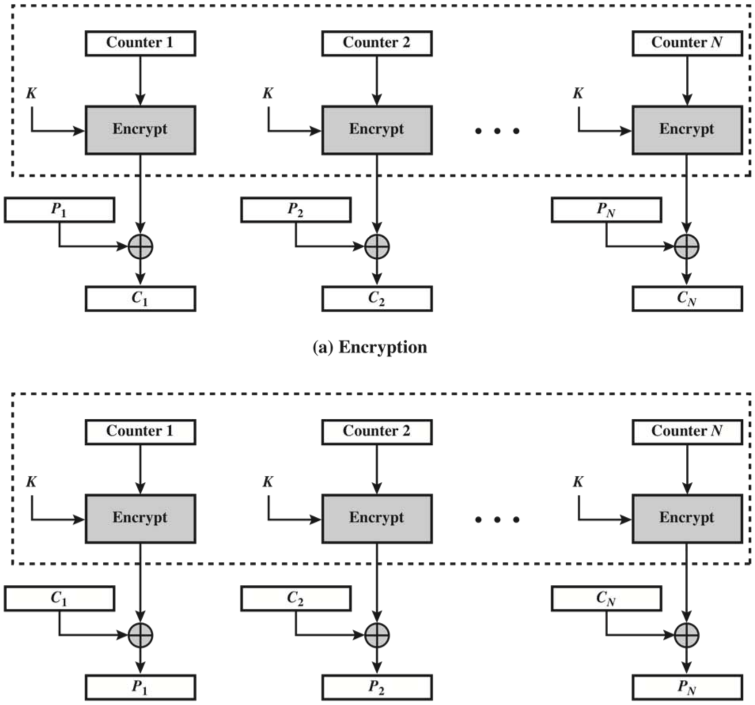
- The Output Feedback (OFB) Mode of Operation:



**(a) Encryption**

**(b) Decryption**

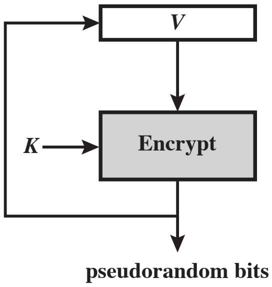
- The Counter (CTR) Mode of Operation:



(a) Encryption

(b) Decryption

- Pseudorandom number generation with the OFB mode:


$V$
$K$
Encrypt
pseudorandom bits