FCCS Competencies and Learning Objectives

By the end of the course, students should be able to demonstrate the following competencies.

Competency 1, Logic Gates: Understand that the fundamental building blocks of computers are logic gates. Given their inputs, determine the output of a simple collection of common gates. [3B-CS-02]

- Explain the general functionality of a(n) [AND | OR | NOT | XOR] gate.
- Given two inputs to an [AND | OR | XOR] gate, identify the output of the gate.
- Given one input to a NOT gate, identify the output of the gate.
- Given up to three inputs to a circuit consisting of a combination of up to three gates, identify the output of the circuit.

Competency 2, Binary and Numerical Encodings: Understand that a computer is built on collections of 0s and 1s (bits). Apply this knowledge to convert between a variety of numerical encodings. [3A-DA-09]

- Convert a base ten value to its binary equivalent (unsigned integer).
- Convert a length 4 binary representation (unsigned integer) to its equivalent hexadecimal value.
- Convert a hexadecimal value to its binary equivalent (unsigned integer).
- Calculate how many unique values can be stored in N bits.
- Convert a length 8 bit-string into its decimal/fractional equivalent assuming the first four bits store the integer, and the second four bits store the fraction.
- Explain how a computer stores decimal numbers n the floating-point format using [8 | 32] bits.

Competency 3, Data Representation: Understand that a computer is built on collections of 0s and 1s (bits). Apply this knowledge to common forms of media, discussing both storage structure and storage size. [3A-DA-09]

- Explain bits and bytes and how they are organized.
- Explain how the same sequence of bits can be interpreted as different types of data (numbers, images, sound, text, etc.)
- Explain how a photo is encoded in [24 | 32] bit format.
- Calculate the size in memory of an uncompressed photo in [24|32]-bit format.
- Explain how a sound file is encoded.
- Calculate the size in memory of an uncompressed sound file.
- Explain how a text file is encoded in [ASCII | UNICODE] format.
- Calculate the size in memory of an uncompressed text file in [ASCII | UNICODE] format.

- Define [Lossy | Lossless] compression.
- Explain the difference between Lossy/Lossless compression.
- Give an example of a Lossy Compression technique and how it works.
- Give an example of a Lossless Compression technique and how it works.
- Given a description of a compression technique, explain if it is lossy or lossless.

Competency 4, Error Recognition and Correction: Recognize that computers are not infallible, but that errors can often be detected and corrected. [3A-DA-09]

- Explain overflow errors.
- Explain truncation (round-off) errors.
- Discuss situations where inexactness of computer calculations matter (and situations where it doesn't matter) explaining the source of the inexactness.
- Explain communication errors.
- Explain how parity bits can be used to detect communication errors.
- Explain the difference between error detection and error correction.

Competency 5, Memory and Storage: Apply an understanding of computer memory and storage in various contexts including the CS classroom and daily life. [3A-DA-10]

- Explain primary uses for various kinds of memory and the impact of speed and persistence/permanence.
- Identify and/or explain the following vocabulary related to Mass Storage
    - Magnetic Storage magnetic disks (aka HDD)
        - track
        - cylinder
        - seek time
        - rotational delay
        - transfer rate
    - Optical Storage (aka, Compact Disks, DVDs, and Blu-ray)
    - Flash Storage (aka, Flash drives, Solid State Drives (SSD), SD cards)
- Explain why we still have three broad classes of secondary/mass storage
- Consider which media type is more appropriate for a particular scenario

Competency 6, Hardware Components: Identify the hardware components of a computer and describe their relationships and interactions. [3A-CS-01, Educator 1b]

- Define the purpose of the [ALU | Control Unit | registers | program counter | instruction register] and the role it plays in the CPU. Talk through Figure 2.1
- Explain how general-purpose registers, main memory, and secondary memory (mass storage) work together and their role in fetching/storing data. As part of this, explain the differences between mass storage, main memory, and general-purpose registers.

- Explain the role of a controller in the operation of a computer.
- Explain the role of a port in the operation of a computer.
- Identify at least three ports common to a [PC | mobile device]

Competency 7, The Instruction Cycle: Apply an understanding of a CPU's instruction set and the instruction cycle to various scenarios. [3A-CS-01]

- Given the language description table (Appendix C in the textbook) and a single VOLE command, convert the command into English.
- Given the language description table and an English description of a computer operation, produce the corresponding VOLE command.
- Given a partial description of memory/registers and a single VOLE command, identify the value of a particular register or memory cell upon completion of the command.
- Given a listing of multiple, sequential, memory addresses, containing a valid program written in the VOLE machine language, trace the execution of the program to answer questions about the status of the machine upon completion.

Competency 8, OS Components: Understand the role and functionality of the components of an operating system. [3B-CS-01, Educator 1b]

- Given one of the following vocabulary words, give a brief definition of the term and how the item applies in the normal operation of an operating system.
    - Job
    - Queue
    - First-in, first out (FIFO)
    - Interactive Processing
    - Real-time processing
    - Time-sharing
    - Multiprogramming
    - Multitasking
    - Application software
    - System software
    - User Interface (Graphical User Interface)
    - Shell
    - Kernel
    - Window manager
    - File manager
    - Memory manager
    - Directory (folder)
    - Device driver
    - Scheduler
    - Dispatcher

    - Read-only memory
    - Boot Loader (Boot-strapping)

Competency 9, OS Processes: Understand the role and functionality of the processes managed by the operating system [3A-CS-02, Educator 1b]

- Explain how a historical batch processing system functioned, using the appropriate vocabulary terms from the chapter.
- Explain how a modern multi-tasking system functions, using the appropriate vocabulary terms from the chapter.
- Given a particular task performed by the computer, identify which part(s) of the operating system would be responsible for the task.
- Given one of the following vocabulary words, give a brief definition of the term and how the item applies in the normal operation of an operating system.
    - Time slice
    - Process (context) switch
    - Interrupt
    - Semaphore
    - Critical Region
    - Mutual Exclusion
    - Deadlock
- Explain the concept of a process in modern operating systems.
- Identify several of the challenges and/or concerns when working with a modern multi-process system when it comes to competition for shared resources.
- Discuss the conditions necessary for deadlock to occur.
- Discuss methods modern operating systems employ to avoid deadlock.

Competency 10, OS Security Issues: Understand the role and functionality of the operating system in addressing various security issues. [2-NI-04]

- Identify existing cybersecurity concerns and the modern operating system security features designed to guard against them.
- Given one of the following vocabulary words, give a brief definition of the term and how the item applies in the normal operation of an operating system.
    - Super user (administrator)
    - Privilege levels
    - Privileged instructions
- Discuss good password management techniques.
- Explain Muti-factor Authentication and why it helps with security.

Competency 11, Network Communication: Explain how a network consists of autonomous systems communicating through established protocols. [3A-NI-04, 3B-NI-03, Educator 1c]

- Define both LAN and WAN.
- In a description of two connected networks identify which is the LAN and which is the WAN.
- Provide the definition of a [bridge | repeater |switch |router |access point].
- Given a description of a network and a particular piece of hardware, identify it as a [bridge | repeater |switch |router |access point].
- Explain the generic concept of a network protocol and its role in network communication.
- Explain [Client-server | Peer-to-peer] communication.
- Compare and contrast client-server vs peer-to-peer communication.
- Explain the client/server relationship and identify key differences between the client and the server.
- Briefly explain the use of a [distributed system | computer cluster | grid computer | cloud computer].

Competency 12, Internet Transactions: Apply and explain network processes using common Internet transactions. [2-NI-04, Educator 1c]

- Explain the difference between "the Internet" and "the World Wide Web."
- Explain the difference between the internet and an intranet.
- Define and explain a/an [ISP | tier-1 ISP | tier-2 ISP].
- Given a URL, identify the [directory path| domain name (host)| document name | protocol | top-level domain]
- Identify and explain at least three internet applications.
- Explain the role of Domain Name Server (DNS).
- Identify and explain at least three internet servers.
- Give a general explanation of how a web page is requested/received by a web browser.
- Explain the concept of ports in internet traffic.
- Explain the difference between TCP and UDP and why we want (need) both.

Competency 13, Cybersecurity: Define and discuss various network-based cybersecurity problems and recommend security measures to address these attacks. [3A-NI-05, 3A-NI-06, Educator 1c]

- Define the following cybersecurity issues:
    - malware
    - virus
    - worm
    - Trojan horse
    - spyware
    - phishing

    - denial of service
- Given a specific scenario, classify it as one of the previous security issues.
- Given a specific security issue, identify ways to protect against that issue.
- Explain how a firewall helps protect a computer.

Competency 14, Database Systems: Recognize and explain the fundamental elements of database systems, including their roles, structure, functionality, and characteristics. [3A-DA-10, 3A-IC-29]

- Explain the difference between a schema and a subschema.
- Given a particular domain and one or more "roles" within that domain, identify data that would be part of the subschema for each "role"
- Explain the different layers in a modern database implementation (Figure 9.2)
- Identify potential redundancy in a dataset and suggest how different relation tables can reduce/eliminate that redundancy.
- Define the concept of a/an [attribute | relation | tuple]
- Identify and/or explain the purpose of the [JOIN | PROJECT | SELECT] operation in database queries.
- Given a description of a database and one or more relational operations, explain the results of the operation(s).

Competency 15, Big Data and Data Mining: Recognize and discuss fundamental techniques of big data and data mining. [3A-DA-12, Educator 1d]

- Explain and give an example of the data mining technique of [class description | class discrimination | cluster analysis | association analysis | outlier analysis | sequential pattern analysis].
- Given a set of data and a need, identify which data mining technique would solve the need.

Competency 16, Artificial Intelligence Foundations: Define and properly use the common vocabulary of artificial intelligence. [3B-AP-08]

- Define and provide examples for foundational vocabulary terms including:
    - Agent
    - Sensor (Not bolded, but on page 562)
    - Actuator (Not bolded, but on page 562)
    - Procedural knowledge
    - Declarative knowledge
    - Strong AI
    - Weak AI
- Identify examples of [procedural | declarative] knowledge.
- Explain the Turing Test.
- Define and provide examples for foundational vocabulary terms including:

    - Production System
    - Production (aka “actions”)
    - State
    - Children
    - State Space
    - Search Tree
    - breadth-first search
    - depth-first search

Competency 17, Artificial Intelligence Techniques: Identify and discuss a variety of historic AI techniques. [3A-DA-12]

- Given a simple search problem and a particular node in the search space for that problem, identify the children that can be generated.
- Given a simple search problem, discuss the order that nodes are visited using:
    - breadth-first search
    - depth-first search
- Provide a definition for [imitation| supervised learning | unsupervised learning | reinforcement learning].
- Discuss a specific example of where a human is learning through [imitation | supervised learning | unsupervised learning | reinforcement learning].
- Briefly explain the process used with [hill climbing | genetic algorithms].
    - Given a scenario to solve a problem, identify if it is using hill climbing or genetic algorithms.
- Identify how [hill climbing | genetic algorithms] is an example of reinforcement learning.
- Explain the concept of a perceptron.
- Given a simple perceptron model and set of inputs, identify the output of the perceptron.
- Given a simple perceptron model, explain the function of the perceptron (explain its outputs).
- Explain how multiple perceptrons are combined to form an artificial neural network (ANN).

Competency 18, Social and Ethical Impacts: Analyze and discuss the social and ethical impacts of computers science with respect to modern society connecting to the topics of the course. [3A-NI-06, 3A-NI-07, 3A-IC-28, 3A-IC-29, 3A-IC-30, 3B-IC-27, 3B-IC-28, Educator 1f]

- Development of substantially more power computer systems such as quantum computing and brain-inspired computers. What might be their impact? What role should the government plan in guiding or controlling their development and use?

- General knowledge. Students study reading, writing, mathematics, and (to a lesser extent) science. Should computer science be included as a basic of education? If so, should that study include the inner workings of computers?
- Should we be worried that some computer manufacturer might build a chip that could spy on the user of any device using the chip?
- Identify a variety of security threats that operating systems can mitigate and identify how that is done.
- Discuss user responsibilities with respect to protecting the computer systems they use, particularly when other users may be impacted.
- Analyze a given issue to formulate responsibility and liability of various stakeholders, i.e., CPU suppliers, computer/device suppliers, government, and users/consumers.
- Consider how the implementation of networks and software that is built on them can have important societal and ethical concerns.
- Discuss ethical issues when networks or network software fail to do what the user intends them to do.
- Analyze actual or proposed uses of database technology legal, ethical/moral, information security, correctness, etc. issues taking into account the data and people involved.
- Analyze various issues to formulate responsibility and liability of various stakeholders, i.e., retail business, data brokers, purchasers of data, government, and users/consumers.
- Describe potential positive and negative consequences of AI on society and the economy, including its impact on employment and privacy.
- Discuss the ethical implications of AI including bias and responsibility.
- Explain how ChatGPT works (in very general terms)
- Evaluate the strengths and limitations of ChatGPT as a language model, including its ability to generate coherent and relevant responses, and its potential for bias or error.
- Discuss how a tool such as ChatGPT could play a future role in domains such as customer service, language translation, and content generation, and be able to identify ethical and societal implications of such use.