Advanced Cryptographic Primitives Training Course

Professional Development Training Course Outline

Category	Data Security	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Advanced Cryptographic Primitives Training Course equips professionals with the deep, mathematically rigorous knowledge and practical implementation skills needed to design and analyze the security foundations of modern digital systems. This program moves far beyond introductory concepts, focusing on cutting-edge primitives that underpin high-stakes applications like Post-Quantum Cryptography (PQC), Blockchain Security, and Confidential Computing. Participants will master the theoretical security models, explore lattice-based and homomorphic encryption, and develop expertise in complex zero-knowledge and multi-party computation protocols. This course is crucial for staying ahead of evolving cybersecurity threats, particularly those posed by advanced adversaries and the impending arrival of quantum computing.

The digital world relies entirely on the robust construction of cryptosystems. This advanced training is specifically designed to transition security engineers and developers from users of cryptographic libraries to expert architects capable of making informed decisions on primitive selection, protocol design, and cryptographic agility. Strong keywords for this domain include Zero-Knowledge Proofs (ZKP), Homomorphic Encryption (HE), Secure Multi-Party Computation (MPC), Post-Quantum Cryptography (PQC), Side-Channel Analysis, Lattice-Based Cryptography, Formal Verification, and Elliptic Curve Cryptography (ECC). By focusing on these advanced topics, the course ensures graduates are prepared to address the critical security challenges of future decentralized and computationally intensive environments, securing sensitive data against both classical and quantum-era attacks.

Programme Curriculum

Advanced Cryptographic Primitives Training Course

Introduction

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Course Duration

10 days

Course Objectives

1. Analyze the computational security of classical and advanced cryptographic primitives, utilizing reduction proofs.
2. Master the principles of Post-Quantum Cryptography (PQC), focusing on Lattice-Based Cryptography algorithms.
3. Design secure, privacy-preserving protocols using Homomorphic Encryption (HE) for cloud computing.
4. Implement and evaluate Zero-Knowledge Proof (ZKP) systems for verifiable computation and private authentication.
5. Develop secure Secure Multi-Party Computation (MPC) protocols for collaborative data analysis.
6. Assess the vulnerability of cryptosystems to Side-Channel Analysis (SCA) and implement countermeasures.
7. Explore the mathematical underpinnings and pairing-based cryptography used in Identity-Based Encryption (IBE).
8. Evaluate the role of advanced primitives in Blockchain Security and decentralized applications (DApps).
9. Differentiate between various Cryptographic Hash Functions (e.g., SHA-3, BLAKE2) and their applications in data integrity.
10. Apply advanced topics in Elliptic Curve Cryptography (ECC), including EdDSA and Key Establishment Schemes.
11. Understand the concepts of Cryptographic Agility and secure Key Management in dynamic environments.
12. Utilize Formal Verification techniques for proving the security properties of cryptographic protocols.
13. Investigate the latest research trends in Fully Homomorphic Encryption (FHE) and Functional Encryption.

Target Audience

1. Cryptography Engineers.
2. Cybersecurity Architects.
3. Software Developers.
4. Security Researchers.
5. Penetration Testers
6. Cloud Security Professionals
7. Data Scientists.
8. Graduate Students and Academics in Computer Science or Mathematics focusing on a Cryptography thesis.

Course Modules

Module 1: Mathematical Foundations & Computational Hardness

- Advanced Number Theory for Cryptography
- Complexity Theory.
- Factoring and Discrete Logarithm Problems
- Security Models
- Case Study: The evolution from the RSA problem to the Elliptic Curve Discrete Logarithm Problem in real-world SSL/TLS implementations.

Module 2: Advanced Symmetric Primitives & Modes

- Block Cipher Design Principles and Cryptanalysis
- Authenticated Encryption Schemes.
- Designing Secure Stream Ciphers and true/pseudo Random Number Generators
- Advanced Key Derivation Functions and Password-Based Key Derivation.
- Case Study: Analysis of the Logjam Attack and its exploitation of weak Diffie-Hellman parameters, highlighting the importance of robust key exchange primitives.

Module 3: Post-Quantum Cryptography (PQC)

- Introduction to Quantum Computing Threats
- Lattice-Based Cryptography and the NTRU algorithm.
- Code-Based Cryptography and Hash-Based Signatures
- NIST PQC Standardization Process and chosen algorithms
- Case Study: Analyzing the Migration Strategy of a major tech company transitioning its internal communication systems to a Quantum-Safe protocol.

Module 4: Homomorphic Encryption (HE) and Privacy

- Concepts of Partially and Somewhat Homomorphic Encryption
- Architecture of Fully Homomorphic Encryption
- Implementing Private Queries and secure computation on encrypted data.
- Performance trade-offs and practical FHE toolkits
- Case Study: Designing a Confidential Cloud Data Analytics service where data owners can run machine learning models on encrypted patient health records

Module 5: Zero-Knowledge Proofs (ZKP)

- Foundations of Interactive ZKPs
- Non-Interactive ZKPs

- zk-STARKs and their applications in scalability and transparency.
- ZKP for private authentication and proving knowledge of a secret without revealing it.
- Case Study: The use of zk-SNARKs in Zcash and other privacy-focused cryptocurrencies for private transaction verification.

Module 6: Secure Multi-Party Computation (MPC)

- Defining the goals and security models of MPC
- Oblivious Transfer and Secret Sharing Schemes
- Protocols for secure function evaluation
- Practical implementation challenges and frameworks for MPC.
- Case Study: Implementing a Secure Auction/Bidding System where bids are compared without revealing the individual amounts to competitors.

Module 7: Cryptography in Decentralized Systems

- Blockchain cryptographic primitives
- Advanced Digital Signature Schemes for transaction signing.
- Consensus Algorithms and their reliance on cryptographic assumptions.
- Smart Contract security vulnerabilities and cryptographic best practices.
- Case Study: Examining the cryptographic failure of the Poly Network Hack and the subsequent rescue, focusing on key management and signature scheme vulnerabilities.

Module 8: Side-Channel Attacks and Countermeasures

- Introduction to Physical Attacks
- Practical Profiling Attacks and tools
- Fault Injection Attacks and their impact on signature generation.
- Countermeasures: Masking, Blinding, and hardware security modules
- Case Study: Analyzing a timing attack vulnerability discovered in a widely used web server?ÇÖs TLS implementation and the resulting code patch.

Module 9: Advanced Cryptographic Protocols

- Threshold Cryptography and its use in decentralized key management.
- Broadcast Encryption and Traitor Tracing schemes.
- Identity-Based Encryption and Attribute-Based Encryption
- Searchable Encryption for secure outsourced data.
- Case Study: Designing an Emergency Decryption Protocol using Threshold Cryptography for a company's disaster recovery plan.

Module 10: Formal Methods and Provable Security

- The Game-Based and Simulation-Based security paradigm.
- Introduction to Formal Verification Tools
- The role of Proof Assistants in validating cryptographic constructions.
- Applying the Bellare-Rogaway model for key exchange security.
- Case Study: Demonstrating the Formal Verification of the TLS 1.3 handshake protocol to prove security properties mathematically.

Module 11: Cryptanalysis Techniques

- Advanced techniques for symmetric-key cryptanalysis
- Index Calculus and other advanced methods for breaking discrete logarithm problems.
- Lattice reduction algorithms (LLL) and their use in attacking PQC candidates.
- Automated Cryptanalysis tools and frameworks.
- Case Study: The historical "Sweet32" attack, a birthday attack on block ciphers with small block sizes (3DES), highlighting the limits of older primitives.

Module 12: Cryptographic Agility and Standards

- Principles of Cryptographic Agility and managing algorithm changes.
- Current and emerging Industry Standards and compliance.
- Implementing a secure Cryptographic Lifecycle Management program.
- Integrating Hardware Security Modules for root of trust.
- Case Study: Developing a Cryptographic Roadmap for a financial institution to manage the transition from RSA to an ECC/PQC hybrid signature scheme.

Module 13: Trusted Execution Environments (TEEs) and Confidential Computing

- Architecture of TEEs and their security goals.
- Cryptographic primitives used for Remote Attestation and integrity checks.
- Programming models and development within TEEs.
- Securing Cloud Workloads using confidential computing principles.
- Case Study: Using Intel SGX to secure a Machine Learning Model by ensuring the weights and inference process remain encrypted and private.

Module 14: Biometric and Physical Cryptography

- Biometric Encryption and Fuzzy Extractors for key generation.
- Protecting biometric templates using Cryptographic Binding.
- Physical Unclonable Functions as a source of hardware-derived keys.
- Lightweight Cryptography for resource-constrained IoT devices.
- Case Study: Designing a secure Access Control System for a data center using PUFs for device identity and key storage.

Module 15: Future Trends and Open Problems

- Introduction to Functional Encryption and its advanced features.
- The role of Artificial Intelligence in both cryptanalysis and secure design.
- The Cryptography of the Internet of Things and constrained environments.
- Major Open Problems in Cryptography
- Case Study: Discussing the Open Challenges in standardizing Fully Homomorphic Encryption for widespread use in the healthcare sector.

Training Methodology

This course employs a participatory and hands-on approach to ensure practical learning, including:

- Interactive lectures and presentations.
- Group discussions and brainstorming sessions.
- Hands-on exercises using real-world datasets.
- Role-playing and scenario-based simulations.

- Analysis of case studies to bridge theory and practice.
- Peer-to-peer learning and networking.
- Expert-led Q&A sessions.
- Continuous feedback and personalized guidance.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.com or call +254769199797

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to FINESKILL TRAINING CENTER account, as indicated in the invoice so as to enable us prepare better for you.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
07 Sep 2026	18 Sep 2026	Online	$2,200
14 Sep 2026	25 Sep 2026	Online	$2,200
21 Sep 2026	02 Oct 2026	Online	$2,200
28 Sep 2026	09 Oct 2026	Online	$2,200
05 Oct 2026	16 Oct 2026	Online	$2,200
12 Oct 2026	23 Oct 2026	Online	$2,200

Start Date	End Date	Location	Price
19 Oct 2026	30 Oct 2026	Online	$2,200
26 Oct 2026	06 Nov 2026	Online	$2,200

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