

# Contents

<b>1</b>	<b>Introduction</b>	<b>5</b>
1.1	Fundamental Knowledge for Cryptographers . . . . .	5
<b>2</b>	<b>Classical Cryptography</b>	<b>7</b>
2.1	The Scytale ( $\sigma\kappaυτάλη$ ) . . . . .	7
2.2	Substitution Cipher . . . . .	7
2.2.1	Caesar Cipher . . . . .	7
2.2.2	Affine Cipher in $Z_m$ . . . . .	7
2.4	Vigenère Cipher . . . . .	7
2.6	Formal Definition of a Cryptosystem and Types of Attacks . . . . .	7
2.6.1	Cryptanalysis . . . . .	7
<b>3</b>	<b>Cryptanalysis of Classical Systems</b>	<b>9</b>
3.1	Frequency Analysis . . . . .	9
3.2	The Friedmann Test . . . . .	9
3.3	Estimating the Keylength of a Vigenère Cipher . . . . .	9
3.4	Attacks Against Vigenère Cipher with Running Key . . . . .	9
<b>4</b>	<b>Entropy and Perfect Secrecy</b>	<b>11</b>
4.1	Foundations of Information Theory . . . . .	11
4.1.1	Entropy . . . . .	11
4.2	Perfect Secrecy . . . . .	11
4.2.1	Perfect Secrecy of the Vernam Cipher . . . . .	11
<b>5</b>	<b>Fast Block Ciphers</b>	<b>13</b>
5.2	The Advanced Encryption Standard (AES) . . . . .	13
5.2.1	Encryption Procedure . . . . .	13
5.2.2	Key Expansion . . . . .	13
5.2.3	Decryption . . . . .	13
5.2.4	Design Considerations and Security . . . . .	13
5.3	Other Block Ciphers . . . . .	13
5.4	Modes of Operation . . . . .	13
5.4.1	Electronic Codebook Mode (ECB) . . . . .	13
5.4.2	Cipher-Block Chaining Mode (CBC) . . . . .	13
5.4.3	Output Feedback Mode (OFB) . . . . .	13
5.4.4	Cipher Feedback Mode (CFB) . . . . .	13
5.4.5	Counter Mode (CTR) . . . . .	13

## Contents

<b>6 Number-Theoretic Reference Problems</b>	<b>15</b>
6.1 Primality Testing . . . . .	15
6.1.1 Fermat Primality Test (FPT) . . . . .	15
6.1.2 Miller-Rabin Primality Test (MRPT) . . . . .	15
6.1.3 Deterministic Primality Testing . . . . .	15
6.1.4 Finding Large Prime Numbers . . . . .	15
6.2 The Integer Factorization Problem . . . . .	15
6.3 The Extended Euclidean Algorithm . . . . .	15
6.4 The Chinese Remainder Theorem . . . . .	15
<b>7 The Discrete Logarithm</b>	<b>17</b>
7.1 Diffie-Hellman Key Distribution and Key Agreement . . . . .	17
7.1.1 Intruder-in-the-Middle Attack on the DH-System . . . . .	17
7.2 Shamir's No-Key Protocol . . . . .	17
<b>8 Public-Key Cryptography</b>	<b>19</b>
8.1 The RSA-Cryptosystem . . . . .	19
8.1.1 Security of RSA . . . . .	19
8.1.2 Implementation of RSA . . . . .	19
8.1.3 The RSA Signature Scheme . . . . .	19
8.2 The ElGamal Cryptosystem . . . . .	19
8.3 Generalized ElGamal Encryption . . . . .	19
8.4 Public Key Infrastructure . . . . .	19
8.4.1 The PGP Hierarchy . . . . .	19
<b>9 Public Key Cryptography (ctd.)</b>	<b>21</b>
9.2 The Rabin Cryptosystem . . . . .	21
<b>10 Cryptographic Hash Functions</b>	<b>23</b>
10.1 Security of Hash Functions . . . . .	23
10.2 Construction of Hash Functions . . . . .	23
<b>11 Signature Schemes</b>	<b>25</b>
11.1 The ElGamal Signature Scheme . . . . .	25
11.1.1 Security of the ElGamal Signature Scheme . . . . .	25
11.2 The Digital Signature Algorithm (DSA) . . . . .	25
<b>13 Elliptic Curves</b>	<b>27</b>
13.1 Foundations and Definitions . . . . .	27
13.2 The Group Law . . . . .	27
13.2.1 Group Order $\#E(\mathbb{F}_q)$ . . . . .	27
13.3 The DLP on Elliptic Curves . . . . .	27
13.3.1 Algorithms for Solving DLP/ECDLP . . . . .	27
13.3.2 Cryptographically Secure Elliptic Curves . . . . .	27
13.3.3 Comparison DLP vs. ECDLP . . . . .	27

*Contents*

13.4 Cryptographic Applications . . . . .	27
13.4.1 Diffie-Hellman Key Exchange . . . . .	27
13.4.2 ElGamal on Elliptic Curves (ECElGamal) . . . . .	27