

**San Pablo Catholic University (UCSP)**  
**Undergraduate Program in**  
**Computer Science**  
**SILABO**



**CS1D3. Abstract Algebra (Mandatory)**

**1. General information**

1.1 School	:	Ciencia de la Computación
1.2 Course	:	CS1D3. Abstract Algebra
1.3 Semester	:	3 <sup>er</sup> Semestre.
1.4 Prerequisites	:	<ul style="list-style-type: none"><li>• CS1D1. Discrete Structures I. (1<sup>st</sup> Sem)</li><li>• CS112. Computer Science I. (2<sup>nd</sup> Sem)</li></ul>
1.5 Type of course	:	Mandatory
1.6 Learning modality	:	Virtual
1.7 Horas	:	2 HT; 2 HL;
1.8 Credits	:	3

**2. Professors**

**3. Course foundation**

En algebra abstracta se explotará las nociones de teoria de números, grupos, anillos y campos para comprender en profundidad temas de computación como criptografía y teoría de la codificación.

**4. Summary**

1. 2. 3. Cryptography 4.

**5. Generales Goals**

- Entender los conceptos de estructuras algebraicas como anillos, dominios, cuerpos y grupos.
- Utilizar las propiedades de las estructuras algebraicas para resolver problemas
- Conocer las técnicas y métodos de sistemas criptográficos y como los teoremas permiten la realización de cálculos rápidos y eficientes.

**6. Contribution to Outcomes**

This discipline contributes to the achievement of the following outcomes:

- 1) Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions. (**Assessment**)
- 6) Apply computer science theory and software development fundamentals to produce computing-based solutions. (**Assessment**)

**7. Content**

<b>UNIT 1: (16)</b>	
<b>Competences:</b>	
<b>Content</b>	<b>Generales Goals</b>
<ul style="list-style-type: none"> <li>• Número enteros, algoritmos de la división, máximo común divisor, algoritmo de Euclides y algoritmo extendido de Euclides. Ecuaciones diofánticas</li> <li>• Aritmética Modular y Operaciones en <math>\mathbb{Z}_n</math>: suma, resta, multiplicación, inversa y exponenciación.</li> <li>• Congruencia, conjunto de residuos, congruencia lineal, teorema chino del resto.</li> <li>• Generadores de números primos y pseudo-aleatorios, función phi de Euler, teorema pequeño de Fermat, teorema de Euler, teorema fundamental de la aritmética y factorización.</li> </ul>	<ul style="list-style-type: none"> <li>• Realizar cálculos que involucren aritmética modular [Usage]</li> <li>• Describir algoritmos numérico teóricos básicos eficientes, incluyendo el algoritmo de Euclides y el algoritmo extendido de Euclides. [Assessment]</li> <li>• Establecer la importancia del estudio de la teoría de números. [Familiarity]</li> <li>• Discuss the importance of prime numbers in cryptography and explain their use in cryptographic algorithms [Familiarity]</li> </ul>
<b>Readings:</b> Rosen (2011), Grimaldi (2003), Koshy (2007)	

<b>UNIT 2: (14)</b>	
<b>Competences:</b>	
<b>Content</b>	<b>Generales Goals</b>
<ul style="list-style-type: none"> <li>• Grupos: propiedades, operaciones, homomorfismos e isomorfismo, orden de un grupo, grupos cíclicos, teorema de Lagrange y raíces primitivas.</li> <li>• Anillos y cuerpos: propiedades, sub-anillos, dominios de integridad.</li> </ul>	<ul style="list-style-type: none"> <li>• Adquirir habilidad en la resolución de problemas abstractos y en la formulación de conjeturas . [Familiarity]</li> <li>• Argumentar como los principales teoremas y algoritmos permiten resolver problemas criptográficos. [Assessment]</li> </ul>
<b>Readings:</b> Grimaldi (2003), Gallian (2012), Koshy (2007)	

**UNIT 3: Cryptography (20)****Competences:****Content****Generales Goals**

- Basic Cryptography Terminology covering notions pertaining to the different (communication) partners, secure/unsecure channel, attackers and their capabilities, encryption, decryption, keys and their characteristics, signatures
- Cipher types (e.g., Caesar cipher, affine cipher) together with typical attack methods such as frequency analysis
- Public Key Infrastructure support for digital signature and encryption and its challenges
- Mathematical Preliminaries essential for cryptography, including topics in linear algebra, number theory, probability theory, and statistics
- Cryptographic primitives:
  - pseudo-random generators and stream ciphers
  - block ciphers (pseudo-random permutations), e.g., AES
  - pseudo-random functions
  - hash functions, e.g., SHA2, collision resistance
  - message authentication codes
  - key derivations functions
- Symmetric key cryptography
  - Perfect secrecy and the one time pad
  - Modes of operation for semantic security and authenticated encryption (e.g., encrypt-then-MAC, OCB, GCM)
  - Message integrity (e.g., CMAC, HMAC)
- Public key cryptography:
  - Trapdoor permutation, e.g., RSA
  - Public key encryption, e.g., RSA encryption, El Gamal encryption
  - Digital signatures
  - Public-key infrastructure (PKI) and certificates
  - Hardness assumptions, e.g., Diffie-Hellman, integer factoring
- Authenticated key exchange protocols, e.g., TLS
- Cryptographic protocols: challenge-response authentication, zero-knowledge protocols, commitment, oblivious transfer, secure 2-party or multiparty computation, secret sharing, and applications
- Motivate concepts using real-world applications, e.g., electronic cash, secure channels between clients and servers, secure electronic mail, entity authentication, device pairing, voting systems.
- Security definitions and attacks on cryptographic primitives:

- Describe the purpose of Cryptography and list ways it is used in data communications [Familiarity]
- Define the following terms: Cipher, Cryptanalysis, Cryptographic Algorithm, and Cryptology and describe the two basic methods (ciphers) for transforming plain text in cipher text [Familiarity]
- Discuss the importance of prime numbers in cryptography and explain their use in cryptographic algorithms [Familiarity]
- Explain how Public Key Infrastructure supports digital signing and encryption and discuss the limitations/vulnerabilities [Familiarity]
- Use cryptographic primitives and their basic properties [Familiarity]
- Illustrate how to measure entropy and how to generate cryptographic randomness [Familiarity]
- Use public-key primitives and their applications [Familiarity]
- Explain how key exchange protocols work and how they fail [Familiarity]
- Discuss cryptographic protocols and their properties [Familiarity]
- Describe real-world applications of cryptographic primitives and protocols [Familiarity]
- Summarize precise security definitions, attacker capabilities and goals [Familiarity]
- Apply appropriate known cryptographic techniques for a given scenario [Familiarity]
- Appreciate the dangers of inventing one's own cryptographic methods [Familiarity]
- Describe quantum cryptography and the impact of quantum computing on cryptographic algorithms [Familiarity]

<b>UNIT 4: (10)</b>	
<b>Competences:</b>	
<b>Content</b>	<b>Generales Goals</b>
<ul style="list-style-type: none"> <li>• Elementos, proceso de transmitir una palabra</li> <li>• Esquemas de codificación: paridad, triple repetición, verificación de paridad y generación de códigos de grupo.</li> </ul>	<ul style="list-style-type: none"> <li>• Utilizar las propiedades de las estructuras algebraicas en el estudio de la teoría algebraica de los códigos. [Familiarity]</li> <li>• Aplicar técnicas que permitan la detección de errores, y si es necesario, proveer de métodos para reconstruir palabras originales. [Usage]</li> </ul>
<b>Readings:</b> Grimaldi (2003), W.Trappe and Washington (2005)	

8. Methodology
<p>El profesor del curso presentará clases teóricas de los temas señalados en el programa propiciando la intervención de los alumnos.</p> <p>El profesor del curso presentará demostraciones para fundamentar clases teóricas.</p> <p>El profesor y los alumnos realizarán prácticas</p> <p>Los alumnos deberán asistir a clase habiendo leído lo que el profesor va a presentar. De esta manera se facilitará la comprensión y los estudiantes estarán en mejores condiciones de hacer consultas en clase.</p>

9. Assessment
<p><b>Continuous Assessment 1</b> : 20 %</p> <p><b>Partial Exam</b> : 30 %</p> <p><b>Continuous Assessment 2</b> : 20 %</p> <p><b>Final exam</b> : 30 %</p>

## References

- A.Menezes (1996). *Handbook of Applied Cryptography (Discrete Mathematics and Its Applications)*. CRC Press.
- Forouzan, B. (2008). *Introduction to Cryptography and Network Security*. McGraw-Hill.
- Gallian, J. (2012). *Contemporary Abstract Algebra*. 8 ed. Brooks/Cole.
- Grimaldi, R. (2003). *Discrete and Combinatorial Mathematics: An Applied Introduction*. 5 ed. Pearson.
- Koshy, T. (2007). *Elementary Number Theory with Applications*. 2 ed. Academic Press.
- Paar, C. and J. Pelzl (2011). *Understanding Cryptography: A Textbook for Students and Practitioners*. Springer.
- Rosen, Kenneth H. (2011). *Matemática Discreta y sus Aplicaciones*. 7 ed. McGraw Hill.
- W.Trappe and C. Washington (2005). *Introduction to Cryptography with Coding Theory*. Pearson Prentice Hall.