Computer Science Metrics

**AL-01 Analyze best, average, and worst-case behaviors of an algorithm. [Analyzing]**

- Emerging Standard
  Illustrate best, average, and worst-case behaviors of an algorithm. [Applying]
- Developed Standard
  Analyze best, average, and worst-case behaviors of an algorithm. [Analyzing]
- Highly Developed Standard
  Evaluate best, average, and worst-case behaviors of an algorithm. [Evaluating]

**AL-02 Estimate time and space complexities for a given algorithm using Big-O notation. [Evaluating]**

- Emerging Standard
  Distinguish between time and space complexities for a given algorithm. [Analyzing]
- Developed Standard
  Estimate time and space complexities for a given algorithm using Big-O notation. [Evaluating]
- Highly Developed Standard
  Critique time and space complexities of several algorithms using Big-O and other notations. [Evaluating]

**AL-03 Contrast standard complexity classes. [Analyzing]**

- Emerging Standard
  Illustrate a few of the standard complexity classes. [Applying]
- Developed Standard
  Contrast standard complexity classes, such as logarithmic, linear, quadratic, and exponential. [Analyzing]
- Highly Developed Standard
  Judge standard complexity classes as either "efficient" or "inefficient" algorithms. [Evaluating]

**AL-04 Analyze the performances of an algorithm with various input sizes. [Analyzing]**

- Emerging Standard
  Discuss the performances of an algorithm with various input sizes. [Understanding]
- Developed Standard
  Compare the performances of an algorithm with various input sizes. [Analyzing]
- Highly Developed Standard
Assess the performances of an algorithm with various input sizes [Evaluating]

**AL-05 Apply an appropriate algorithmic approach to a given problem. [Applying]**

Emerging Standard
Demonstrate an algorithmic approach to a given problem. [Understanding]
Developed Standard
Apply an appropriate algorithmic approach to a given problem, such as brute-force, greedy, recursive, divide-and-conquer, and dynamic programming. [Applying]
Highly Developed Standard
Analyze the tradeoffs of various algorithmic approaches to a given problem. [Analyzing]

**AL-06 Investigate the use of random/pseudo random number generation in cybersecurity applications. [Applying]**

Emerging Standard
Describe the use of random numbers in cybersecurity applications. [Understanding]
Developed Standard
Investigate the use of random/pseudo random number generation in cybersecurity applications, such as password generation and data encryption. [Applying]
Highly Developed Standard
Analyze the use of random/pseudo random number generation in a range of cybersecurity applications. [Analyzing]

**AL-07 Implement basic numerical algorithms. [Applying]**

Emerging Standard
Describe the use of basic numerical algorithms. [Understanding]
Developed Standard
Implement basic numerical algorithms, such as min, max, and mode. [Applying]
Highly Developed Standard
Develop complex numerical algorithms. [Creating]

**AL-08 Implement common search algorithms, including linear and binary searches. [Applying]**

Emerging Standard
Exemplify common search algorithms, including linear and binary searches. [Understanding]
Developed Standard
Implement common search algorithms, including linear and binary searches. [Applying]
Highly Developed Standard
Compare the efficiency of common search algorithms, including linear and binary searches. [Analyzing]
AL-09 Implement common sorting algorithms, including iterative, quadratic, and recursive. [Applying]

Emerging Standard
Exemplify common sorting algorithms, including iterative, quadratic, and recursive. [Understanding]
Developed Standard
Implement common sorting algorithms, including iterative, quadratic, and recursive. [Applying]
Highly Developed Standard
Compare the efficiency of common sorting algorithms, including iterative, quadratic, and recursive. [Analyzing]

AL-10 Implement hash tables, including collision avoidance and resolution. [Applying]

Emerging Standard
Explain the general idea of a hash table. [Understanding]
Developed Standard
Implement hash tables, including collision avoidance and resolution. [Applying]
Highly Developed Standard
Compare common collision resolution techniques for hash tables. [Analyzing]

AL-11 Explain the runtime and memory efficiency of principal sorting, searching, and hashing functions. [Understanding]

Emerging Standard
Summarize the runtime and memory efficiency of either a sorting, a searching, or a hashing function. [Understanding]
Developed Standard
Explain the runtime and memory efficiency of principal sorting, searching, and hashing functions. [Understanding]
Highly Developed Standard
Analyze the runtime and memory efficiency of principal sorting, searching, and hashing functions. [Analyzing]

AL-12 Investigate factors other than computational efficiency that influence the choice of algorithms. [Applying]

Emerging Standard
Describe factors other than computational efficiency that ought to be considered when choosing an algorithm. [Understanding]
Developed Standard
Investigate factors other than computational efficiency that influence the choice of algorithms, such as programming time, maintainability, and the size and patterns of input data. [Applying]
Highly Developed Standard
Critique factors other than computational efficiency that influence the choice of algorithms. [Evaluating]
AL-13 Compare various data structures for a given problem. [Analyzing]

Emerging Standard
Investigate a few data structures for a given problem. [Applying]
Developed Standard
Compare various data structures for a given problem, such as array, list, set, map, stack, queue, hash table, tree, and graph. [Analyzing]
Highly Developed Standard
Justify a choice of data structure for a given problem. [Evaluating]

AL-14 Investigate security vulnerabilities in various data structures. [Applying]

Emerging Standard
Summarize security vulnerabilities in various data structures [Understanding]
Developed Standard
Investigate security vulnerabilities in various data structures, such as out-of-bounds arrays and buffer overflows. [Applying]
Highly Developed Standard
Analyze security vulnerabilities in various data structures. [Analyzing]

AL-15 Write a regular expression to match a pattern. [Applying]

Emerging Standard
Explain the use of regular expressions in pattern matching. [Understanding]
Developed Standard
Write a regular expression to match a pattern. [Applying]
Highly Developed Standard
Write a regular expression to perform complex pattern matching. [Applying]

AL-16 Describe the concept of finite state machines. [Understanding]

Emerging Standard
Recognize a finite state machine. [Remembering]
Developed Standard
Describe the concept of finite state machines. [Understanding]
Highly Developed Standard
Diagram a finite state machine. [Applying]

AL-17 Explain why the halting problem has no algorithmic solution. [Understanding]

Emerging Standard
Recognize that some problems have no algorithmic solution. [Remembering]
Developed Standard
Explain why the halting problem has no algorithmic solution. [Understanding]

Highly Developed Standard
Illustrate a proof of the halting problem. [Applying]

AR-01 Diagram the digital components of computing architecture. [Applying]

Emerging Standard
Discuss some of the digital components of computing architecture. [Understanding]

Developed Standard
Diagram the digital components of computing architecture, such as logic gates, registers, and memory. [Applying]

Highly Developed Standard
Evaluate the digital component design of a computing architecture for accuracy. [Evaluating]

AR-02 Analyze alternative formats to represent numerical data. [Analyzing]

Emerging Standard
Explain reasons for using alternative formats to represent numerical data. [Understanding]

Developed Standard
Analyze alternative formats to represent numerical data. [Analyzing]

Highly Developed Standard
Choose optimal formats to represent a given set of numerical data. [Evaluating]

AR-03 Illustrate how fixed-length number representations could affect accuracy and precision, causing vulnerabilities. [Applying]

Emerging Standard
Explain how fixed-length number representations could affect accuracy and precision, causing vulnerabilities. [Understanding]

Developed Standard
Illustrate how fixed-length number representations could affect accuracy and precision, causing vulnerabilities. [Applying]

Highly Developed Standard
Examine how fixed-length number representations could affect accuracy and precision, causing vulnerabilities. [Analyzing]

AR-04 Examine the internal representation of non-numeric data. [Analyzing]

Emerging Standard
Illustrate internal representation of non-numeric data. [Applying]

Developed Standard
Examine the internal representation of non-numeric data, such as characters, strings, records, and arrays. [Analyzing]

Highly Developed Standard
Estimate memory requirements for non-numeric data, such as characters, strings, records, and arrays. [Evaluating]

**AR-05 Compare different methods for converting numerical data from one format to another.** [Analyzing]

Emerging Standard
Convert numerical data from one format to another. [Understanding]
Developed Standard
Compare different methods for converting numerical data from one format to another, such as converting negative integers into sign-magnitude and two’s-complement representations. [Analyzing]
Highly Developed Standard
Evaluate different methods for converting numerical data from one format to another. [Evaluating]

**AR-06 Decompose the organization and major functional units of the classical von Neumann machine.** [Analyzing]

Emerging Standard
Diagram the organization of the classical von Neumann machine and its major functional units. [Applying]
Developed Standard
Decompose the organization and major functional units of the classical von Neumann machine. [Analyzing]
Highly Developed Standard
Assess the organization of the classical von Neumann machine and its major functional units. [Evaluating]

**AR-07 Diagram how high-level language patterns map to assembly/machine language, including subroutine calls.** [Applying]

Emerging Standard
Summarize how high-level language patterns map to assembly/machine language, including subroutine calls. [Understanding]
Developed Standard
Diagram how high-level language patterns map to assembly/machine language, including subroutine calls. [Applying]
Highly Developed Standard
Examine how high-level language patterns map to assembly/machine language, including subroutine calls. [Analyzing]

**AR-08 Create simple assembly language program segments.** [Creating]

Emerging Standard
Implement simple assembly language program segments. [Applying]
Developed Standard
Create simple assembly language program segments. [Creating]
Highly Developed Standard
Create complex assembly language program segments. [Creating]
AR-09 Demonstrate the basic concepts of interrupts and I/O operations. [Understanding]

- Emerging Standard
  List basic concepts of interrupts and I/O operations. [Remembering]
- Developed Standard
  Demonstrate the basic concepts of interrupts and I/O operations. [Understanding]
- Highly Developed Standard
  Implement basic concepts of interrupts and I/O operations. [Applying]

AR-10 Compare the cost and performance of different types of memory technology. [Analyzing]

- Emerging Standard
  Describe different types of memory technology. [Understanding]
- Developed Standard
  Compare the cost and performance of different types of memory technology, such as SRAM, DRAM, virtual, and cache. [Analyzing]
- Highly Developed Standard
  Critique the cost and performance of different types of memory technology. [Evaluating]

AR-11 Calculate the effect of memory latency on execution time across the memory hierarchy. [Applying]

- Emerging Standard
  Explain the effect of memory latency on execution time across the memory hierarchy. [Understanding]
- Developed Standard
  Calculate the effect of memory latency on execution time across the memory hierarchy. [Applying]
- Highly Developed Standard
  Examine the effect of memory latency on execution time across the memory hierarchy. [Analyzing]

CN-01 Illustrate the concepts of modeling and abstraction with respect to problem solving. [Applying]

- Emerging Standard
  Explain the concepts of modeling and abstraction with respect to problem solving. [Understanding]
- Developed Standard
  Illustrate the concepts of modeling and abstraction with respect to problem solving. [Applying]
- Highly Developed Standard
  Contrast the concepts of modeling and abstraction with respect to problem solving. [Analyzing]

CN-02 Illustrate the relationship between modeling and simulation. [Applying]

- Emerging Standard
  Describe the relationships between modeling and simulation. [Understanding]
- Developed Standard
  Illustrate the relationship between modeling and simulation. [Applying]
- Highly Developed Standard
Examine the relationship between modeling and simulation. [Analyzing]

**CN-03 Exemplify different types of simulations. [Understanding]**

Emerging Standard
Identify different types of simulations. [Remembering]
Developed Standard
Exemplify different types of simulations, such as physical simulations, human-guided simulations, and virtual reality. [Understanding]
Highly Developed Standard
Compare different types of simulations. [Analyzing]

**CYB-01 Describe security as a continuous process of tradeoffs, balancing between protection mechanisms and availability. [Understanding]**

Emerging Standard
Recognize the importance of security as a continuous process of tradeoffs. [Remembering]
Developed Standard
Describe security as a continuous process of tradeoffs, balancing between protection mechanisms and availability. [Understanding]
Highly Developed Standard
Illustrate security as a continuous process of tradeoffs, balancing between protection mechanisms and availability. [Applying]

**CYB-02 Illustrate through examples the concepts of risk, threats, vulnerabilities, attack vectors, and exploits, noting there is no such thing as perfect security. [Applying]**

Emerging Standard
Differentiate the concepts of risk, threats, vulnerabilities, attack vectors, and exploits. [Understanding]
Developed Standard
Illustrate through examples the concepts of risk, threats, vulnerabilities, attack vectors, and exploits, noting there is no such thing as perfect security. [Applying]
Highly Developed Standard
Compare the concepts of risk, threats, vulnerabilities, attack vectors, and exploits to a given scenario. [Analyzing]

**CYB-03 Investigate various countermeasures and security controls to minimize risk and exposure. [Applying]**

Emerging Standard
Explain the importance of countermeasures and security controls to minimize risk and exposure. [Understanding]
Developed Standard
Investigate various countermeasures and security controls to minimize risk and exposure. [Applying]
Highly Developed Standard
Choose among various countermeasures and security controls to minimize risk and exposure in a given scenario. [Evaluating]

**CYB-04 Analyze the tradeoffs of balancing key security properties, including Confidentiality, Integrity, and Availability (CIA). [Analyzing]**

Emerging Standard
Investigate the tradeoffs of balancing key security properties, including Confidentiality, Integrity, and Availability (CIA). [Applying]

Developed Standard
Analyze the tradeoffs of balancing key security properties, including Confidentiality, Integrity, and Availability (CIA). [Analyzing]

Highly Developed Standard
Evaluate the tradeoffs of balancing key security properties, including Confidentiality, Integrity, and Availability (CIA). [Evaluating]

**CYB-05 Explain the concepts of trust and trustworthiness related to cybersecurity. [Understanding]**

Emerging Standard
Define the concepts of trust and trustworthiness. [Remembering]

Developed Standard
Explain the concepts of trust and trustworthiness related to cybersecurity. [Understanding]

Highly Developed Standard
Diagram trust relationships in a given cybersecurity scenario. [Applying]

**CYB-06 Examine ethical issues related to cybersecurity. [Analyzing]**

Emerging Standard
Exemplify ethical issues in cybersecurity. [Understanding]

Developed Standard
Examine ethical issues related to cybersecurity. [Analyzing]

Highly Developed Standard
Argue ethical issues related to cybersecurity. [Evaluating]

**CYB-07 Illustrate various ways to minimize privacy risks and maximize anonymity. [Applying]**

Emerging Standard
Describe one way to minimize privacy risks and maximize anonymity. [Understanding]

Developed Standard
Illustrate various ways to minimize privacy risks and maximize anonymity. [Applying]

Highly Developed Standard
Analyze ways to minimize privacy risks and maximize anonymity in an always connected, mobile computing environment. [Analyzing]
CYB-08 Apply security principles and practices in a dynamic environment. [Applying]

Emerging Standard
Summarize security principles and practices. [Understanding]
Developed Standard
Apply security principles and practices in a dynamic environment. [Applying]
Highly Developed Standard
Examine security principles and practices in a dynamic environment. [Analyzing]

CYB-09 Illustrate through examples the key role risk management frameworks play in identifying, assessing, prioritizing, and controlling risks to organizational assets. [Applying]

Emerging Standard
Paraphrase the key role risk management frameworks play in identifying, assessing, prioritizing, and controlling risks to organizational assets. [Understanding]
Developed Standard
Illustrate through examples the key role risk management frameworks play in identifying, assessing, prioritizing, and controlling risks to organizational assets. [Applying]
Highly Developed Standard
Analyze a given scenario with a specific risk management framework, such as NIST, to identify, assess, prioritize, and control risks to organizational assets. [Analyzing]

CYB-10 Illustrate with examples the goals of end-to-end data security. [Applying]

Emerging Standard
Explain the goals of end-to-end data security. [Understanding]
Developed Standard
Illustrate with examples the goals of end-to-end data security. [Applying]
Highly Developed Standard
Outline the goals of end-to-end data security. [Analyzing]

CYB-11 Use the principles of secure design. [Applying]

Emerging Standard
Demonstrate some of the principles of secure design as related to cybersecurity. [Understanding]
Developed Standard
Use the principles of secure design, such as least privilege, isolation, fail-safe, and deny-by-default. [Applying]
Highly Developed Standard
Choose appropriate secure design principles for a given cybersecurity scenario. [Evaluating]

CYB-12 Illustrate the security implications of relying on open design vs the secrecy of design. [Applying]
Emerging Standard
Discuss the security implications of relying on open design vs the secrecy of design. [Understanding]

Developed Standard
Illustrate the security implications of relying on open design vs the secrecy of design. [Applying]

Highly Developed Standard
Analyze the security implications of relying on open design vs the secrecy of design. [Analyzing]

**CYB-13 Discuss the benefits and limitations of designing multiple layers of defenses.** [Understanding]

Emerging Standard
Identify the benefits and limitations of designing multiple layers of defenses. [Remembering]

Developed Standard
Discuss the benefits and limitations of designing multiple layers of defenses. [Understanding]

Highly Developed Standard
Implement multiple layers of defenses for a given scenario [Applying]

**CYB-14 Analyze the tradeoffs associated with designing security into a product.** [Analyzing]

Emerging Standard
Summarize the tradeoffs associated with designing security into a product. [Understanding]

Developed Standard
Analyze the tradeoffs associated with designing security into a product. [Analyzing]

Highly Developed Standard
Evaluate the tradeoffs associated with designing security into a product. [Evaluating]

**CYB-15 Construct input validation and data sanitization in applications, considering adversarial control of the input channel.** [Creating] See also SDF-06.

Emerging Standard
Implement simple input validation and data sanitization in applications. [Applying]

Developed Standard
Construct input validation and data sanitization in applications, considering adversarial control of the input channel. [Creating]

Highly Developed Standard
Develop complex input validation and data sanitization in applications, considering adversarial control of the input channel. [Creating]

**CYB-16 Explain the tradeoffs of developing a program in a type-safe language.** [Understanding] See also PL-10.

Emerging Standard
List some of the tradeoffs of developing a program in a type-safe language. [Remembering]

Developed Standard
Explain the tradeoffs of developing a program in a type-safe language. [Understanding]

Highly Developed Standard
Compare the tradeoffs of developing a program in a type-safe language vs other types of programming languages. [Analyzing]

**CYB-17 Implement programs that properly handle exceptions and error conditions.** [Applying] See also **SDF-12.**

Emerging Standard
Explain the importance of writing programs that properly handle exceptions and error conditions. [Understanding]
Developed Standard
Implement programs that properly handle exceptions and error conditions. [Applying]
Highly Developed Standard
Analyze the implementation of exception handling in programs and error conditions. [Analyzing]

**CYB-18 Examine the need to update software to fix security vulnerabilities.** [Analyzing]

Emerging Standard
Explain the need to update software. [Understanding]
Developed Standard
Examine the need to update software to fix security vulnerabilities. [Analyzing]
Highly Developed Standard
Justify the need to update software to fix security vulnerabilities. [Evaluating]

**CYB-19 Examine likely attack types against standalone and networked systems.** [Analyzing]

Emerging Standard
Summarize likely attack types against software systems. [Understanding]
Developed Standard
Examine likely attack types against standalone and networked systems. [Analyzing]
Highly Developed Standard
Assess likely attack types against standalone and networked systems. [Evaluating]

**CYB-20 Illustrate the key principles of social engineering, including membership and trust.** [Applying] 
See also **SP-04.**

Emerging Standard
Discuss some of the key principles of social engineering. [Understanding]
Developed Standard
Illustrate the key principles of social engineering, including membership and trust. [Applying]
Highly Developed Standard
Outline the key principles of social engineering, including membership and trust. [Analyzing]

**CYB-21 Describe key terms in cryptology, including cryptography, cryptanalysis, cipher, cryptographic**
algorithm, and public key infrastructure. [Understanding]

Emerging Standard
Define some key terms in cryptology. [Remembering]
Developed Standard
Describe key terms in cryptology, including cryptography, cryptanalysis, cipher, cryptographic algorithm, and public key infrastructure. [Understanding]
Highly Developed Standard
Categorize key terms in cryptology, including cryptography, cryptanalysis, cipher, and cryptographic algorithm. [Analyzing]

CYB-22 Use a variety of ciphers to encrypt plaintext into ciphertext. [Applying]

Emerging Standard
Describe basic methods for transforming plaintext into ciphertext. [Understanding]
Developed Standard
Use a variety of ciphers to encrypt plaintext into ciphertext. [Applying]
Highly Developed Standard
Design a simple program to encrypt plaintext into ciphertext. [Creating]

CYB-23 Apply cryptographic hash functions for authentication and data integrity. [Applying]

Emerging Standard
Summarize the use of cryptographic hash functions for authentication and data integrity. [Understanding]
Developed Standard
Apply cryptographic hash functions for authentication and data integrity. [Applying]
Highly Developed Standard
Deconstruct a cryptographic hash function used for authentication and data integrity. [Analyzing]

CYB-24 Contrast symmetric and asymmetric encryption in relation to securing electronic communications and transactions. [Analyzing]

Emerging Standard
Exemplify the difference between symmetric and asymmetric encryption. [Understanding]
Developed Standard
Contrast symmetric and asymmetric encryption in relation to securing electronic communications and transactions. [Analyzing]
Highly Developed Standard
Design a security solution for a given scenario that integrates symmetric encryption with asymmetric encryption. [Creating]

CYB-25 Explain browser and web security model concepts including same-origin policy, web sessions, and secure communication channels. [Understanding]

Emerging Standard
Identify one or more browser and web security model concepts. [Remembering]
Developed Standard
Explain browser and web security model concepts including same-origin policy, web sessions, and secure communication channels such as TLS. [Understanding]
Highly Developed Standard
Apply browser and web security model concepts including same-origin policy, web sessions, and secure communication channels such as TLS. [Applying]

DS-01 Explain with examples the basic terminology of functions, relations, and sets. [Understanding]
Emerging Standard
Identify the defining features of functions, relations, and sets.[Remembering]
Developed Standard
Explain with examples the basic terminology of functions, relations, and sets.[Understanding]
Highly Developed Standard
Use function, relations, and set terminology in a correct and meaningful way.[Applying]

DS-02 Perform the operations associated with sets, functions, and relations. [Applying]
Emerging Standard
Describe the operations associated with sets, functions, and relations. [Understanding]
Developed Standard
Perform the operations associated with sets, functions, and relations. [Applying]
Highly Developed Standard
Compare the operations of sets, functions, and relations. [Analyzing]

DS-03 Compare practical examples to the appropriate set, function, or relation model, and interpret the associated operations and terminology in context. [Analyzing]
Emerging Standard
Implement a solution to a programming problem using a specific set, function, or relation model. [Applying]
Developed Standard
Compare practical examples to the appropriate set, function, or relation model, and interpret the associated operations and terminology in context. [Analyzing]
Highly Developed Standard
Justify the choice of a specific set, function, or relation model. [Evaluating]

DS-04 Convert logical statements from informal language to propositional and predicate logic expressions. [Understanding]
Emerging Standard
Recognize the relationship between logical statements from informal language and propositional and predicate logic expressions. [Remembering]
Developed Standard
Convert logical statements from informal language to propositional and predicate logic expressions.
[Understanding]
Highly Developed Standard
Produce propositional and predicate logic expressions from a given logical statement from an informal language. [Applying]

DS-05 Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems such as predicting the behavior of software or solving problems such as puzzles. [Applying]

Emerging Standard
Describe the steps in formal logic proofs and/or informal logical reasoning to solve real problems. [Understanding]
Developed Standard
Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems such as predicting the behavior of software or solving problems such as puzzles. [Applying]
Highly Developed Standard
Compare different logic proofs and informal logical reasoning to determine correct methods to solve real problems. [Analyzing]

DS-06 Use the rules of inference to construct proofs in propositional and predicate logic. [Applying]

Emerging Standard
Discuss the rules of inference to construct proofs in propositional and predicate logic. [Understanding]
Developed Standard
Use the rules of inference to construct proofs in propositional and predicate logic. [Applying]
Highly Developed Standard
Analyze the rules of inference to construct proofs in propositional and predicate logic. [Analyzing]

DS-07 Describe how symbolic logic can be used to model real-life situations or computer applications. [Understanding]

Emerging Standard
List ways that symbolic logic can be used to model real-life situations or computer applications. [Remembering]
Developed Standard
Describe how symbolic logic can be used to model real-life situations or computer applications, such as software analysis, database queries, and algorithms. [Understanding]
Highly Developed Standard
Use symbolic logic to model real-life situations or computer applications. [Applying]

DS-08 Apply formal methods of symbolic propositional and predicate logic, such as calculating validity of formulae and computing normal forms. [Applying]

Emerging Standard
Demonstrate formal methods of symbolic propositional and predicate logic. [Understanding]
Developed Standard
Apply formal methods of symbolic propositional and predicate logic, such as calculating validity of formulae
and computing normal forms. [Applying]

Highly Developed Standard
Distinguish between formal methods of propositional and predicate logic to determine the most effective solutions to a given problem. [Analyzing]

**DS-09 Describe the strengths and limitations of propositional and predicate logic. [Understanding]**

Emerging Standard
List the strengths and limitations of propositional and predicate logic. [Remembering]

Developed Standard
Describe the strengths and limitations of propositional and predicate logic. [Understanding]

Highly Developed Standard
Illustrate the strengths and limitations of propositional and predicate logic. [Applying]

**DS-10 Outline the basic structure of each proof technique, including direct proof, proof by contradiction, and induction. [Analyzing]**

Emerging Standard
Use the basic structure of each proof technique to solve a problem. [Applying]

Developed Standard
Outline the basic structure of each proof technique, including direct proof, proof by contradiction, and induction. [Analyzing]

Highly Developed Standard
Choose the most effective proof technique to solve a problem. [Evaluating]

**DS-11 Apply each of the proof techniques (direct proof, proof by contradiction, and induction) correctly in the construction of a sound argument. [Applying]**

Emerging Standard
Demonstrate each of the proof techniques by correctly constructing a sound argument. [Understanding]

Developed Standard
Apply each of the proof techniques (direct proof, proof by contradiction, and induction) correctly in the construction of a sound argument. [Applying]

Highly Developed Standard
Use each of the proof techniques correctly in the construction of a sound argument. [Applying]

**DS-12 Deduce the best type of proof for a given problem. [Analyzing]**

Emerging Standard
Compare the different proof methods. [Analyzing]

Developed Standard
Deduce the best type of proof for a given problem. [Analyzing]

Highly Developed Standard
Construct a correct proof using the best method for a given problem. [Creating]
DS-13 Explain the parallels between ideas of mathematical and/or structural induction to recursion and recursively defined structures. [Understanding]

Emerging Standard
Identify the parallels between ideas of mathematical and/or structural induction to recursion and recursively defined structures. [Remembering]
Developed Standard
Explain the parallels between ideas of mathematical and/or structural induction to recursion and recursively defined structures. [Understanding]
Highly Developed Standard
Illustrate the parallels between ideas of mathematical and/or structural induction to recursion and recursively defined structures. [Applying]

DS-14 Explain the relationship between weak and strong induction and give examples of the appropriate use of each. [Understanding]

Emerging Standard
Identify the relationship between weak and strong induction. [Remembering]
Developed Standard
Explain the relationship between weak and strong induction and give examples of the appropriate use of each. [Understanding]
Highly Developed Standard
Solve problems using both weak and strong induction. [Applying]

DS-15 Apply counting arguments, including sum and product rules, inclusion-exclusion principle and arithmetic/geometric progressions. [Applying]

Emerging Standard
Describe counting arguments. [Understanding]
Developed Standard
Apply counting arguments, including sum and product rules, inclusion-exclusion principle and arithmetic/geometric progressions. [Applying]
Highly Developed Standard
Outline counting arguments. [Analyzing]

DS-16 Apply the pigeonhole principle in the context of a formal proof. [Applying]

Emerging Standard
Demonstrate the pigeonhole principle. [Understanding]
Developed Standard
Apply the pigeonhole principle in the context of a formal proof. [Applying]
Highly Developed Standard
Analyze the pigeonhole principle in the context of a formal proof. [Analyzing]
DS-17 Calculate permutations and combinations of a set, and interpret the meaning in the context of the particular application. [Applying]

Emerging Standard
Explain the calculation of permutations and combinations of a set. [Understanding]

Developed Standard
Calculate permutations and combinations of a set, and interpret the meaning in the context of the particular application. [Applying]

Highly Developed Standard
Discriminate between computation of st permutations and combinations. [Analyzing]

DS-18 Compare real-world applications appropriate to counting formalisms. [Analyzing]

Emerging Standard
Use counting formalisms to solve real-world applications. [Applying]

Developed Standard
Compare real-world applications appropriate to counting formalisms, such as determining the number of ways to arrange people around a table, subject to constraints on the seating arrangement. [Analyzing]

Highly Developed Standard
Choose appropriate counting formalisms to solve real-world applications. [Evaluating]

DS-19 Solve a variety of basic recurrence relations. [Applying]

Emerging Standard
Demonstrate a variety of basic recurrence relations. [Understanding]

Developed Standard
Solve a variety of basic recurrence relations. [Applying]

Highly Developed Standard
Compare a variety of basic recurrence relations. [Analyzing]

DS-20 Analyze a problem to determine underlying recurrence relations. [Analyzing]

Emerging Standard
Carry out a problem with an underlying recurrence relation. [Applying]

Developed Standard
Analyze a problem to determine underlying recurrence relations. [Analyzing]

Highly Developed Standard
Evaluate a problem with an underlying recurrence relation. [Evaluating]

DS-21 Perform computations involving modular arithmetic. [Applying]

Emerging Standard
Discuss computations involving modular arithmetic. [Understanding]

Developed Standard
Perform computations involving modular arithmetic. [Applying]
Highly Developed Standard
Examine computations involving modular arithmetic. [Analyzing]

**DS-22** Illustrate the basic terminology of graph theory including properties and special cases for each type of graph/tree. [Applying]

Emerging Standard
Describe the basic terminology of graph theory. [Understanding]
Developed Standard
Illustrate the basic terminology of graph theory including properties and special cases for each type of graph/tree. [Applying]
Highly Developed Standard
Outline the basic terminology of graph theory. [Analyzing]

**DS-23** Demonstrate different traversal methods for trees and graphs, including pre-, post-, and in-order traversal of trees. [Understanding]

Emerging Standard
List the different traversal methods for trees and graphs [Remembering]
Developed Standard
Demonstrate different traversal methods for trees and graphs, including pre-, post-, and in-order traversal of trees. [Understanding]
Highly Developed Standard
Execute different traversal methods for trees and graphs. [Applying]

**DS-24** Solve a variety of real-world problems in computer science using appropriate forms of graphs and trees, such as representing a network topology or the organization of a hierarchical file system. [Applying]

Emerging Standard
Discuss a variety of real-world problems in computer science using appropriate forms of graphs and trees. [Understanding]
Developed Standard
Solve a variety of real-world problems in computer science using appropriate forms of graphs and trees, such as representing a network topology or the organization of a hierarchical file system. [Applying]
Highly Developed Standard
Distinguish between real-world problems solvable by using graphs and trees. [Analyzing]

**DS-25** Implement and use balanced trees and B-trees. [Applying]

Emerging Standard
Explain balanced trees and B-trees. [Understanding]
Developed Standard
Implement and use balanced trees and B-trees. [Applying]
Highly Developed Standard
Analyze the use of balanced trees and B-trees. [Analyzing]

**DS-26 Implement graph algorithms. [Applying]**

Emerging Standard
Classify graph algorithms. [Understanding]

Developed Standard
Implement graph algorithms, such as graph search, union-find, minimum spanning trees, and shortest paths. [Applying]

Highly Developed Standard
Categorize different implementations of graph algorithms. [Analyzing]

**DS-27 Demonstrate how concepts from graphs and trees appear in data structures, algorithms, proof techniques (structural induction), and counting. [Understanding]**

Emerging Standard
Identify how concepts from graphs and trees appear in data structures, algorithms, proof techniques, and counting. [Remembering]

Developed Standard
Demonstrate how concepts from graphs and trees appear in data structures, algorithms, proof techniques (structural induction), and counting. [Understanding]

Highly Developed Standard
Implement data structures, algorithms, proof techniques, and counting using graphs and trees. [Applying]

**DS-28 Describe binary search trees and AVL trees. [Understanding]**

Emerging Standard
Define binary search and AVL trees. [Remembering]

Developed Standard
Describe binary search trees and AVL trees. [Understanding]

Highly Developed Standard
Apply binary search and AVL trees. [Applying]

**DS-29 Explain complexity in the ideal and in the worst-case scenario for both implementations. [Understanding]**

Emerging Standard
State complexity in the ideal and in the worst-case scenario for both implementations. [Remembering]

Developed Standard
Explain complexity in the ideal and in the worst-case scenario for both implementations. [Understanding]

Highly Developed Standard
Calculate complexity in the ideal and in the worst-case scenario for both implementations. [Applying]
DS-30 Calculate probabilities of events and expectations of random variables for elementary problems. [Applying]

Emerging Standard
Exemplify probabilities of events and expectations of random variables for elementary problems such as games of chance. [Understanding] v
Developed Standard
Calculate probabilities of events and expectations of random variables for elementary problems such as games of chance. [Applying]
Highly Developed Standard
Examine probabilities of events and expectations of random variables for elementary problems such as games of chance. [Analyzing]

DS-31 Differentiate between dependent and independent events. [Understanding]

Emerging Standard
Identify dependent and independent events. [Remembering]
Developed Standard
Differentiate between dependent and independent events. [Understanding]
Highly Developed Standard
Illustrate dependent and independent events. [Applying]

DS-32 Explain the significance of binomial distribution in probabilities. [Understanding]

Emerging Standard
Recognize the notation and parameters that a binomial distribution has. [Remembering]
Developed Standard
Explain the significance of binomial distribution in probabilities. [Understanding]
Highly Developed Standard
Calculate the probabilities from a binomial distribution. [Applying]

DS-33 Apply Bayes Theorem to determine conditional probabilities in a problem. [Applying]

Emerging Standard
Explain Bayes Theorem to determine conditional probabilities in a problem. [Understanding]
Developed Standard
Apply Bayes Theorem to determine conditional probabilities in a problem. [Applying]
Highly Developed Standard
Outline Bayes Theorem to determine conditional probabilities in a problem. [Analyzing]

DS-34 Apply the tools of probability to solve problems. [Applying]

Emerging Standard
Discuss the tools of probability to solve problems such as the average case analysis of algorithms or analyzing
hashing. [Understanding]
Developed Standard
Apply the tools of probability to solve problems such as the average case analysis of algorithms or analyzing hashing. [Applying]
Highly Developed Standard
Analyze the tools of probability in solving problems such as the average case analysis of algorithms or analyzing hashing. [Analyzing]

**GV-01 Compare transformation and changes in dimension and coordinate systems for 2D and 3D design.** [Analyzing]

Emerging Standard
Explain how to use dimensions and coordinate systems. [Understanding]
Developed Standard
Compare transformation and changes in dimension and coordinate systems for 2D and 3D design. [Analyzing]
Highly Developed Standard
Evaluate the uses of both 3D coordinate systems and 2D planar systems with respect to computer graphics. [Evaluating]

**GV-02 Demonstrate common uses of digital presentation to human senses.** [Understanding]

Emerging Standard
Identify common uses of digital presentation to human senses. [Remembering]
Developed Standard
Demonstrate common uses of digital presentation to human senses, such as computer graphics, sound, and haptic devices. [Understanding]
Highly Developed Standard
Categorize types of digital presentation to human senses. [Analyzing]

**GV-03 Illustrate color models and their use in computer graphics.** [Applying]

Emerging Standard
Describe color models and their use in computer graphics. [Understanding]
Developed Standard
Illustrate color models and their use in computer graphics. [Applying]
Highly Developed Standard
Contrast color models and their use in computer graphics. [Analyzing]

**GV-04 Analyze image types according to output choices.** [Analyzing]

Emerging Standard
Differentiate multimedia file types, resolution needs, conversion, and appropriate use. [Understanding]
Developed Standard
Analyze image types according to output choices. [Analyzing]
Highly Developed Standard
Evaluate multiple multimedia files based on given criteria. [Evaluating]

**GV-05 Perform information hiding through steganography in images, messages, videos, or other media files. [Applying]**

Emerging Standard
Demonstrate information hiding through steganography. [Understanding]
Developed Standard
Perform information hiding through steganography in images, messages, videos, or other media files. [Applying]
Highly Developed Standard
Choose appropriate steganography technique to conceal information. [Evaluating]

**HCI-01 Analyze the importance of human-centered software. [Analyzing]**

Emerging Standard
Discuss the importance of human-centered software development. [Understanding]
Developed Standard
Analyze the importance of human-centered software. [Analyzing]
Highly Developed Standard
Defend the importance of human-centered software. [Evaluating]

**HCI-02 Implement a simple usability test for an existing software application. [Applying]**

Emerging Standard
Summarize usability testing. [Understanding]
Developed Standard
Implement a simple usability test for an existing software application. [Applying]
Highly Developed Standard
Design a usability test for an existing software application [Creating]

**HCI-03 Examine the issues of trust in HCI, including examples of both high and low trust systems. [Analyzing]**

Emerging Standard
Demonstrate design elements that make a human-computer interface trustworthy. [Understanding]
Developed Standard
Examine the issues of trust in HCI, including examples of both high and low trust systems. [Analyzing]
Highly Developed Standard
Critique interface designs between high trust and low trust. [Evaluating]

**HCI-04 Write a simple application that uses a modern graphical user interface. [Applying]**

Emerging Standard
Summarize the components of a modern graphical user interface. [Understanding]
Developed Standard
Write a simple application that uses a modern graphical user interface. [Applying]
Highly Developed Standard
Examine a complete application that uses a modern graphical interface and documentation. [Analyzing]

**HCI-05 Use at least one national or international user interface design standard in a simple application.**
[Applying] See also SP-02.

Emerging Standard
Identify national and international user interface design standards. [Remembering]
Developed Standard
Use at least one national or international user interface design standard in a simple application, such as U.S. ADA Standards. [Applying]
Highly Developed Standard
Compare among national and international user interface design standards. [Analyzing]

**HCI-06 Analyze the interaction between a security mechanism and its usability.** [Analyzing]

Emerging Standard
Discuss potential usability issues related to a security mechanism. [Understanding]
Developed Standard
Analyze the interaction between a security mechanism and its usability. [Analyzing]
Highly Developed Standard
Design a user interface that balances the tradeoffs between usability and security. [Creating]

**IM-01 Contrast the difference between information and data.** [Analyzing]

Emerging Standard
Explain information and data. [Understanding]
Developed Standard
Contrast the difference between information and data. [Analyzing]
Highly Developed Standard
Critique the attributes of both information and data. [Evaluating]

**IM-02 Describe the advantages and disadvantages of central organizational control over data.**
[Understanding]

Emerging Standard
List some advantages and disadvantages of central organizational control over data. [Remembering]
Developed Standard
Describe the advantages and disadvantages of central organizational control over data. [Understanding]
Highly Developed Standard
Examine the advantages and disadvantages of central organizational control over data. [Analyzing]
IM-03 Investigate contingency planning with respect to business continuity, disaster recovery and incident response. [Applying]

Emerging Standard
Describe contingency planning with respect to business continuity, disaster recovery and incident response. [Understanding]

Developed Standard
Investigate contingency planning with respect to business continuity, disaster recovery and incident response. [Applying]

Highly Developed Standard
Compare contingency plans of various size organizations with respect to business continuity, disaster recovery and incident response. [Analyzing]

IM-04 Describe proven techniques to secure data and information. [Understanding]

Emerging Standard
List proven techniques used to secure data and information. [Remembering]

Developed Standard
Describe proven techniques to secure data and information. [Understanding]

Highly Developed Standard
Implement specific proven techniques to secure data and information. [Applying]

IM-05 Describe approaches to scale up information systems. [Understanding]

Emerging Standard
List approaches to scale up information systems. [Remembering]

Developed Standard
Describe approaches to scale up information systems. [Understanding]

Highly Developed Standard
Compare several approaches to scale up information systems. [Analyzing]

IM-06 Explain the characteristics that distinguish the database approach from the approach of programming with data files. [Understanding]

Emerging Standard
Identify the characteristics that distinguish the database approach from the approach of programming with data files. [Remembering]

Developed Standard
Explain the characteristics that distinguish the database approach from the approach of programming with data files. [Understanding]

Highly Developed Standard
Contrast the characteristics that distinguish the database approach from the approach of programming with data files. [Analyzing]
IM-07 Diagram the components of a database system and give examples of their use. [Applying]

Emerging Standard
Identify the components of a database system. [Remembering]
Developed Standard
Diagram the components of a database system and give examples of their use. [Applying]
Highly Developed Standard
Organize the components of a database system into a secure, functioning system. [Analyzing]

IM-08 Explain the concept of data independence and its importance in a database system. [Understanding]

Emerging Standard
Define the concept of data independence and its importance in a database system. [Remembering]
Developed Standard
Explain the concept of data independence and its importance in a database system. [Understanding]
Highly Developed Standard
Examine the concept of data independence and its importance in a database system. [Analyzing]

IM-09 Formulate queries in SQL or a similar query language to elicit information from a database. [Creating]

Emerging Standard
Edit queries in SQL or a similar query language to elicit information from a database. [Applying]
Developed Standard
Formulate queries in SQL or a similar query language to elicit information from a database. [Creating]
Highly Developed Standard
Formulate complex queries in SQL or a similar query language to elicit information from a database. [Creating]

IM-10 Investigate vulnerabilities and failure scenarios in database systems. [Applying]

Emerging Standard
Identify vulnerabilities and failure scenarios in information systems. [Remembering]
Developed Standard
Investigate vulnerabilities and failure scenarios in database systems, such as SQL injection and cross-site scripting. [Applying]
Highly Developed Standard
Examine vulnerabilities and failure scenarios in information systems. [Analyzing]

IM-11 Contrast appropriate data models, including internal structures for different data types. [Analyzing]
Emerging Standard
Diagram appropriate data models, including internal structures for different data types. [Applying]

Developed Standard
Contrast appropriate data models, including internal structures for different data types. [Analyzing]

Highly Developed Standard
Evaluate appropriate data models, including internal structures for different data types. [Evaluating]

**IM-12** Diagram a relational data model for a given scenario that addresses security and privacy concerns. [Applying]

Emerging Standard
Describe a relational data model for a given scenario that addresses security and privacy concerns. [Understanding]

Developed Standard
Diagram a relational data model for a given scenario that addresses security and privacy concerns. [Applying]

Highly Developed Standard
Analyze a relational data model for a given scenario that addresses security and privacy concerns. [Analyzing]

**IM-13** Describe the differences among relational data models and other models. [Understanding]

Emerging Standard
Recognize the differences among relational data models and other models. [Remembering]

Developed Standard
Describe the differences among relational data models and other models such as Object-Oriented, JSON, NoSQL. [Understanding]

Highly Developed Standard
Analyze the differences among relational data models and other models. [Analyzing]

**NC-01** Diagram the basic structure of the Internet. [Applying]

Emerging Standard
Explain the basic structure of the Internet. [Understanding]

Developed Standard
Diagram the basic structure of the Internet. [Applying]

Highly Developed Standard
Analyze the basic structure of the internet. [Analyzing]

**NC-02** Describe the layered structure of a typical networked architecture, including routing and switching. [Understanding]

Emerging Standard
Label the components of a typical networked architecture. [Remembering]
Developed Standard
Describe the layered structure of a typical networked architecture, including routing and switching. [Understanding]

Highly Developed Standard
Diagram the layered structure of a typical networked architecture. [Applying]

NC-03 Diagram the layers of the OSI model, including associated protocols. [Applying]

Emerging Standard
Describe the layers of the OSI model. [Understanding]

Developed Standard
Diagram the layers of the OSI model, including associated protocols. [Applying]

Highly Developed Standard
Compare the layers of the OSI model with the TCP/IP model. [Analyzing]

NC-04 Categorize the principles used for naming schemes and resource location.[Analyzing]

Emerging Standard
Summarize principles used for naming schemes and resource location. [Understanding]

Developed Standard
Categorize the principles used for naming schemes and resource location. [Analyzing]

Highly Developed Standard
Evaluate the principles used for naming schemes and resource location. [Evaluating]

NC-05 Implement a simple distributed network application. [Applying]

Emerging Standard
Identify the components of a simple distributed network application. [Remembering]

Developed Standard
Implement a simple distributed network application. [Applying]

Highly Developed Standard
Integrate a simple distributed network application within a server program to exchange data with a client. [Analyzing]

NC-06 Describe security concerns in designing applications for use over wireless networks. [Understanding]

Emerging Standard
Recognize security concerns in designing applications for use over wireless networks. [Remembering]

Developed Standard
Describe security concerns in designing applications for use over wireless networks. [Understanding]

Highly Developed Standard
Illustrate security concerns in designing applications for use over wireless networks. [Applying]
NC-07 Illustrate secure connectivity among networked applications. [Applying]

Emerging Standard
Explain secure connectivity among networked applications. [Understanding]
Developed Standard
Illustrate secure connectivity among networked applications, such as SSH, HTTPS, SFTP. [Applying]
Highly Developed Standard
Critique secure connectivity among networked applications. [Evaluating]

NC-08 Explain the advantages and disadvantages of using virtualized infrastructure in cloud computing. [Understanding] See also PD-05

Emerging Standard
List the advantages and disadvantages of using virtualized infrastructure in cloud computing. [Remembering]
Developed Standard
Explain the advantages and disadvantages of using virtualized infrastructure in cloud computing. [Understanding]
Highly Developed Standard
Investigate the advantages and disadvantages of using virtualized infrastructure in cloud computing. [Applying]

OS-01 Examine major objectives, functions, features, and concepts of modern operating systems. [Analyzing]

Emerging Standard
Describe objectives, functions, features, and concepts of modern operating systems. [Understanding]
Developed Standard
Examine major objectives, functions, features, and concepts of modern operating systems. [Analyzing]
Highly Developed Standard
Assess major objectives, functions, and concepts of modern operating systems. [Evaluating]

OS-02 Compare prevailing types of operating systems. [Analyzing]

Emerging Standard
Investigate prevailing types of operating systems. [Applying]
Developed Standard
Compare prevailing types of operating systems, such as networked, mobile, embedded, and real-time. [Analyzing]
Highly Developed Standard
Assess prevailing types of operating systems. [Evaluating]

OS-03 Illustrate potential threats to operating systems and appropriate security measures. [Applying]
Emerging Standard
Describe potential threats to operating systems and appropriate security measures. [Understanding]

Developed Standard
Illustrate potential threats to operating systems and appropriate security countermeasures. [Applying]

Highly Developed Standard
Examine potential threats to operating systems and appropriate security countermeasures. [Analyzing]

OS-04 Diagram the interaction of an Application Programming Interface (API) with an operating system. [Applying]

Emerging Standard
Summarize the interaction of an Application Programming Interface (API) with an operating system. [Understanding]

Developed Standard
Diagram the interaction of an Application Programming Interface (API) with an operating system. [Applying]

Highly Developed Standard
Test the interaction of an Application Programming Interface (API) with an operating system. [Evaluating]

OS-05 Illustrate how computing resources are used by applications and managed by the operating system. [Applying]

Emerging Standard
Exemplify how computing resources are used by applications and managed by the operating system. [Understanding]

Developed Standard
Illustrate how computing resources are used by applications and managed by the operating system. [Applying]

Highly Developed Standard
Test how computing resources are used by applications and managed by the operating system. [Evaluating]

OS-06 Manipulate a device list or driver I/O queue. [Applying]

Emerging Standard
Explain the purpose of a device list and driver I/O queue. [Understanding]

Developed Standard
Manipulate a device list or driver I/O queue. [Applying]

Highly Developed Standard
Categorize device types of a modern operating system. [Analyzing]

OS-07 Investigate the need for concurrency within an operating system. [Applying] See also PD-01.

Emerging Standard
Describe the need for concurrency within an operating system. [Understanding]

Developed Standard
Investigate the need for concurrency within an operating system. [Applying]

Highly Developed Standard
Analyze the need for concurrency within an operating system. [Analyzing]

**OS-08 Illustrate the principles of memory management. [Applying]**

Emerging Standard
Describe the principles of memory management. [Understanding]

Developed Standard
Illustrate the principles of memory management, such as memory hierarchy and allocation, tradeoffs, and caching. [Applying]

Highly Developed Standard
Analyze the principles of memory management. [Analyzing]

**OS-09 Illustrate the concepts of virtual memory, including paging, thrashing, and partitioning. [Applying]**

Emerging Standard
Describe the concepts of virtual memory, including paging, thrashing, and partitioning [Understanding]

Developed Standard
Illustrate the concepts of virtual memory, including paging, thrashing, and partitioning. [Applying]

Highly Developed Standard
Examine the concepts of virtual memory, including paging, thrashing, and partitioning [Analyzing]

**OS-10 Investigate the features and limitations of an operating system used to provide protection and security. [Applying]**

Emerging Standard
Explain the features and limitation of an operating system used to provide protection and security. [Understanding]

Developed Standard
Investigate the features and limitation of an operating system used to provide protection and security. [Applying]

Highly Developed Standard
Examine the features and limitation of an operating system used to provide protection and security. [Analyzing]

**OS-11 Use mechanisms available in an operating system to control access to resources. [Applying]**

Emerging Standard
Summarize the mechanisms available in an operating system to control access to resources. [Understanding]

Developed Standard
Use the mechanisms available in an operating system to control access to resources. [Applying]

Highly Developed Standard
Test the mechanisms available in an operating system to control access to resources. [Evaluating]
OS-12 Analyze the concept of virtualization with respect to hardware and software. [Analyzing]

Emerging Standard
Investigate the concept of virtualization with respect to hardware and software. [Applying]

Developed Standard
Analyze the concept of virtualization with respect to hardware and software. [Analyzing]

Highly Developed Standard
Assess a given implementation of virtualization with respect to hardware and software. [Evaluating]

OS-13 Diagram the physical hardware devices and the virtual devices maintained by an operating system. [Applying]

Emerging Standard
Explain the relationship between the physical hardware devices and virtual devices maintained by an operating system. [Understanding]

Developed Standard
Diagram the physical hardware devices and the virtual devices maintained by an operating system. [Applying]

Highly Developed Standard
Distinguish between the physical hardware devices and virtual devices used by an operating system for a given implementation of virtualization. [Analyzing]

PD-01 Analyze the goals of parallelism and concurrency. [Analyzing] See also OS-07 and SF-08.

Emerging Standard
Differentiate the goal of parallelism, such as throughput, from the goal of concurrency, such as controlling access to shared resources. [Understanding]

Developed Standard
Analyze the goals of parallelism and concurrency. [Analyzing]

Highly Developed Standard
Evaluate the performance of a given program that was implemented using parallelism and concurrency techniques. [Evaluating]

PD-02 Implement various programming constructs for synchronization. [Applying]

Emerging Standard
Summarize various programming constructs for synchronization. [Understanding]

Developed Standard
Implement various programming constructs for synchronization. [Applying]

Highly Developed Standard
Integrate synchronization routines/techniques into a non-synchronized programming constructs. [Analyzing]

PD-03 Contrast low-level data races with higher level races. [Analyzing]

Emerging Standard
Differentiate low-level data races from higher level races. [Understanding]
Developed Standard
Contrast low-level data races with higher level races. [Analyzing]
Highly Developed Standard
Create a low-level data race among two concurrent threads. [Creating]

PD-04 Implement mutual exclusion in order to avoid race conditions that could cause security vulnerabilities. [Applying]

Emerging Standard
Explain mutual exclusion in order to avoid race conditions. [Understanding]
Developed Standard
Implement mutual exclusion in order to avoid race conditions that could cause security vulnerabilities. [Applying]
Highly Developed Standard
Categorize critical and noncritical race conditions. [Analyzing]

PD-05 Investigate the challenges and concerns related to security and privacy in Cloud computing. [Applying] See also NC-08.

Emerging Standard
Describe the challenges and concerns related to security and privacy in Cloud computing. [Understanding]
Developed Standard
Investigate the challenges and concerns related to security and privacy in Cloud computing. [Applying]
Highly Developed Standard
Examine the challenges and concerns related to security and privacy in Cloud computing. [Analyzing]

PL-01 Design a simple class hierarchy using superclasses, subclasses, and abstract classes. [Creating]

Emerging Standard
Implement a simple class hierarchy using superclasses, subclasses, and abstract classes. [Applying]
Developed Standard
Design a simple class hierarchy using superclasses, subclasses, and abstract classes. [Creating]
Highly Developed Standard
Develop a complex class hierarchy using superclasses, subclasses, and abstract classes. [Creating]

PL-02 Diagram control flow in a program using dynamic dispatch. [Applying]

Emerging Standard
Demonstrate control flow that uses dynamic dispatch. [Understanding]
Developed Standard
Diagram control flow in a program using dynamic dispatch. [Applying]
Highly Developed Standard
Contrast control flow that uses a static environment vs a dynamic environment. [Analyzing]
PL-03 Use access and visibility modifiers to secure class data and methods. [Applying]

Emerging Standard
Describe access modifiers to secure class data such as private and protected. [Understanding]

Developed Standard
Use access and visibility modifiers to secure class data and methods, such as private and protected. [Applying]

Highly Developed Standard
Analyze the security effect of using access and visibility modifiers in code. [Analyzing]

PL-04 Implement in code OOP constructs, including encapsulation, abstraction, inheritance, and polymorphism. [Applying]

Emerging Standard
Demonstrate the tenets of OOP, including encapsulation, abstraction, inheritance, and polymorphism. [Understanding]

Developed Standard
Implement in code OOP constructs, including encapsulation, abstraction, inheritance, and polymorphism. [Applying]

Highly Developed Standard
Create a program that utilizes OOP constructs, including encapsulation, abstraction, inheritance, and polymorphism. [Analyzing]

PL-05 Implement algorithms which utilize immutable and mutable variables. [Applying]

Emerging Standard
Discuss how functional languages handle both immutable and mutable variables. [Understanding]

Developed Standard
Implement algorithms which utilize immutable and mutable variables. [Applying]

Highly Developed Standard
Evaluate the efficiency of different algorithms which utilize immutable vs mutable variables. [Evaluating]

PL-06 Contrast functional and object-oriented programming paradigms. [Analyzing]

Emerging Standard
Explain major differences between functional and object-oriented programming paradigms. [Understanding]

Developed Standard
Contrast functional and object-oriented programming paradigms. [Analyzing]

Highly Developed Standard
Appraise functional and object-oriented programming paradigms. [Evaluating]

PL-07 Create an interactive program using an event-driven style. [Creating]

Emerging Standard
Describe advantages of having an event-driven programming style vs a pre-defined programming style.
Understanding Developed Standard
Create an interactive program using an event-driven style. [Creating]
Highly Developed Standard
Create a complex program using an event-driven style. [Creating]

PL-08 Describe potential security vulnerabilities in event-driven GUI applications. [Understanding]
Emerging Standard
Identify potential security vulnerabilities in event-driven GUI applications. [Remembering]
Developed Standard
Describe potential security vulnerabilities in event-driven GUI applications, such as injection-based attacks. [Understanding]
Highly Developed Standard
Illustrate potential security vulnerabilities in event-driven GUI applications. [Applying]

PL-09 Investigate potential errors detected from both strong-type and weak-type languages. [Applying]
Emerging Standard
Summarize possible errors detected from both strong-type and weak-type languages. [Understanding]
Developed Standard
Investigate possible errors detected from both strong-type and weak-type languages. [Applying]
Highly Developed Standard
Discriminate among errors detected from strong-type and from weak-type languages. [Analyzing]

PL-10 Explain the security implications of a type-safe language for software development. [Understanding]
Emerging Standard
Recognize the security implications of a type-safe language for software development. [Remembering]
Developed Standard
Explain the security implications of a type-safe language for software development. [Understanding]
Highly Developed Standard
Examine the security advantages and disadvantages of a type-safe language for software development. [Analyzing]

SDF-01 Design an algorithm in a programming language to solve a simple problem. [Creating]
Emerging Standard
Implement an algorithm in a programming language to solve a simple problem. [Applying]
Developed Standard
Design an algorithm in a programming language to solve a simple problem. [Creating]
Highly Developed Standard
Design an algorithm in a programming language to solve a complex problem. [Creating]
SDF-02 Use the techniques of decomposition to modularize a program. [Applying]

Emerging Standard
Explain program decomposition. [Understanding]

Developed Standard
Use the techniques of decomposition to modularize a program. [Applying]

Highly Developed Standard
Analyze code to see how decomposition techniques were used. [Analyzing]

SDF-03 Compare multiple algorithms for a given problem. [Analyzing]

Emerging Standard
Investigate multiple algorithms for a given problem. [Applying]

Developed Standard
Compare multiple algorithms for a given problem. [Analyzing]

Highly Developed Standard
Evaluate the strengths and weaknesses of multiple algorithms for a problem. [Evaluating]

SDF-04 Create simple programs that use abstract data types (ADTs). [Creating]

Emerging Standard
Implement simple programs that use abstract data types (ADTs). [Applying]

Developed Standard
Create simple programs that use abstract data types (ADTs). [Creating]

Highly Developed Standard
Write complex programs that use abstract data types (ADTs). [Creating]

SDF-05 Investigate potential vulnerabilities in provided programming code. [Applying] See also AL-16, CYB-28, PL-10, SDF-12.

Emerging Standard
Summarize potential vulnerabilities in programming code. [Understanding]

Developed Standard
Investigate potential vulnerabilities in provided programming code. [Applying]

Highly Developed Standard
Choose a solution to mitigate vulnerabilities in programming code. [Evaluating]

SDF-06 Create programs which use defensive programming techniques, including input validation, type checking, and protection against buffer overflow. [Creating] See also CYB-15.

Emerging Standard
Investigate defensive programming techniques. [Applying]

Developed Standard
Create programs which use defensive programming techniques, including input validation, type checking, and
protection against buffer overflow. [Creating]
Highly Developed Standard
Create complex programs which use defensive programming techniques, including input validation, type checking, and protection against buffer overflow. [Creating]

SDF-07 Create code in a programming language that includes primitive data types, references, variables, expressions, assignments, I/O, control structures, and functions. [Creating]

Emerging Standard
Implement code in a programming language that includes primitive data types, references, variables, expressions, assignments, I/O, control structures, and functions. [Applying]
Developed Standard
Create code in a programming language that includes primitive data types, references, variables, expressions, assignments, I/O, control structures, and functions. [Creating]
Highly Developed Standard
Create complex programs that include primitive data types, references, variables, expressions, assignments, I/O, control structures, and functions. [Creating]

SDF-08 Create a simple program that uses persistence to save data across multiple executions. [Creating]

Emerging Standard
Implement a simple program that uses persistence to save data across multiple executions. [Applying]
Developed Standard
Create a simple program that uses persistence to save data across multiple executions. [Creating]
Highly Developed Standard
Create a complex program that uses persistence to save data across multiple executions. [Creating]

SDF-09 Create a simple program that uses recursion. [Creating]

Emerging Standard
Implement a simple program that uses recursion. [Applying]
Developed Standard
Create a simple program that uses recursion. [Creating]
Highly Developed Standard
Develop a complex program that includes various types of recursive techniques, such as binary, tail, and natural recursion. [Creating]

SDF-10 Create simple programs that include each of the following data structures: lists, stacks, queues, hash tables, graphs and trees. [Creating]

Emerging Standard
Implement programs that include each of the following data structures: lists, stacks, queues, hash tables, graphs and trees. [Applying]
Developed Standard
Create simple programs that include each of the following data structures: lists, stacks, queues, hash tables,
graphs and trees. [Creating]
Highly Developed Standard
Create complex programs that include each of the following data structures: lists, stacks, queues, hash tables, graphs and trees. [Creating]

SDF-11 Compare the efficiency of basic operations across various data structures. [Analyzing]

Emerging Standard
Investigate the efficiency of basic operations across various data structures. [Applying]
Developed Standard
Compare the efficiency of basic operations, such as insertion and deletion, across various data structures. [Analyzing]
Highly Developed Standard
Critique the efficiency of basic operations across various data structures. [Evaluating]

SDF-12 Investigate common coding errors that introduce security vulnerabilities. [Applying]

Emerging Standard
Describe common coding errors that expose security vulnerabilities. [Understanding]
Developed Standard
Investigate common coding errors that introduce security vulnerabilities, such as buffer overflows, integer errors, and memory leaks. [Applying]
Highly Developed Standard
Test for common coding errors that introduce security vulnerabilities and the associated techniques for securing the code. [Evaluating]

SDF-13 Implement refactoring within given program components. [Applying]

Emerging Standard
Recognize refactoring opportunities within given program components. [Remembering]
Developed Standard
Implement refactoring within given program components. [Applying]
Highly Developed Standard
Create program components utilizing refactoring. [Applying]

SDF-14 Analyze programming code that utilizes preconditions, postconditions, and invariants. [Analyzing]

Emerging Standard
Describe programming by contract. [Understanding]
Developed Standard
Analyze programming code that utilizes preconditions, postconditions, and invariants. [Analyzing]
Highly Developed Standard
Create a program utilizing preconditions, postconditions, and invariants. [Creating]
SDF-15 Apply a variety of strategies to test and debug programs. [Applying]

Emerging Standard
Explain strategies to test and debug programs. [Understanding]

Developed Standard
Apply a variety of strategies to test and debug programs, such as unit testing and test-case generation. [Applying]

Highly Developed Standard
Analyze a variety of strategies to test and debug programs. [Analyzing]

SDF-16 Use an integrated development environment (IDE) to create, execute, test, and debug secure programs. [Applying]

Emerging Standard
Discuss the benefits of using an integrated development environment (IDE) to create, execute, test, and debug secure programs. [Understanding]

Developed Standard
Use an integrated development environment (IDE) to create, execute, test, and debug secure programs. [Applying]

Highly Developed Standard
Compare integrated development environments (IDEs) for a given programming language. [Analyzing]

SDF-17 Use standard libraries for a given programming language. [Applying]

Emerging Standard
Describe standard libraries for a given programming language. [Understanding]

Developed Standard
Use standard libraries for a given programming language. [Applying]

Highly Developed Standard
Choose appropriate components from standard libraries to solve a given problem. [Evaluating]

SDF-18 Apply consistent documentation and program style standards. [Applying]

Emerging Standard
Explain the reasons for using consistent documentation and program style standards. [Understanding]

Developed Standard
Apply consistent documentation and program style standards. [Applying]

Highly Developed Standard
Assess documentation and program style in a given program. [Evaluating]

SDF-19 Carry out a code review on a program component using a provided security checklist. [Applying]
Emerging Standard
Explain the process of a code review. [Understanding]

Developed Standard
Carry out a code review on a program component using a provided security checklist. [Applying]

Highly Developed Standard
Organize a team code review on a program component using a provided security checklist. [Analyzing]

**SE-01 Diagram how software interacts with various systems, including information management, embedded, process control, and communications systems.** [Applying]

Emerging Standard
Describe how software interacts with various systems including information management, embedded, process control, and communications systems. [Understanding]

Developed Standard
Diagram how software interacts with various systems, including information management, embedded, process control, and communications systems. [Applying]

Highly Developed Standard
Assess how software interacts with various systems, including information management, embedded, process control, and communications systems. [Evaluating]

**SE-02 Compare the features of various process models.** [Analyzing]

Emerging Standard
Describe the features of a process model. [Understanding]

Developed Standard
Compare the features of various process models, such as waterfall, iterative, and agile. [Analyzing]

Highly Developed Standard
Critique various process models. [Evaluating]

**SE-03 Diagram the phases of the secure software development lifecycle (SecSDLC).** [Applying]

Emerging Standard
Exemplify the phases the software development lifecycle (SecSDLC). [Understanding]

Developed Standard
Diagram the phases of the secure software development lifecycle (SecSDLC). [Applying]

Highly Developed Standard
Examine the phases of the secure software development lifecycle (SecSDLC). [Analyzing]

**SE-04 Illustrate common behaviors that contribute to the effective functioning of a team.** [Applying]

Emerging Standard
Describe common behaviors that contribute to the effective functioning of a team. [Understanding]
Developed Standard
Illustrate common behaviors that contribute to the effective functioning of a team, such as good communication skills. [Applying]

Highly Developed Standard
Examine common behaviors that contribute to the effective functioning of a team. [Analyzing]

**SE-05 Investigate the risks in using third-party applications, software tools, and libraries.** [Applying]

Emerging Standard
Explain the risks in using third-party code. [Understanding]

Developed Standard
Investigate the risks in using third-party applications, software tools, and libraries. [Applying]

Highly Developed Standard
Evaluate the risks in using third-party applications, software tools, and libraries. [Evaluating]

**SE-06 Use a set of development tools for software systems.** [Applying]

Emerging Standard
Summarize a set of development tools for software systems. [Understanding]

Developed Standard
Use a set of development tools for software systems, such as requirements tracking, modeling, version control, automation, and testing. [Applying]

Highly Developed Standard
Choose a set of development tools for software systems. [Evaluating]

**SE-07 Implement the requirements for a secure software system.** [Applying]

Emerging Standard
Paraphrase the requirements for a key feature for a secure software system. Understanding]

Developed Standard
Implement the requirements for a secure software system. [Applying]

Highly Developed Standard
Develop the requirements for a secure software system. [Creating]

**SE-08 Illustrate principles of secure software design** [Applying]

Emerging Standard
Describe different software design principles. [Understanding]

Developed Standard
Illustrate principles of secure software design, such as least privilege, simplicity, separation of concerns, information hiding, coupling and cohesion, and code reuse. [Applying]

Highly Developed Standard
Create a program that employs secure software design principles. [Creating]
SE-09 Analyze an existing software design to improve its security. [Analyzing]

Emerging Standard
Identify possible stages of software design that may introduce a security vulnerability. [Remembering]

Developed Standard
Analyze an existing software design to improve its security. [Analyzing]

Highly Developed Standard
Debate whether a proposed solution/patch to the design can fix the vulnerability in a viable and effective way. [Evaluating]

SE-10 Describe the cost and tradeoffs associated with designing security into software. [Understanding]

Emerging Standard
Recognize situations where security designs are effectively applied in software. [Remembering]

Developed Standard
Describe the cost and tradeoffs associated with designing security into software. [Understanding]

Highly Developed Standard
Compare security software designs and associated costs and tradeoffs. [Analyzing]

SE-11 Implement a small software project that uses a defined coding standard. [Applying]

Emerging Standard
Demonstrate a defined coding standard in a small software project. [Understanding]

Developed Standard
Implement a small software project that uses a defined coding standard. [Applying]

Highly Developed Standard
Justify the reason for using a given coding standard. [Evaluating]

SE-12 Differentiate between program validation and verification. [Understanding]

Emerging Standard
Define software engineering terms verification and validation. [Remembering]

Developed Standard
Differentiate between program validation and verification. [Understanding]

Highly Developed Standard
Apply software validation and verification for a given piece of code. [Applying]

SE-13 Implement in code different types of testing, including security, unit testing, system testing, integration testing, and interface usability. [Applying]

Emerging Standard
Describe different types and levels of testing. [Understanding]

Developed Standard
Implement in code different types of testing, including security, unit testing, system testing, integration testing,
and interface usability. [Applying]
Highly Developed Standard
Examine different types of testing for given code. [Analyzing]

**SE-14 Design a test plan that validates software security. [Creating]**

Emerging Standard
Implement a given test plan that validates software security. [Applying]
Developed Standard
Design a test plan that validates software security. [Creating]
Highly Developed Standard
Develop a test plan that validates software security. [Creating]

**SF-01 Illustrate the basic building blocks of computers and their role in the historical development of computer architecture. [Applying]**

Emerging Standard
Describe some of the basic building blocks of computers. [Understanding]
Developed Standard
Illustrate the basic building blocks of computers and their role in the historical development of computer architecture. [Applying]
Highly Developed Standard
Outline the basic building blocks of computers and their role in the historical development of computer architecture. [Analyzing]

**SF-02 Discuss the differences between single thread and multiple thread, as well as single server and multiple server models. [Understanding]**

Emerging Standard
Identify some differences between single thread and multiple thread, as well as single server and multiple server models. [Remembering]
Developed Standard
Discuss the differences between single thread and multiple thread, as well as single server and multiple server models. [Understanding]
Highly Developed Standard
Illustrate the differences between single thread and multiple thread, as well as single server and multiple server models. [Applying]

**SF-03 Investigate security implications related to emerging computational paradigms. [Applying]**

Emerging Standard
Report security implications related to computational paradigms. [Understanding]
Developed Standard
Investigate security implications related to emerging computational paradigms, such as quantum computing and biological computing. [Applying]

Highly Developed Standard
Analyze security implications related to emerging computational paradigms. [Analyzing]

**SF-04 Describe how computing systems are constructed of layers upon layers. [Understanding]**

Emerging Standard
Recognize that computing systems are constructed of layers upon layers. [Remembering]

Developed Standard
Describe how computing systems are constructed of layers upon layers, such as separation of concerns, well-defined interfaces, and abstraction. [Understanding]

Highly Developed Standard
Diagram a computing system constructed of layers upon layers. [Applying]

**SF-05 Implement a program using methods of layering. [Applying]**

Emerging Standard
Exemplify a program that uses methods of layering. [Understanding]

Developed Standard
Implement a program using methods of layering, such as error detection, recovery and status across layers. [Applying]

Highly Developed Standard
Develop a program using methods of layering. [Creating]

**SF-06 Investigate defects in a layered program using tools for program tracing, single stepping, and debugging. [Applying]**

Emerging Standard
Demonstrate defects in a layered program using tools for program tracing, single stepping, and debugging. [Understanding]

Developed Standard
Investigate defects in a layered program using tools for program tracing, single stepping, and debugging. [Applying]

Highly Developed Standard
Categorize defects by security risk in a layered program using tools for program tracing, single stepping, and debugging. [Analyzing]

**SF-07 Illustrate the performance of simple sequential and parallel versions of the same program with different problem sizes. [Applying]**
Emerging Standard
Summarize the general performance of simple sequential and parallel versions of the same program. [Understanding]

Developed Standard
Illustrate the performance of simple and parallel versions of the same program with different problem sizes. [Applying]

Highly Developed Standard
Compare the performance of simple and parallel versions of the same program with different problem sizes. [Analyzing]

SF-08 Summarize the differences among the concepts of instruction parallelism, data parallelism, thread parallelism/multitasking, and task/request parallelism. [Understanding] See also PD-01.

Emerging Standard
Define the concepts of instruction parallelism, data parallelism, thread parallelism/multitasking, and task/request parallelism. [Remembering]

Developed Standard
Summarize the differences among the concepts of instruction parallelism, data parallelism, thread parallelism/multitasking, and task/request parallelism. [Understanding]

Highly Developed Standard
Investigate the differences among the concepts of instruction parallelism, data parallelism, thread parallelism/multitasking, and task/request parallelism. [Applying]

SF-09 Investigate other uses of parallelism, including reliability and redundancy of execution. [Applying]

Emerging Standard
Describe other uses of parallelism, including reliability and redundancy of execution. [Understanding]

Developed Standard
Investigate other uses of parallelism, including reliability and redundancy of execution. [Applying]

Highly Developed Standard
Examine other uses of parallelism, including reliability and redundancy of execution. [Analyzing]

SP-01 Investigate both positive and negative ways in which computing technology impacts information exchange and social interaction. [Applying]

Emerging Standard
Describe different ways in which computing technology impacts information exchange and social interaction. [Understanding]

Developed Standard
Investigate both positive and negative ways in which computing technology impacts information exchange and social interaction, such as the Internet, mobile computing, and social media. [Applying]

Highly Developed Standard
Analyze positive and negative ways in which computing technology impacts information exchange and social interactions. [Analyzing]
**SP-02 Examine developers’ assumptions and values embedded in hardware and software design, especially with respect to underrepresented groups and diverse populations. [Analyzing]** See also HCI-06.

Emerging Standard
Infer developers’ assumptions and values embedded in hardware and software design, especially with respect to underrepresented groups and diverse populations. [Understanding]

Developed Standard
Examine developers’ assumptions and values embedded in hardware and software design, especially with respect to underrepresented groups and diverse populations, such as persons with disabilities. [Analyzing]

Highly Developed Standard
Critique developers’ assumptions and values embedded in hardware and software design, especially as pertinent to underrepresented groups and the disabled. [Evaluating]

**SP-03 Analyze the impact of diversity on the computing profession. [Analyzing]**

Emerging Standard
Discuss the impact of diversity on the computing profession. [Understanding]

Developed Standard
Analyze the impact of diversity on the computing profession, such as industry culture and product development. [Analyzing]

Highly Developed Standard
Assess the impact of diversity on the computing profession. [Evaluating]

**SP-04 Investigate social engineering attacks and the types of bad actors who might perform them. [Applying]**

Emerging Standard
Describe social engineering attacks and the types of bad actors who might perform them. [Understanding]

Developed Standard
Investigate social engineering attacks and the types of bad actors who might perform them. [Applying]

Highly Developed Standard
Analyze the impact and likelihood of social engineering attacks. [Analyzing]

**SP-05 Contrast stakeholder positions in a given scenario. [Analyzing]**

Emerging Standard
Infer stakeholder positions in a given scenario. [Understanding]

Developed Standard
Contrast stakeholder positions in a given scenario. [Analyzing]

Highly Developed Standard
Debate stakeholder positions in a given scenario. [Evaluating]
SP-06 Analyze social tradeoffs in technical decisions. [Analyzing]

Emerging Standard
Explain social tradeoffs in technical decisions. [Understanding]

Developed Standard
Analyze ethical and social tradeoffs in technical decisions. [Analyzing]

Highly Developed Standard
Justify social tradeoffs in technical decisions. [Evaluating]

SP-07 Examine various ethics scenarios in computing. [Analyzing]

Emerging Standard
Discuss ethics scenarios in computing. [Understanding]

Developed Standard
Analyze various ethics scenarios in computing. [Analyzing]

Highly Developed Standard
Debate various ethics scenarios in computing. [Evaluating]

SP-08 Support the ethical responsibility of ensuring software correctness, reliability, and safety. [Evaluating]

Emerging Standard
Examine the ethical responsibility in ensuring software correctness, reliability, and safety. [Analyzing]

Developed Standard
Support the ethical responsibility of ensuring software correctness, reliability, and safety. [Evaluating]

Highly Developed Standard
Hypothesize various ethical responsibilities of ensuring software correctness, reliability, and safety. [Creating]

SP-09 Compare professional codes of conduct from the ACM, IEEE Computer Society, and other organizations. [Analyzing]

Emerging Standard
Discuss professional codes of conduct from the ACM, IEEE Computer Society, and other organizations. [Understanding]

Developed Standard
Compare professional codes of conduct from the ACM, IEEE Computer Society, and other organizations. [Analyzing]

Highly Developed Standard
Evaluate professional codes of conduct from the ACM, IEEE Computer Society, and other organizations. [Evaluating]
SP-10 Differentiate the terms among intellectual property, fair-use, copyright, patent, trademark, and plagiarism. [Understanding]

Emerging Standard
Define the terms intellectual property, fair-use, copyright, and plagiarism. Give examples of each. State the plagiarism policy at your school. [Remembering]

Developed Standard
Differentiate the terms intellectual property, fair-use, copyright, patent, trademark, and plagiarism. [Understanding]

Highly Developed Standard
Investigate ethics violations related to intellectual property rights, fair-use, copyright, patents, trademarks, and plagiarism. [Applying]

SP-11 Discuss the rationale for legal protection of intellectual property. [Understanding]

Emerging Standard
Recognize the rationale for legal protection of intellectual property. [Remembering]

Developed Standard
Discuss the rationale for legal protection of intellectual property. [Understanding]

Highly Developed Standard
Examine the rationale for legal protection of intellectual property. [Analyzing]

SP-12 Outline the need for legal protection of personal privacy. [Analyzing]

Emerging Standard
Discuss the need for legal protection of personal privacy. [Understanding]

Developed Standard
Outline the need for legal protection of personal privacy. [Analyzing]

Highly Developed Standard
Defend the need for legal protection of personal privacy. [Evaluating]

SP-13 Investigate threats to privacy rights in personally identifiable information (PII). [Applying]

Emerging Standard
Summarize threats to privacy rights in personally identifiable information (PII). [Understanding]

Developed Standard
Investigate threats to privacy rights in personally identifiable information (PII). [Applying]

Highly Developed Standard
Analyze solutions for privacy threats to personally identifiable Information. [Analyzing]

SP-14 Illustrate the role of data collection in the implementation of pervasive surveillance systems. [Applying]

Emerging Standard
Discuss the role of data collection in the implementation of pervasive surveillance systems. [Understanding]
Developed Standard
Illustrate the role of data collection in the implementation of pervasive surveillance systems, such as RFID, face recognition, and mobile computing. [Applying]
Highly Developed Standard
Assess the role of data collection in the implementation of pervasive surveillance systems. [Evaluating]

**SP-15 Analyze technological solutions to privacy concerns. [Analyzing]**

Emerging Standard
Investigate technological solutions to privacy concerns. [Applying]
Developed Standard
Analyze technological solutions to privacy concerns. [Analyzing]
Highly Developed Standard
Choose a technological solution to solve a privacy problem. [Evaluating]

**SP-16 Use effective oral, written, electronic, and visual communication techniques with stakeholders. [Applying]**

Emerging Standard
Demonstrate effective oral, written, electronic, and visual communication techniques. [Understanding]
Developed Standard
Use effective oral, written, electronic, and visual communication techniques with stakeholders. [Applying]
Highly Developed Standard
Choose the appropriate oral, written, electronic or visual communication technique with stakeholders. [Evaluating]

**SP-17 Interpret the impact of both verbal and nonverbal cues during communication among team members. [Understanding]**

Emerging Standard
Recognize both verbal and nonverbal cues during communication among team members. [Remembering]
Developed Standard
Interpret the impact of both verbal and nonverbal cues during communication among team members. [Understanding]
Highly Developed Standard
Analyze the impact of both verbal and nonverbal cues during communication among team members. [Analyzing]

**SP-18 Develop technical artifacts. [Creating]**

Emerging Standard
Write a technical artifact. [Applying]
Developed Standard
Develop technical artifacts, such as documentation of source code and user requirements, as well as project
Highly Developed Standard
Create technical artifacts of considerable length and/or complexity. [Creating]

SP-19 Analyze case studies related to sustainable computing efforts. [Analyzing]

Emerging Standard
Paraphrase case studies related to sustainable computing efforts. [Understanding]
Developed Standard
Analyze case studies related to sustainable computing efforts. [Analyzing]
Highly Developed Standard
Critique case studies related to sustainable computing efforts. [Evaluating]

SP-20 Investigate laws applicable to computer crimes. [Applying]

Emerging Standard
Paraphrase laws applicable to computer crimes. [Understanding]
Developed Standard
Investigate laws applicable to computer crimes. [Applying]
Highly Developed Standard
Debate laws applicable to computer crimes. [Evaluating]

SP-21 Examine the motivation and ramifications of cyber terrorism and criminal hacking. [Analyzing]

Emerging Standard
Discuss the motivation and ramifications of cyber terrorism and criminal hacking. [Understanding]
Developed Standard
Examine the motivation and ramifications of cyber terrorism and criminal hacking. [Analyzing]
Highly Developed Standard
Evaluate the motivation and ramifications of cyber terrorism and criminal hacking. [Evaluating]

SP-22 Write a company-wide security policy. [Applying]

Emerging Standard
Exemplify a company-wide security policy. [Understanding]
Developed Standard
Write a company-wide security policy, such as procedures for managing passwords, avoiding social engineering attacks, and monitoring employees. [Applying]
Highly Developed Standard
Compare several company-wide security policies. [Analyzing]

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