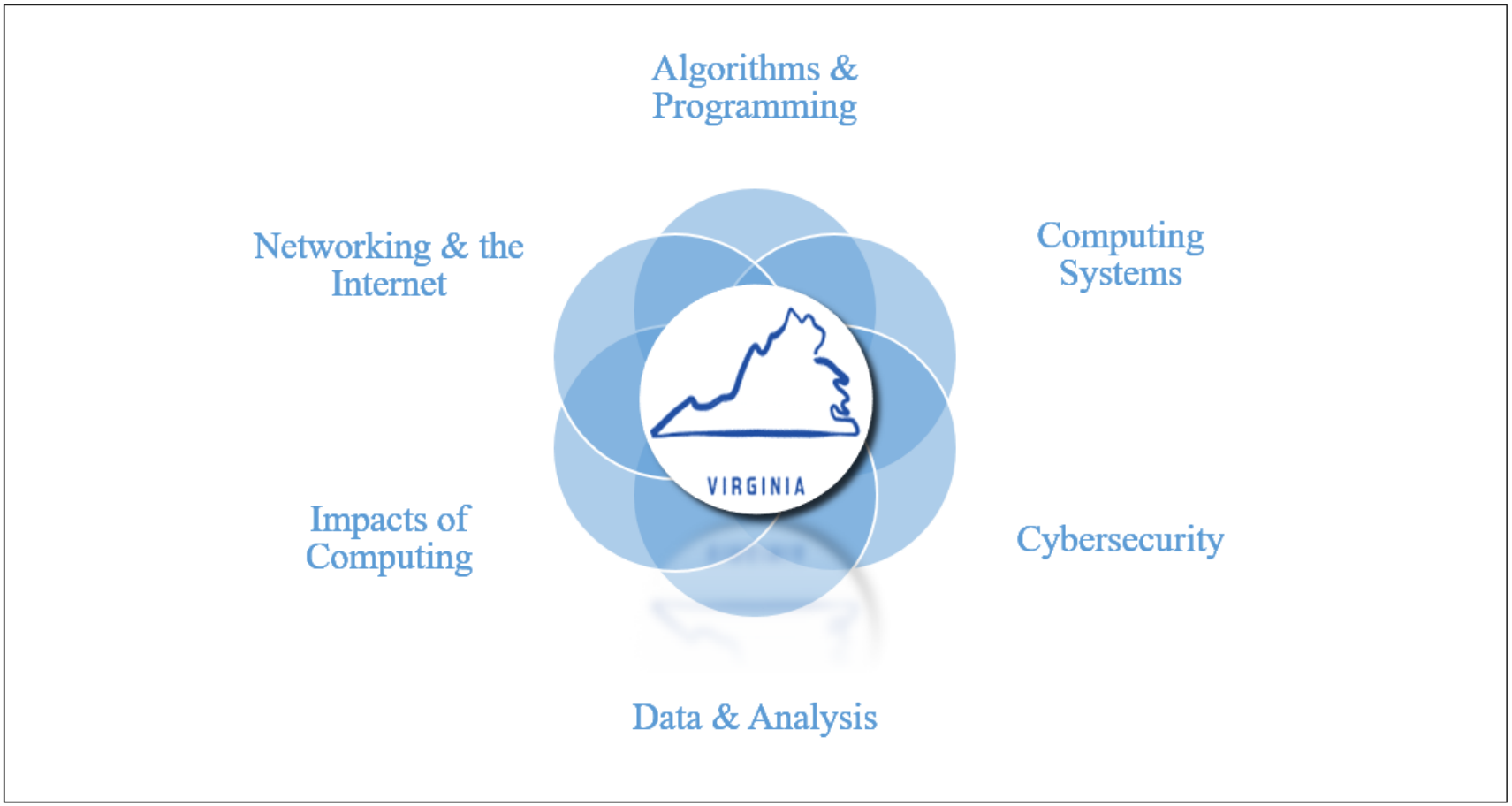
Computer Science Standards of Learning

Curriculum Framework



Board of Education
Commonwealth of Virginia

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The 2017 *Computer Science Curriculum Framework* can be found on the Virginia Department of Education's Web site.

Introduction

The *Computer Science Standards of Learning* Curriculum Framework amplifies the *Computer Science Standards of Learning for Virginia Public Schools* and defines the content knowledge, skills, and understandings that are measured by the Standards of Learning. The Computer Science Curriculum Framework provides additional guidance to school divisions and their teachers as they develop an instructional program appropriate for their students. It assists teachers as they plan their lessons by identifying essential questions and vocabulary to drive instruction and defining the essential skills students should demonstrate. This supplemental framework delineates in greater specificity the minimum content that all teachers should teach and all students should learn.

School divisions should use the *Computer Science Curriculum Framework* as a resource for developing sound curricular and instructional programs. This framework should not limit the scope of instructional programs. Additional knowledge and skills that can enrich instruction and enhance students' understanding of the content identified in the Standards of Learning should be included as part of quality learning experiences.

Each topic in the *Computer Science Standards of Learning* Curriculum Framework is developed around the Standards of Learning. The format of the Curriculum Framework facilitates teacher planning by broadening the context of the standards and identifying essential student skills that should be the focus of instruction for each standard.

Context of the Standard

The Context of the Standard provides educators an explanation of the standard, including a description and the vertical development of the concept. This context will support teachers in incorporating computer science content into discipline-specific lessons. The intention of the Computer Science standards in grades K-8 is that Computer Science principles be integrated throughout content area instruction.

Essential Skills

The Essential Skills define student performance expectations aligned to each standard. The intent of the K-8 computer science standards is that the concepts are integrated into existing disciplines and this will result in these skills being emphasized differently in each content area. The expectation is that these Essential Skills are partnered with content area performance expectations as appropriate in instruction. At the high school level, the expectations in the 2017 *Computer Science Standards of Learning Curriculum Framework* are to be used in the support of standalone computer courses; the essential skills outlined in the document are not intended to be integrated into other coursework unless a teacher chooses to use the content to support discipline practices.

Essential Questions
Each standard has identified key questions to drive classroom instruction. These questions lead teachers and students toward the big ideas of each concept and provide a more holistic viewpoint used to lead instruction relating to the context of each standard.

Essential Vocabulary
In order to effectively communicate Computer Science concepts, essential vocabulary terms are defined in grade-level appropriate terms. These definitions are found in the glossary (Appendix A).

Grade Eight

The eighth-grade standards emphasize constructing programs and utilizing algorithms to accomplish a task. Students continue to decompose larger problems into smaller tasks and recognize the impacts of computing and computing devices. Students in eighth grade continue to work with data including how it can be vulnerable and how it can be protected. The accurate use of terminology as well as the responsible use of technology will continue to be built upon. The foundational understanding of computing and the use of technology will be an integral component of successful acquisition of skills across content areas.

Algorithms and Programming

8.1 The student will construct programs to accomplish a task as a means of creative expression or scientific exploration using a block-based or text-based programming language, both independently and collaboratively,

a. combining control structures such as if-statements and loops including nested conditionals and loops;
b. using clearly named variables that represent different data types, including numeric and non-numeric data, and perform operations on their values; and
c. create functions with parameters.

Context of the Standard
Programs are collections of code organized in algorithms that can accomplish a variety of tasks. Programs can be developed to perform calculations, manipulate data, or simply to be creative. Programs can involve different control structures such as loops and if-statements; these control structures are blocks of programming that analyze variables within the program code to adjust and use accurate values as they change. Control structures help students develop their problem solving skills and foster computational thinking. Effective variable use including naming conventions, makes the problem solving process easier and faster. In elementary school, students begin their study of programming through a focus on algorithms. They work both collaboratively and individually to develop algorithms to reflect tasks in daily life; these algorithms become more complex as they recognize and use loops and events in the algorithms they construct. Although the use of plugged and unplugged activities is encouraged in early elementary, the expectation is that students use of block- and text-based programming as they progress in elementary years. In seventh grade, students added compound conditionals to their programs. A compound condition specifies a combination of other conditions, allowing for two or more conditions to be tested in a single statement, such as “if-and” and “if-or.” In eighth grade, students begin to use nested control structures. Placing a structure such as a loop within another loop allows for a greater level of

Context of the Standard
complexity in the program's function. These often substitute for what would have been very large sections of repeated code. Functions are named sections of code that allow a programmer to call it from multiple locations and repeat the functionality. Parameters offer an increased level of flexibility in these functions by passing in additional information.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Create programs which specify the order (sequence) in which instructions are executed within a block-based and/or text-based program. • Combine and nest if-statements and loops to create more complex programs. • Write programs to accomplish tasks. • Use if statements and loops to complete a task. • Define functions with parameters in program construction.	Students should *investigate* these concepts: • How can students use if or else statements to control programs? • How can functions be called from various locations in a program? • What are the advantages of nesting a conditional statement within another conditional statement?	Students should *apply* these terms in context: • Pseudocode • Loop • If-else statement • Nesting

8.2 The student will systematically test and refine programs using a range of test cases.

Context of the Standard
As part of the iterative design process, programs should be reviewed and tested to determine if the design goal is met through the generation of specific output. Testing programs using a range of test cases is a necessary step for assessing program correctness. A test case is a single input with an expected output to test the correctness of a program. Programmers need to test a program to make sure it works for all the possible values received as input. This can include values within the range of expected values as well as those outside the given range. Often, programmers will use "edge cases" - parameters that test the extremes of a scenario - to test their programs, ensuring that they will work with even the largest and smallest inputs. In beta test situations programmers use random people to test a program to find "bugs." Programmers record "versions" of programs as they update and improve their code.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Identify an appropriate range of test cases to use with a program. • Use a range of test cases and test a program for correctness. • Refine a program based on results from test cases.	Students should *investigate* these concepts: • Why is there a need to debug? • Why is it important to test a variety of test cases? • How does testing the program with a wide range of values help confirm its effectiveness?	Students should *apply* these terms in context: • Debugging • Command

8.3 The student will explain how effective communication between participants is required for successful collaboration when developing programs.

Context of the Standard
Because of the highly collaborative nature of programming projects, team members need to employ effective communication strategies. In order to avoid redundant work or gaps in the necessary code, all groups need to have open communication to help standardize the flow of the program. In order to develop a program, tasks can be broken down and created in modules by different groups of students, which requires clear and consistent communication between these groups. Additionally, the peer review fosters effective communication, and helps students see a variety of coding styles as well as identify common mistakes. Program documentation allows for writing that does not affect the flow of a program. This writing is intended to clarify the purpose of a section of code, note a troublesome section for review, or otherwise communicate between group members. In 8th grade, students should be employing these effective communication strategies as well as explain why these techniques are essential for successful programming.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Work collaboratively to produce a computational artifact. • Work with peers to write a program. • Use proper code documentation. • Communicate effectively to solve a problem.	Students should *investigate* these concepts: • What are examples of communication skills that assist in group programming? • How can students use effective communication skills to solve common mistakes in programming?	Students should *apply* these terms in context: • Documentation

8.4 The student will use flowcharts and/or pseudocode to address complex problems as algorithms.

Context of the Standard
In computer science, the development of programs uses an iterative design process involving design, implementation (programming), and review (debugging) until the program runs correctly. The design stage occurs before beginning to program. The planning stage is when the programmers gather information about the problem and sketch out a solution. This design process may include the use of pseudocode - writing out the steps of a program in English to make sure the flow of control and logic make sense. Flowcharts are another tool programmers may use when designing an algorithm or computer program. The flowchart outlines the steps that are needed in the development of an algorithm or program.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Breakdown code into parts to enable creation of a program. • Design an algorithm using a planning tool. • Review and revise a plan to better fit the needs of a task.	Students should *investigate* these concepts: • How does pseudocode help programmers organize their thoughts?	Students should *apply* these terms in context: • Flowchart • Pseudocode

Computing Systems

8.5 The student will, using the elements of computing devices such as primary memory, secondary storage, processor, input and output devices, and network connectivity, analyze the advantages and limitations of a given computing system.

Context of the Standard
Computing devices can have large variation in their functionality, speed, processing ability, data storage capacity, network speed, and other such details. This variability can be related to the hardware components or the choice of software that is being used. These choices are affected by the intended use of a device - a computer that is set up for gaming will have different hardware and software capabilities and limitations than one that is designed for the purposes of data manipulation or architectural renderings. In 8th Grade, students will examine these choices and analyze the pros and cons of different computing systems.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Understand the components of a computer. • Understand how the components of a computer work and interact with each other. • Understand how the components of a computer system are impacted by its primary task.	Students should *investigate* these concepts: • What are the components of a computing device? • How do the components of a computer interact with each other? • What are the advantages and disadvantages computing systems create individually? Locally? Globally? • What features would be best for a gaming/digital art/data science computer?	Students should *apply* these terms in context: • Motherboard • CPU • GPU • RAM • NIC

Cybersecurity

8.6 The student will evaluate physical and digital security measures used to protect electronic information.

Context of the Standard
Students will extend their knowledge of the need for physical and digital security measures to understanding and explaining that both types of measures protect our data and personal information. Students can explore different types of security measures and understand how each one protects us in different ways from different types of electronic breaches and attacks. Physical security measures include locking rooms with devices, badges, fingerprints, security cameras, paper shredding, etc. Digital security measures include firewalls, anti-virus software, strong passwords, anti-spyware, etc. In eighth grade, students will analyze the advantages and disadvantages of different physical and digital security systems.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Distinguish between physical and digital security measures. • Identify examples of physical and digital security measures. • Understand why data security is necessary. • Explain how security measures protect electronic information. • Evaluate the physical and digital measures in existing computing system setups and make recommendations on improvements.	Students should *investigate* these concepts: • Why is data security necessary? • How do physical security measures protect us? • How do digital security measures protect us? • Why should a student implement security measures when working with digital information?	Students should *apply* these terms in context: • Digital footprint • Hacking

8.7 The student will identify impacts of hacking, ransomware, scams, fake vulnerability scans, and the ethical and legal concerns involved. *Exclusion: Students do not need to implement solutions.*

Context of the Standard
Students will identify issues and impacts associated with electronic crimes such as hacking, phishing, identity and password theft, ransomware, scams, etc. Hacking is an attempt to exploit a computer system or a private network inside a computer. Ransomware is malicious software that encrypts a computer's files unless its owner pays a ransom. It is the unauthorized access to or control over computer network security systems for some illicit purpose. This discussion will include the ethical and legal concerns that have arisen as more sensitive data is stored and transmitted electronically.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Identify cybersecurity concerns. • Identify reasons data must be protected. • Identify risks of using public devices and WiFi. • Identify options to reduce the risks of Internet use. • Explain the consequences of misuse of electronic information. • Understand the legal and ethical implications of crimes involving stealing/distributing/using electronic data.	Students should *investigate* these concepts: • What are some current cybersecurity concerns? • What are the risks of using public devices and public WiFi connections? • How can we protect our data on the Internet? • What are the consequences of a data breach or misuse of information? • What is hacking? • Why do hacking and other digital exploits occur?	Students should *apply* these terms in context: • Cybersecurity • Internet • Identity theft • IP address • URL

Data and Analysis

8.8 The student will

a. explain the difference between a model and a simulation, and
b. create computational models to conduct simulations.

Context of the Standard
Students will understand and explain the difference between a model and a simulation. Modeling means creating a physical replica or equations of a situation or activity. A simulation is a virtual representation of a process that reflects how a real physical situation would most likely happen. Simulations are created using models that were developed based on data. Programmers will create computational models to conduct simulations of familiar systems. Computational models can be created in pseudocode (written) or equations, in block languages (e.g., Scratch), or in text-based languages (e.g., Java, Python). There are also content specific tools for modeling such as MatLab for mathematics. Some examples of computation models might be modeling and simulating a bungee jump, investigating the temperature of melting ice, or investigating the forces and attractions in the states of matter.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Identify examples of models and explain how a model can represent a system. • Determine the best tool to create the model. • Identify the essential components of the model. • Use data to create an accurate model. • Compare models and simulations.	Students should *investigate* these concepts: • What are some examples of systems we can model? • What are some examples of simulations? • How do models differ from simulations? • What are some tools for creating computational models? • What components do we need to consider for our model?	Students should *apply* these terms in context:

Essential Skills	Essential Questions	Essential Vocabulary
• Identify examples of simulations and provide examples of possible simulations. • Create a computational model to provide simulated data.	• What is will be the input and the output of our model?	

Impacts of Computing

8.9 The student will describe tradeoffs between allowing information to be public and keeping information private.

Context of the Standard
The Fourth Amendment of the US Constitution protects every American's right to privacy. However, this amendment was written long before the advent of the Internet, where personal information is easily accessed and, in some cases, exploited. Modern tech companies, such as Facebook, Google, Amazon, and others, mine users' personal data and online habits to better advertise content and products towards individuals. Students will explore what information they think should be publicly available. Students discuss the benefits and drawbacks to keeping information private when compared to public release.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Identify and describe what information is appropriate, safe and responsible to share publicly.	Students should *investigate* these concepts: • What kind of personal information is regularly collected by web-based businesses? • What value is your personal information to another person or business?	Students should *apply* these terms in context: • Privacy • Public domain • Private sector

Essential Skills	Essential Questions	Essential Vocabulary
• Identify and describe what information is appropriate, safe and responsible to keep private. • Analyze the tradeoffs between allowing access to private and public information.	• What information is appropriate to be public? Private? • Why should we allow certain information to be public vs. private? What are the consequences?	

8.10 The student will evaluate online and print sources for appropriateness and credibility.

Context of the Standard
While the Internet has made research much easier than in the past, this access has also allowed for non-vetted and factually inaccurate sources to be presented as equal in validity to more legitimately reviewed and researched outlets. Students will find sources that pertain to a particular topic and evaluate them for inclusion in their work. Students need to assess multiple aspects of a source to test its credibility. Criteria such as those listed in the Currency, Relevancy, Authority, Accuracy, and Purpose (CRAAP) Model should be employed when evaluating online resources.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Identify the author of a print and an online source. • Assess the appropriateness of various online resources.	Students should *investigate* these concepts: • How can you identify a valid source on the Internet? • Do Internet providers have a responsibility to control the spread of false or misleading information? If they	Students should *apply* these terms in context:

Essential Skills	Essential Questions	Essential Vocabulary
	do, what are some potential downsides to this action? • What criteria should be used to determine if a website is a valid source of information?	

8.11 The student will discuss the social impacts and ethical considerations associated with the field of cybersecurity.

Context of the Standard
Cybersecurity is a growing industry in the world as more of our personal, financial, government, and military information is transmitted electronically and housed in data centers. Today's cybersecurity concerns are varied and complex and include actions like breaching of private information from governmental or business sources, the use of ransomware to withhold access to a computing system, or global threats from the hacking of confidential data by hostile entities. Cybersecurity encompasses many aspects of data protection in our society. Some examples are the protection of individual privacy, military information, credit card and banking information, and social media profiles. In order to prevent loss of data, identity theft, or other cyberthreats, physical and digital security measures must be practiced at all times. In eighth grade, students will weigh the advantages of cybersecurity in protecting individuals and systems against potential disadvantages of the over-restriction of content and delivery.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Understand the importance of encryption. • Understand the importance of anti-virus software. • Explain the need of cybersecurity in protecting computing systems.	Students should *investigate* these concepts: • How should a list of passwords be protected? • What are examples, globally, of societies that restrict access to information? • Does restricting access to information benefit or harm a society?	Students should *apply* these terms in context: • Virus • Trojan horse • Encryption

8.12 The student will explore careers related to the field of cybersecurity.

Context of the Standard
Due to the rise in cybersecurity threats and the increasing value of information and resources that are potentially vulnerable to these threats, the career field in cybersecurity has grown tremendously over the past decades. Examples of these kinds of jobs include security software developer, information security analyst, ethical hacker (white hat), computer forensics analyst, and many others. In eighth grade, Students will explore various aspects of these careers such as work done, pay rate, and education needed. Current information on education, pay, and employment projections can be found through the U.S.Bureau of Labor Statistics (https://www.bls.gov/emp/).

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Identify cybersecurity jobs available today. • Explain related training needed prior to working in a cybersecurity field.	Explore a *career field* to answer the following questions: • What are the different cybersecurity jobs available? • What education is needed to work in a cybersecurity field? • What do jobs in the various cybersecurity fields pay? • What kind of work that is usually done in an office can be done from home using the Internet?	Students should *apply* these terms in context:

Networking and the Internet

8.13 The student will identify existing cybersecurity concerns associated with Internet use and Internet-based systems and potential options to address these issues.

Context of the Standard
Cybersecurity risks can take many forms and have many consequences. The consequences of hacking can be serious and depend on what level of access the hackers have achieved. Examples of cybersecurity breaches include the theft of social security and credit information from Experian and the hack of Sony Pictures by the North Korean government. Computer viruses (scripts that may be hidden in existing files or programs) and other malware (malicious software installed on a computer) generally have two goals: to propagate from system to system and to perform some action on each system they infect. Similarly, denial-of-service attacks can cripple an online business for long periods of time, which can greatly affect a business's financials. In eighth grade, students will explore possible risks to the data involved in their use of the Internet. They will also explore the risks and cyber threats for which companies plan and prepare.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Describe what may happen when a hacker gains access to a computer. • Explain what measures can be taken to prevent hacking. • Describe what happens to a website or server during a denial-of-service attack.	Students should *investigate* these concepts: • How can hackers damage a computer? • What are the different types of malware? • What happens when a phisher steals one's personal information? • What can happen to a website or server during a denial-of-service attack?	Students should *apply* these terms in context: • Hacker • Malware • Denial-of-Service attack • Phishing

Grade 8

Term	Definition
Command	An instruction telling a computer program to do something
Cybersecurity	The study and practice of protecting computers and programs from unwanted access and theft of data
Debugging	Systematically finding the cause of an error in a program and fixing it
Denial-of-Service attack	A cyber-attack where a machine is flooded with simple requests making it unable to respond to more meaningful requests
Digital footprint	The collection of data that is associated with your actions and communication on the Internet
Digital forensics	The investigation and recovery of material found in digital devices
Encryption	Encoding a message so that only the intended parties can read it
Flowchart	A type of diagram that represents the path and logic through a program
Hacker	A person who uses computers to gain unauthorized access to data
Hacking	Gaining access to a website, program, or other resource you are not supposed to
Identity theft	The deliberate use of someone's personal data for financial gain or to harm their reputation

Term	Definition
If-else statement	A programming conditional statement that defines two actions to be run depending on the result of a particular condition
Internet	A global computer network consisting of multiple interconnected networks
IP address	A numerical label assigned to each computing device on a network
Loop	A control structure that repeats a section of code until a condition is met
Malware	Software that is intentionally designed to cause damage to a computer, server, or network
Nesting	Organizing control structures such as if statements or loops within other control structures
Phishing	The fraudulent practice of sending emails purporting to be from reputable companies in order to induce individuals to reveal personal information, such as passwords and credit card numbers
Privacy	Protecting data or actions performed on a computing system
Private sector	The part of the economy that is not under government control
Public domain	All the creative works which have no intellectual property rights applied
Trojan horse	A form of malware that appears to be harmless software but performs more malicious actions
URL	Uniform Resource Locator, or more commonly known as a web address

Term	Definition
Virus	A piece of malware that is capable of replicating itself and embedding in various aspects of a computer