Florida Department of Education
Curriculum Framework

Program Title: **Artificial Intelligence (AI) Foundations**
Program Type: **Career Preparatory**
Career Cluster: **Engineering Technology**

Program Number	PENDING
CIP Number	PENDING
Grade Level	9-12
Standard Length	3 credits
Teacher Certification	Refer to the **Course/Program Structure** section.
SOC Code	N/A
CTSO	N/A
CTE Program Resources	http://www.fldoe.org/academics/career-adult-edu/career-tech-edu/program-resources.stml

Purpose

This program offers a sequence of courses that provides coherent and rigorous content aligned with challenging academic standards and relevant technical knowledge and skills needed to prepare for further education and careers in Artificial Intelligence (AI)-enabled careers; provides technical skill proficiency, and includes competency-based applied learning that contributes to the academic knowledge, higher-order reasoning and problem-solving skills, work attitudes, general employability skills, technical skills, and occupation-specific skills, and knowledge of all aspects of AI and Machine Learning required for AI-enabled professionals working in business and academic environments. The intention of this course is to prepare students to be successful both personally and professionally in an AI-based society.

The content includes fundamental understanding of the Five Big Ideas in AI: Perception, Representation & Reasoning, Machine Learning, Human AI Interaction, Societal impacts of AI; AI system and their components; problems and tools AI-enabled workers use to build models and systems that leverage data to make decisions; mastery of foundational skills required to become power AI users. In addition, the course content includes but is not limited to practical experiences in AI system design, deployment, and evaluation; problem identification; creation, selection, and curation of data sets; computer programming, use of machine learning algorithms, program design structure, evaluation of the societal impact of AI, employing ethical and responsible development methodologies and decision making, essential programming techniques, and implementation issues. Specialized programming skills involving advanced mathematical calculations and statistics are also integrated into the curriculum.

Additional Information relevant to this Career and Technical Education (CTE) program is provided at the end of this document.

Program Structure

This program is a planned sequence of instruction consisting of 4 courses.

To teach the course(s) listed below, instructors must hold at least one of the teacher certifications indicated for that course.

The following table illustrates the secondary course/program structure:

PENDING	Artificial Intelligence in the World	BUS ED 1@2 COMPU SCI 6	0.5 credit	2	
PENDING	Applications of Artificial Intelligence	INFO TECH 7G WEB DEV 7G COMP PROG 7G	0.5 credit	2	
PENDING	Procedural Programming	ENG 7G EG TEC 7G	1 credit	2	
PENDING	Foundations of Machine Learning	TECH ED 1 @2 ENG & TEC ED 1@2 MATH 6-12	1 credit	2	

(Graduation Requirement Abbreviations- EQ= Equally Rigorous Science, PA= Practical Arts, EC= Economics)

Common Career Technical Core – Career Ready Practices

Career Ready Practices describe the career-ready skills that educators should seek to develop in their students. These practices are not exclusive to a Career Pathway, program of study, discipline or level of education. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

1. Act as a responsible and contributing citizen and employee.

2. Apply appropriate academic and technical skills.

3. Attend to personal health and financial well-being.

4. Communicate clearly, effectively and with reason.

5. Consider the environmental, social and economic impacts of decisions.

6. Demonstrate creativity and innovation.

7. Employ valid and reliable research strategies.

8. Utilize critical thinking to make sense of problems and persevere in solving them.

9. Model integrity, ethical leadership and effective management.

10. Plan education and career path aligned to personal goals.

11. Use technology to enhance productivity.

12. Work productively in teams while using cultural/global competence.

Standard

After successfully completing this program, the student will be able to perform the following:

Artificial Intelligence in the World:
01.0   Identify and define intelligent behavior.
02.0   Articulate the relationship between AI, machine learning, and computer science.
03.0   Explain the history and evolution of AI
04.0   Define and investigate examples of AI applications.
05.0   Identify examples of computer perception systems built into AI-enabled technologies.
06.0   Describe different types of data and how they are used in AI.
07.0   Describe the high-level processes, methods and conventions used in computer perception.
08.0   Identify and describe the types of representations and algorithms designed into AI-enabled technologies.
09.0   Explain how agents maintain representations of the world and use them for reasoning.
10.0   Describe machine learning and neural networks in AI-enabled technologies.
11.0   Describe the different methods computers use to learn from data (machine learning).
12.0   Collect and analyze a data set.
13.0   Conduct an investigation of a machine learning model.
14.0   Characterize major elements of intelligent behavior.
15.0   Explain how domain knowledge is used in the design of AI systems.
16.0   Articulate the many types of knowledge needed by AI agents to interact naturally with humans and the current limitations of AI to interact naturally with humans.
17.0   Understand and articulate how AI can impact society in both positive and negative ways.
18.0   Explain the best practices and key characteristics of bias, fairness, transparency, explainability, accountability of ethically designed AI systems and decision-making practices.
19.0   Identify deep fakes and explain critical information processing.

Applications of Artificial Intelligence:
20.0   Design and evaluate a perception system and its limits.
21.0   Train and evaluate a range of ML models based on specific accuracy, inclusivity, and ethical design criteria.
22.0   Design and evaluate a data set to solve a problem using specific accuracy, inclusivity, ethical design criteria.
23.0   Design AI solutions using embedded computing.
24.0   Explore the characteristics, tasks, work attributes, options, and tools associated with AI-enabled careers.
25.0   Identify how leadership development, school and community service projects and competitive events are integral parts of career and technology education.
26.0   Use appropriate tools to design an AI System to solve problems.
27.0   Characterize important issues related to privacy and security in the development and use of AI-enable technologies.
28.0   Explain the key technical challenges in design and responsible use of AI technologies.
29.0   Set up and use a ML pipeline to solve a problem.
30.0   Appropriately use automated AI services to accomplish common tasks.
31.0   Explain and use design thinking to solve a problem.
32.0   Show how a system is composed and interacts and be able to express verbally, graphically and in writing how the system functions.

33.0   Understand and interpret different types of data.
34.0   Understand how data is accessed, sorted, and stored.
35.0   Generate and tell stories with data.
36.0   Think critically about data.

Procedural Programming:
37.0   Design a computer program to meet specific physical, operational and interaction criteria.
38.0   Create and document a computer program that uses a variety of internal and control structures for manipulating varied data types.
39.0   Create and document an interactive computer program that employs functions, subroutines, or methods to receive, validate, and process user input.
40.0   Demonstrate responsible use of technology and information.

Foundations of Machine Learning:
41.0   Explain the nature of representations and their importance in AI.
42.0   Use search algorithms to reason with symbolic representations.
43.0   Explain the relationship between representation and reasoning.
44.0   Explain the nature of machine learning.
45.0   Use and evaluate supervised learning techniques to classify or predict outputs.
46.0   Use and evaluate unsupervised learning techniques to solve problems.
47.0   Use and evaluate reinforcement learning techniques to solve problems.
48.0   Use and evaluate different types of neural network architectures and their applications.
49.0   Illustrate Neural Networks and their components.
50.0   Recognize and identify mathematical principles upon which machine learning and AI are built such as calculus, linear algebra, probability, statistics, and optimization partial derivatives.
51.0   Use the most common machine learning algorithms to solve a problem.
52.0   Identify the types of problems that can be solved with machine learning algorithms.
53.0   Evaluate the sources of bias in machine learning/AI and identify appropriate mitigation strategies.
54.0   Program machine learning algorithms to train a model on real world data, then evaluate the results.
55.0   Identify different kinds of data, sources, and how they might be used in decision making.
56.0   Explain the characteristics, collection, storage, and uses of datasets in AI.
57.0   Work with datasets to gain insight, using data analysis and visualization tools.
58.0   Critique data and data-based claims to avoid being misled by data through identifying bias, confounding and random error.
59.0   Apply the machine learning life cycle in the development and use of a machine learning model.
60.0   Design and develop AI systems to solve a problem or design solutions for social and ethical issues.
61.0   Understand how machine learning is applied to solve problems.
62.0   Describe the limitations of machine learning and the decisions that can be made with data.
63.0   Evaluate societal impacts of AI on individuals, society, and the environment.
64.0   Evaluate AI applications to ensure they provide solutions to difficult problems without any unintended negative consequences.
65.0   Research and explain the advancements in computing hardware that make AI possible.
66.0   Create a portfolio of AI projects that demonstrate ability to program machine learning models using a wide range of AI algorithms.
67.0   Research and evaluate various AI careers involved in AI system usage, design, development, deployment, and maintenance.

Florida Department of Education
Student Performance Standards

Course Title: **Artificial Intelligence in the World**
Course Number: **PENDING**
Course Credit: **0.5**

Course Description:

This Course introduces students to the principles of Artificial Intelligence (AI). The course defines "Intelligent Behavior", describes the relationship between AI and computer science, explains the history of AI and showcases applications of AI in the real world. Students will explore the role of data in AI applications and the algorithms which guide AI decision making. Students will learn about the role of perception in AI and how AI agents use information in decision making. Students will engage in hands-on activities related to use of AI in machine learning. This course also covers ethics in AI applications.

CTE Standards and Benchmarks	
01.0	Identify and define intelligent behavior. The student will be able to:
01.01	Explain that "knowing" something means the ability to both represent and reason with it.
01.02	Explain the difference between knowledge/information and "knowing" (e.g., books can represent knowledge, but they do not "know" things because they cannot make use of that knowledge.)
01.03	Know and state conditions where behavior is intelligent using non-trivial sense-deliberate-act cycle.
01.04	Identify examples of intelligent and non-intelligent machine/agent behavior
02.0	Articulate the relationship between AI, Machine learning, and Computer Science. The student will be able to:
02.01	Describe computer science as a discipline focused on the study of computers and algorithmic processes, including their principles, their hardware and software designs, their implementation, and their impact on society.
02.02	Describe AI as a branch of computer science that studies the science and engineering of making intelligent machines, especially intelligent computer programs that enable them to make predictions, decisions, plans, and solve problems.
02.03	Describe machine learning as a set of techniques that that enables a computer system to learn from data rather than through explicit programming. Machine learning techniques can be used to build models that make solve problems, make predictions, and make decisions.
02.04	Describe the differences between the field of AI and ML
03.0	Explain the history and evolution of AI. The student will be able to:
03.01	Research AI and reflect on its current state.

	03.02	Describe the history and evolution of AI over time.
	03.03	Identify important early examples of AI and contributors to AI development.
	03.04	Describe how AI could be used to solve problems, including historical, current, and future problems.
04.0	Define and investigate examples of AI applications. The student will be able to:	
	04.01	Identify and describe current examples of AI applications in everyday life
	04.02	Identify and describe AI technologies students interact with frequently and determine what problems and/or needs the AI is intended to solve.
	04.03	Investigate how the different examples AI you interact with daily work and determine what type(s) of AI is being used
	04.04	Discuss how AI is and could be used to enhance areas of student interest, real-world problems, business needs, and the future of work.
	04.05	Identify and analyze how AI is impacting art and other creative fields.
	04.06	Define critical and contemporary areas of AI including machine learning, natural language processing, and computer vision.
05.0	Identify examples of computer perception systems built into AI-enabled technologies. The student will be able to:	
	05.01	Explain differences between sensing in intelligent vs. non-intelligent machines.
	05.02	Identify basic types of perception algorithms and explain how they are used in real-world applications.
	05.03	Describe and provide examples of the advantages and limitations of sensors and computer perception and their impact on meaning making.
06.0	Describe different types of data and how they are used in AI. The student will be able to:	
	06.01	Identify the different kinds of data we collect and share as Internet users.
	06.02	Define numeric, text, date, graphics and sound types of data that computers use.
	06.03	Distinguish that data requires context to be information.
	06.04	Describe how computers store data using bits (binary digits).
	06.05	Describe and construct a simple model of the data processing cycle (input-processing-output).
	06.06	Define Big Data and describe how it is used in AI.
	06.07	Describe how AI uses data to make predictions or decisions.

CTE Standards and Benchmarks	
	06.08 Define logic and summarize its use in programming, including AI.
07.0	Describe the high-level processes, methods, and conventions used in computer perception. The student will be able to:
	07.01 Describe the differences between human senses vs. animal senses vs. computer sensors in capturing, storing/representing, and making meaning from data.
	07.02 Explain how AI move from sensing data to perceiving meaning for language and vision systems (e.g., sense, perceive, act cycle)
	07.03 Illustrate abstraction hierarchies for speech understanding and perceptual reasoning to highlight the relationship between higher level and lower levels of abstraction in resolving ambiguities in the levels below.
08.0	Identify and describe the types of representations and algorithms designed into AI-enabled technologies. The student will be able to:
	08.01 Identify different types of representations in AI and their uses.
	08.02 Explain how heuristic, combinatorial, state space search algorithms and operators are commonly used in AI to find answers to questions and problems.
	08.03 Identify and describe classification, approximation, inference, optimization, recognition, search families of reasoning algorithms and the work they do.
	08.04 Identify and explain how AI representations and types of reasoning are used in AI systems used in everyday life.
09.0	Explain how agents maintain representations of the world and use them for reasoning. The student will be able to:
	09.01 Explain how representation supports reasoning and reasoning algorithms operate on representations.
	09.02 Describe and provide examples of common implementations of decision trees, rule-based inference, and statistical inference reasoning algorithms and their advantages and limitations in solving problems (human interpretability, transparency).
10.0	Describe machine learning and neural networks in AI-enabled technologies. The student will be able to:
	10.01 Explain the difference between machine learning and human learning.
	10.02 Identify supervised, unsupervised, reinforcement, and transfer learning types of machine learning) and provide examples of the types of problems they solve.
	10.03 Identify CNN, RNN, GAN types of neural networks and the image classification, speech recognition, deep fakes/creativity/art applications they are used in.
11.0	Describe the different methods computers use to learn from data (Machine Learning). The student will be able to
	11.01 Explain how supervised, unsupervised, reinforcement, and transfer learning function.
	11.02 Identify and describe layers (input, hidden, output), activation functions, learning rules and transfer learning components of a neural network and explain how they function.

11.03	Explain how CNN, RNN, GAN types of neural networks function.
11.04	Explain the difference between systems designed using symbolic AI vs neural networks

12.0	**Collect and analyze a data set. The student will be able to:**
12.01	Identify different kinds of data and how they might be used in decision making
12.02	Describe and construct a simple model of the data processing cycle (input-processing-output).
12.03	Collect, organize, manipulate and analyze different types of data using preset spreadsheet functions.
12.04	Analyze one or more online datasets, describe the information the datasets provide, and identify the types of questions it can and cannot answer
12.05	Analyze data to construct informed summaries, decisions, and predictions related to the data.
12.06	Use spreadsheet functions to create tables and graphs to visually represent and communicate data.
12.07	Explain and demonstrate the ways training data influences learning and decisions made by the model.

13.0	**Conduct an investigation of a Machine Learning Model. The student will be able to do:**
13.01	Plan and conduct an experiment using a web tool that trains a machine learning model without coding to train a model to recognize data and distinguish between at least three different categories.
13.02	Predict what information the trained model from your experiment might use to classify data.
13.03	Construct an argument using data that explains how your machine learning experiment model works and evaluate if it was. successful
13.04	Plan and conduct an experiment using a Computer Vision service to analyze an image dataset from an online source.
13.05	Plan and conduct an experiment using a Text Analytics service to analyze a text dataset from an online source.

14.0	**Characterize major elements of intelligent behavior. The student will be able to:**
14.01	Explain differences between intelligent vs. non-intelligent machines.
14.02	Explain common sense reasoning, emotional intelligence, deductive, and inductive reasoning and characteristics of quintessential human intelligence.
14.03	Explain and provide examples of intelligent behavior through computer modeling and robotics.
14.04	Describe the major branches of AI including expert systems, natural language processing, machine perception, machine learning.
14.05	Describe the limitations of AI for natural interaction.

14.06	Identify and debate the issues of AI and consciousness (e.g., human-level consciousness vs. similar outcomes).
14.07	Explain why common-sense reasoning is hard for AI.
14.08	Identify the types of problems that are difficult for AI to solve (e.g, AI General Intelligence/Strong AI, natural language understanding, computer vision)
14.09	Explain the basic concepts involved with determining consciousness and understanding philosophy of mind.
15.0	**Explain how domain knowledge is used in the design of AI systems. The student will be able to:**
15.01	Understand and describe how AIAI systems rely on domain knowledge from many fields including visual perception, linguistics, human behavior, psychology, anatomy and physiology, philosophy, mathematics.
15.02	Explain how domain knowledge in AI systems can be provided by human experts or derived from statistics collected from millions of sentences, images, or expert labeled data.
15.03	Explain and demonstrate how natural language understanding including speech recognition, speech generation, speech translation is used in speech recognition systems.
15.04	Explain and demonstrate how human language can be ambiguous and strategies AI uses to resolve ambiguity.
15.05	Explain and demonstrate how domain knowledge is used to determine ambiguity in human writing.
15.06	Explain and demonstrate how domain knowledge is used to classify, compare, or generate music.
15.07	Explain and demonstrate how domain knowledge is used to play board games and solve puzzles.
15.08	Explain and demonstrate how domain knowledge is used to recognize faces, gestures, and scenes.
15.09	Explain and demonstrate how domain knowledge is used to recognize affect from images (e.g., gestures, facial expressions).
15.10	Explain and demonstrate how domain knowledge is used to recognize sentiment from text or speech.
15.11	Identify and demonstrate the use of domain knowledge in the creation and use of medical diagnosis, finance, or manufacturing systems.
15.12	Understand that domain knowledge and best practices can be one-way human bias can affect the decisions AI systems make, either in the collection and selection of examples to train systems or the interpretation of results of an AI system.
16.0	**Articulate the many types of knowledge needed by AI agents to interact naturally with humans and the current limitations of AI to interact naturally with humans. The student will be able to:**
16.01	Identify how natural language understanding of tone, speaker intent and similar attributes impacts AI systems.
16.02	Explain why it is challenging for AI to demonstrate common sense reasoning to include identification of characteristics of commonsense knowledge and causal reasoning how these differ from encyclopedic knowledge and statistical inference.
16.03	Explore the knowledge and techniques used by AI systems to understand and recognize human affect or emotion and sentiment

16.04	Identify and describe the range of natural interactions used to develop AI applications.
16.05	Explore the AI techniques used to approximate human creativity (e.g., art, music, prose)
16.06	Explore the techniques use to facilitate smooth human-robot interaction.
16.07	Explore the limitations of AI for supporting natural interactions.
16.08	Identify, explain and debate the issues of AI and consciousness.
16.09	Construct a chatbot and describe the factors that constrain the range of responses.
16.10	Experiment with software that recognizes emotions in facial expressions.
16.11	Describe the types of tasks where AI outperforms humans and those where humans outperform AI.
17.0	Understand and articulate how AI can impact society in both positive and negative ways. The student will be able to:
17.01	Explain the ways that AI Impacts different communities/people in different ways.
17.02	Demonstrate the use of AI is an economic driver that makes new services possible and businesses more efficient.
17.03	Describe the ways AI technologies are changing business, healthcare, education, and government.
17.04	Explain and provide examples of the ways AI and robotics will change the way people work, create new jobs, and eliminate some jobs.
17.05	Identify, research, and analyze current events in the field of AI, considering new technology developments, social and ethical impact, and future implication.
17.06	Identify and describe current challenges and opportunities in AI technologies using non-Machine Learning aspects of AI such as genetic algorithms, robotics, and computer vision.
17.07	Make predictions about the future trends or developments in the field of AI based on current AI applications.
17.08	Research the purpose of organizations that consider how AI can be used for social and ethical good and describe their role in AI development.
17.09	Define and compare ethical and legal implications of AI.
17.10	Identify and describe ethical and societal AI issues in a variety of settings such as public safety, financial implications, social media marketing, government uses, different cultures and countries.
17.11	Analyze participation in collective online activities considering the possibilities over problems, opportunities over risks, and community successes over personal gain.
17.12	Explain the ethical use of technology and digital content with a specific understanding of ownership, licensing, and fair use.

17.13	Students understand consequences of inappropriate technology use.
18.0	**Explain the best practices and key characteristics of bias, fairness, transparency, explainability, accountability of ethically designed AI systems and decision-making practices. The student will be able to:**
18.01	Define bias, perception, privacy, and accuracy in the context of AI.
18.02	Explore potential examples of bias using a web tool that trains a machine learning model without coding.
18.03	Describe and critique how ethics and philosophy explicitly and implicitly play a role in AI applications.
18.04	Explain the ways in which developing an AI application involves humans making numerous technical and ethical decisions.
18.05	Explain the key principles of responsible and ethical AI design that result in AI systems that keep fairness, transparency, explainability, human-centeredness, privacy and security interests of users in mind.
18.06	Explain the range of views on the need for and types of ethical standards for AI systems that make decisions about people.
18.07	Describe the importance of minimizing bias in AI systems to increase people's trust in AI systems.
18.08	Identify the sources of bias in AI systems and models and explain the key approaches to minimizing bias.
18.09	Describe group and individual types of fairness and various views of fairness that affect the metrics for evaluating fairness in systems.
18.10	Describe model, algorithm, data, goals, outcomes, compliance, influence, and usage principles of transparency in AI and explain the regulatory, responsibility, privacy, security considerations that are important when making decisions with AI systems.
18.11	Explain the challenges of implementing transparency in AI for companies such as vulnerabilities and security, privacy, intellectual property, legal and risk management.
18.12	Provide examples of how explainability vs. interpretability is the most effective means of ensuring AI solutions are transparent, accountable, responsible, fair, and ethical across use cases and industries.
18.13	Provide examples of the judgements humans in the loop make in the development of AI, and the responsibility they have to consider the system's impact in the world.
18.14	Explain how AI designers and developers have an ethical responsibility to be able to explain how AI systems and their components work.
18.15	Provide examples or explain how a company, developer, or decision maker can establish accountability in the development and use of AI to make decisions (e.g., codes of ethics/responsible design, ethical design consideration and choices, and decision tracking).
18.16	Understand the subjective nature of values across cultures and describe the key principles, importance, and challenges of designing AI to align with the norms and values of the user group in mind (e.g., understanding user's values, culture, and norms; defining the value system the AI system is designed for).
18.17	Describe the expertise and process needed to ethically design AI to support users (e.g., multi-disciplinary team incl. Ethicist/sociologist, developers, legal/compliance, tracking, etc.).
19.0	**Identify deep fakes and explain critical Information processing. The student will be able to:**

CTE Standards and Benchmarks
19.01   Distinguish between credible and unreliable information sources.
19.02   Recognize and describe signs of compromised information or data.

Florida Department of Education
Student Performance Standards

Course Title: **Applications of Artificial Intelligence**
Course Number: **Pending**
Course Credit: **0.5**

Course Description:

The purpose of this course is to assist students in deepening understanding for application of AI and to explore methods and tools utilized to build AI models. The content includes but is not limited to foundational knowledge and skills related to methods and software used to develop AI applications using data sets. Instruction and learning activities are provided in a laboratory setting using hands-on experiences with the equipment, materials and technology appropriate to the course content and in accordance with current practices.

CTE Standards and Benchmarks
20.0   Design and evaluate a perception system and its limits. The student will be able to:
20.01   Use a software tool such as a speech transcription or visual object recognition demo to demonstrate machine perception.
20.02   Explain the difference between sensing and perception.
20.03   Illustrate how sequences of sounds can be recognized as candidate words, even if some sounds are unclear.
20.04   Illustrate how face detection works by extracting facial features.
20.05   Illustrate and explain how outlines of partially occluded (blocked) objects in an image differ from the real shapes of the objects and the affects this has on accurate object recognition.
20.06   Demonstrate how a text to speech system can resolve ambiguity based on context, and how its error rate goes up when given ungrammatical or meaningless inputs.
20.07   Describe how domain knowledge needs to encompass the diversity of groups an application is intended to serve.
20.08   Classify a given image and describe the kinds of knowledge a computer needed to understand classifications of this type.
20.09   Analyze one or more online image datasets and describe the information the datasets provide and how this can be used to extract domain knowledge for a computer vision system.
20.10   Describe how a vision system might exhibit cultural bias if it lacked knowledge of objects not found in the culture of the people who created it.
20.11   Describe the technical difficulties in making computer perception systems function well for diverse groups.
21.0   Train and evaluate a range of ML models based on specific accuracy, inclusivity, and ethical design criteria. The student will be able to:

	21.01	Demonstrate how to train a computer to recognize something.
	21.02	Train a classification model using machine learning and examine the accuracy of the model on new inputs.
	21.03	Using software to calculate misclassification rates and comparing classification algorithms/models to decide which is the better based on total misclassification rate.
	21.04	Explain how a goodness of fit measure can be used to quantify the success of the prediction made by the algorithm/model.
	21.05	Train and evaluate a classification or prediction model using machine learning on a tabular dataset.
	21.06	Use a supervised or unsupervised learning algorithm to train a model on real world data, then evaluate the results.
	21.07	Evaluate the accuracy, inclusivity, and ethical design of the model
	21.08	Explore and utilize packages from a data analysis and manipulation tool when training a machine learning model.
	21.09	Utilize visual reporting and statistical tools to perform, understand, and interpret statistics such as regression analysis, ANOVA, hypothesis testing, and sampling distributions.
22.0		Design and evaluate a data set to solve a problem using specific accuracy, inclusivity, ethical design criteria. The student will be able to:
	22.01	Explain the data pipeline including data collection, manipulation, cleansing, and transformation and describe how these can be used to ethically and responsibly improve datasets.
	22.02	Define and explain the difference between training, validation, and test datasets.
	22.03	Define and distinguish between balanced and imbalanced datasets and Identify potential problems with imbalance datasets.
	22.04	Identify different kinds of data and how they might be used in decision making
	22.05	Identify patterns in labeled data and determine the features that predict labels.
	22.06	Demonstrate how supervised learning identifies patterns in labeled data.
	22.07	Demonstrate how unsupervised learning finds patterns in unlabeled data.
	22.08	Create a labeled dataset with explicit features to illustrate how computers can learn to classify things like foods, movies, or toys.
	22.09	Create a labeled dataset to solve a problem and note the range of labels that can be used to describe the dataset depending on the problem and desire solution space.
	22.10	Identify, evaluate, and utilize existing datasets from reliable sources to train machine learning models.
	22.11	Identify bias and ethical factors to consider when evaluating sources of data.

CTE Standards and Benchmarks

	22.12	Evaluate and discuss the sources of bias in the dataset and use ethical design principles to address the issues.
	22.13	Explain and demonstrate the ways training data influences learning and decisions made by the model.
23.0	Design AI solutions using embedded computing. The student will be able to:	
	23.01	Identify and define the function of circuits, sensors, microcontrollers, motors, and other components used in embedded systems.
	23.02	Assemble an embedded or robotic system that use circuits, sensor(s), microcontroller, microcomputers, motor(s) to complete a specific task.
	23.03	Write a program for an embedded or robotic system that makes a decision based on sensor/user input, controls mechanics of the robot, and completes a "human" task (e.g., delivers items, opens a door for someone, solves a puzzle, etc.).
	23.04	Use a problem-solving method to debug hardware issues.
24.0	Explore the characteristics, tasks, work attributes, options, and tools associated with AI-enabled careers. The student will be able to:	
	24.01	Explore a variety of careers that leverage AI tools and systems.
	24.02	Discuss the impact of AI on business and commerce.
	24.03	Evaluate the impacts of irresponsible use of AI technologies.
	24.04	Identify tasks performed by AI-enable professionals.
	24.05	Identify and explain the ways businesses use AI to solve business problems.
	24.06	Investigate AI-enabled career opportunities in business, medicine, engineering, construction, science, social services, government, military, computing, education, manufacturing, and finance/banking fields.
	24.07	Explain different specializations and the related training in AI-enabled careers.
	24.08	Explain the need for continuing education and training of AI-enabled professionals.
	24.09	Explain how AI is used in enterprise software systems and how insights from AI impact decision-making.
	24.10	Describe ethical responsibilities of AI-enabled professionals.
	24.11	Identify credentials and certifications that may improve employability for an AI-enabled professional.
	24.12	Identify devices, datasets, tools, and other environments for which AI-enabled professionals may use, modify, and develop AI systems
	24.13	Students learn that people in various work roles engage in continuous learning to upgrade skills and adapt to change

	24.14	Students execute projects that demand critical and creative thinking, planning and problem-solving using research and investigation skills
	24.15	Students learn that people in various work roles engage in continuous learning to upgrade skills and adapt to change
25.0		Identify how leadership development, school and community service projects and competitive events are integral parts of career and technology education. The student will be able to:
	25.01	Explain the goals, mission, and objectives of the career-technical student organization (CTSO).
	25.02	Explore the impact and opportunities a student organization can develop to bring business and education together in a positive working relationship through innovative leadership and career development programs.
	25.03	Explore the local, state, and national opportunities available to students through participation in related student organization including but not limited to conferences, competitions, community service, philanthropy, and other CTSO activities.
	25.04	Explain how participation in career and technology education student organizations can promote lifelong responsibility for community service and professional development.
	25.05	Explore the competitive events related to the content of this course and the required competencies, skills, and knowledge for each related event for individual, team, and chapter competitions.
	25.06	Students learn that learning can occur in both formal and informal environments and seek opportunities outside of school.
	25.07	Express a positive attitude towards lifelong learning and how it relates to various careers.
	25.08	Students begin to familiarize themselves with and adopt professional qualities such as self-management, agency, self-efficacy, initiative and enterprise.
	25.09	Students learn that people in various work roles engage in continuous learning to upgrade skills and adapt to change.
	25.10	Students execute projects that demand critical and creative thinking, planning and problem-solving using research and investigation skills.
26.0		Use appropriate tools to design an AI System to solve problems. The student will be able to:
	26.01	Select a dataset that is appropriate for a given AI application.
	26.02	Curate and clean a dataset for use.
	26.03	Employ one or more technological tools such as data science, machine learning, natural language processing, neural networks, decision-tree, signal procession, computer vision, and facial recognition to expedite workflow.
	26.04	Provide examples of how AI can inform and drive decision-making and automatization.
	26.05	Use an ethical development process to create, analyze and iterate an AI-enabled solution, individually and collaboratively.
	26.06	Distinguish between the range of tools and services available for AI-enabled professionals and AI experts/developers/engineers.

	26.07	Determine the computing resources (e.g., desktop vs GPU) and time needed (e.g., minutes, hours, days, weeks) to complete a ML/AI task.
	26.08	Identify and research networks and cloud services that use AI solutions (Neural Networks, data management, different industry-specific solutions and services, Edge AI).
	26.09	Identify AI in a variety of industry solutions and services and make appropriate recommendations of AI applications based on an industry need.
	26.10	Define and identify and use basic functions of proprietary AI tools.
27.0		Characterize important issues related to privacy and security in the development and use of AI-enable technologies. The student will be able to:
	27.01	Identify and debate the range of views on government regulation of AI usage due to concerns such as privacy, ethics, and security.
	27.02	Identify AI and ethics-related laws and analyze their impact on digital privacy, security, intellectual property, network access, contracts, and harassment.
	27.03	Identify the methods/techniques for collecting data from people and explain the privacy and security risks to people for whom data is collected for use in training machine learning models.
	27.04	Discuss security and privacy issues that relate to networked AI Applications.
	27.05	Explain and demonstrate how training data influences learning.
28.0		Explain the key technical challenges in design and responsible use of AI technologies. The student will be able to:
	28.01	Explain and demonstrate how training data influences learning
	28.02	Explain how developing an AI application involves humans making numerous technical and ethical decisions
	28.03	Explain the current issues with explainability of decisions made with neural networks and other deep learning architectures
	28.04	Explore the challenges of using explainable AI (e.g., cost, ability to develop solutions when issues are discovered)
29.0		Set up and use a ML pipeline to solve a problem. The student will be able to:
	29.01	Identify problem that can be solved with ML.
	29.02	Use appropriate techniques and best practices for selection, collection, and/or curation of data to gain insight on a problem.
	29.03	Use appropriate techniques and best practices for selection of algorithms and architectures to develop and train a model to solve a problem.
	29.04	Use of appropriate tools to evaluate the quality and accuracy of the model.

	29.05	Use of appropriate tools and techniques to deploy and use model.
	29.06	Evaluate the important issues related to privacy and security in the development and use of ML models
	29.07	Demonstrate awareness of the issues that arise in model use (e.g., model degradation) and best practices for maintaining the accuracy of deployed models.
	29.08	Demonstrate an awareness that training a machine learning model is an iterative process that requires time and compute resources.
30.0	Appropriately use automated AI services to accomplish common tasks. The student will be able to:	
	30.01	Train a ML model and deploy a model as a service.
	30.02	Select and use of appropriate techniques for setting up a workspace, create computing resource, and exploring data.
	30.03	Create and run a training pipeline, evaluate a regression model, create an inference pipeline, deploy a predictive service.
	30.04	Selection and use of appropriate AI services to create a regression model that predicts numeric values.
	30.05	Selection and use of appropriate AI services to create a clustering model that groups similar entities based on their features.
	30.06	Selection and use of appropriate AI services to create a classification model that predict categories or classes.
	30.07	Selection and use of appropriate AI services to detect and analyze faces.
	30.08	Selection and use of appropriate AI services to analyze and classify images.
	30.09	Selection and use of appropriate AI services to detect objects in images.
	30.10	Selection and use of appropriate AI services to read and analyze text.
	30.11	Selection and use of appropriate AI services to recognize and synthesize speech.
	30.12	Selection and use of appropriate AI services to translate.
	30.13	Selection and use of appropriate AI services to create a language model with language understanding.
	30.14	Selection and use of appropriate AI services to build a QnA or language understanding bot.
31.0	Explain and use design thinking to solve a problem. The student will be able to:	
	31.01	Distinguish between social and personal problems to be solved through a design.
	31.02	Identify a challenge of social importance and personal interest.

	31.03	Students develop problem statements embedded within a complex challenge.
	31.04	Understanding challenges and user needs more deeply.
	31.05	Pattern and sort user data to define design challenges.
	31.06	Use a formal brainstorming process to generate ideas.
	31.07	Test and iterate prototypes.
	31.08	Refine prototypes based on user feedback.
	31.09	Create stakeholder maps.
	31.10	Develop point-of-view statements for users.
	31.11	Develop a blueprint for a prototype.
	31.12	Gather feedback from users.
	31.13	Revise prototypes and present rationale for final design.
32.0		Show how a system is composed and interacts and be able to express verbally, graphically and in writing how the system functions. The student will be able to:
	32.01	Recognize and define components of an AI system.
	32.02	Determine the purpose and function of different systems.
	32.03	Draw arrows showing how one part interacts with other parts. Students tell a story about the interactions between parts of a system (in writing and verbally).
	32.04	Observe and analyze different systems that have the same outcome (for example, how one class transitions from reading to lunch compared to another class).
	32.05	Apply multiple literacies (data, information, historical, etc) to identify and understand problems; ask appropriate questions; and design an appropriate solution.
	32.06	Reflect on cause and effect within an observed system.
	32.07	Recognize relationships between variables in a system (feedback loops, interactions between human and physical environment, different information sources related to the same problem).
	32.08	Complete a systems map demonstrating interrelationships between components of a system.
	32.09	Select, observe, and improve a specific component of a system.

	32.10	Conduct interviews and use empathy to understand the role of specific stakeholders within a system.
33.0	**Understand and interpret different types of data. The student will be able to:**	
	33.01	Observe and measure differences between objects, (qualitative or quantitative) and uses charts/graphs to illustrate differences.
	33.02	Understand and explain how information can be collected, used, and presented.
	33.03	Recognize and understand data in various forms including charts, graphs, text, etc.
	33.04	Identify and understand the roles of databases in everyday life.
34.0	**Understand how data is accessed, sorted, and stored. The student will be able to:**	
	34.01	Explain the role that computers play in storing and accessing data.
	34.02	Describe databases and how they organize and transform data.
	34.03	Understand data sets with multiple categories/arranged in scaled graphs (one bar represents 5 items).
	34.04	Collect, organize, manipulate, and transform data, and identify databases.
	34.05	Create a model and use data from a simulation.
	34.06	Understand and show ability to represent and manipulate data/data bases.
	34.07	Explain how computing devices represent and manipulate information.
	34.08	Create, modify, and manipulate databases.
35.0	**Generate and tell stories with data. The student will be able to:**	
	35.01	Collect, organize and arrange data into charts/graphs.
	35.02	Identify structural components of data representations (e.g. axes on a graph, table rows and columns, scale on a geographic map, key on a color map.
	35.03	Organize data and tell the data story presented in simple charts and graphs.
	35.04	Interpret and explain more complex charts that record more variables.
	35.05	Decode data: Identify and extract measurements, values or data points and what they represent from graphs, tables, or other data representations.

CTE Standards and Benchmarks	
35.06	Identify structural components of data representations (e.g. axes on a graph, table rows and columns, scale on a geographic map, key on a color map.
35.07	Identify most appropriate visualization for a given data set.
36.0	Think critically about data. The student will be able to:
36.01	Understand and explain how data changes over time; e.g. weather through seasons.
36.02	Analyze information and derive conclusions based on data presented.
36.03	Show ability to interpret and make predictions based on data that changes over time.
36.04	Interpret data representations accurately; identify potential bias and missing data; accurately connect position statements with data sets that support them.
36.05	Decode, analyze and interpret data describing meaningful patterns, separate factual information from inferences.
36.06	Analyze and interpret data and identify and describe meaningful patterns in data.
36.07	Make quantitative and qualitative comparisons of data; communicate scientific information/tell a story with data.
36.08	Separate factual information from inferences,
36.09	Use data, math, and statistics to develop and/or support claims that address specific scientific questions.

Florida Department of Education
Student Performance Standards

Course Title: **Procedural Programming**
Course Number: **PENDING**
Course Credit: **1**

Course Description:

The purpose of this course is to provide students with the computer programming skills necessary to perform AI applications using data sets. The content includes but is not limited to foundational knowledge and skills related to computer coding and software development. Instruction and learning activities are provided in a laboratory setting using hands-on experiences with the equipment, materials and technology appropriate to the course content and in accordance with current practices.

CTE Standards and Benchmarks
37.0 Design a computer program to meet specific physical, operational and interaction criteria. The student will be able to:
37.01 Choose appropriate data types depending on the needs of the program.
37.02 Define appropriate user prompts for clarity and usability (*e.g.*, user guidance for data ranges, data types).
37.03 Design and develop program for efficiency (*e.g.*, less memory usage, less inputs/outputs, faster processing).
37.04 Compare techniques for analyzing massive data collections.
37.05 Identify the software environment required for a program to run (*e.g.*, operating system required, mobile, web-based, desktop, delivery method).
37.06 Create mobile computing applications and/or dynamic webpages through the use of a variety of design and development tools, programming languages and mobile devices/emulators.
37.07 Explain the role of an application programming interface (API) in the development of applications and the distinction between a programming language's syntax and the API.
37.08 Identify the tools required to develop a program (*e.g.*, editors, compilers, linkers, integrated development environments, APIs, libraries).
37.09 Use an industrial-strength integrated development environment to implement a program.
38.0 Create and document a computer program that uses a variety of internal and control structures for manipulating varied data types. The student will be able to:
38.01 Use appropriate naming conventions to define program variables and methods.
38.02 Use a program editor to write the source code for a program.

	38.03	Write programs that use selection structures.
	38.04	Write programs that use repetition structures.
	38.05	Write programs that use nested structures.
	38.06	Use internal documentation (*e.g.*, single-line and multi-line comments, program headers, module descriptions, meaningful variable and function/module names) to document a program according to accepted standards.
	38.07	Compile, run, test and debug programs.
	38.08	Write programs that use standard arithmetic operators with different numerical data types.
	38.09	Write programs that use standard logic operators.
	38.10	Write programs that use a variety of common data types.
	38.11	Write programs that perform data conversion between standard data types.
	38.12	Write programs that define, use, search, and sort arrays.
	38.13	Write programs that use user-defined data types.
	38.14	Demonstrate understanding and use of appropriate variable scope.
	38.15	Explain recursive programming structure.
	38.16	Use global and local scope appropriately in program implementation.
39.0		Create and document an interactive computer program that employs functions, subroutines, or methods to receive, validate, and process user input. The student will be able to:
	39.01	Critically examine classical algorithms and implement an original algorithm.
	39.02	Write programs that perform user input and output.
	39.03	Write programs that validate user input (e.g., range checking, data formats, valid/invalid characters).
	39.04	Write program modules such as functions, subroutines, or methods.
	39.05	Write program modules that accept arguments.
	39.06	Write program modules that return values.
	39.07	Write program modules that validate arguments and return error codes.

CTE Standards and Benchmarks	
39.08	Design and implement a simple simulation algorithm to analyze, represent and understand natural phenomena.
39.09	Use APIs and libraries to facilitate programming solutions.
39.10	Participate in a peer code review to verify program functionality, programming styles, program usability, and adherence to common programming standards.
40.0	Demonstrate responsible use of technology and information. The student will be able to:
40.01	Explain the principles of cryptography by examining encryption, digital signatures, and authentication methods (e.g., explain why and how certificates are used with https for authentication and encryption).
40.02	Implement an encryption, digital signature, or authentication method.
40.03	Describe computer security vulnerabilities and methods of attack and evaluate their social and economic impact on computer systems and people.

Florida Department of Education
Student Performance Standards

Course Title: **Foundations of Machine Learning**
Course Number: **PENDING**
Course Credit: **1**

Course Description:

The purpose of this course is to provide students with core foundational knowledge to deepen understanding of machine learning (ML) practices and applications. This course builds understanding of the mathematical foundation needed to create algorithms for use in artificial intelligence and machine learning. The content includes but is not limited to foundational knowledge and skills related to computer coding and software development. Instruction and learning activities are provided in a laboratory setting using hands-on experiences with the equipment, materials and technology appropriate to the course content and in accordance with current practices.

CTE Standards and Benchmarks	
41.0	Explain the nature of representations and their importance in AI. The student will be able to:
41.01	Identify examples of abstractions used in everyday life, describe the characteristics of abstractions, and explain how they are different than their real-world counterparts.
41.02	Describe the two major types of knowledge representations (i.e., symbolic and numerical representations), identify examples of each type, and explain when each is used in AI solutions.
41.03	Explain how and when data structures (e.g., trees, graphs, arrays, schema) are used to represent data in AI (e.g., search trees, decision trees, maps, 1D Arrays -feature vectors. 2D-Arrays – tables, matrices).
41.04	Construct a representation of data, game, map, or real-world object/scenario/problem using a data structure (e.g., graph – map or game board, tree – classification and moves in a game, array – feature vector, schema – description of a concept), identify the parts of the representation and explain how to reason with them.
41.05	Evaluate and use the appropriate data structure for programming a specific machine learning algorithm.
41.06	Explain how representations work with reasoning to solve problems.
41.07	Research the different kinds of symbolic representations used to encode information about the world (e.g., symbols, relationships, properties, etc.) in ways a computer can reason with to solve complex tasks (i.e. diagnosing a medical condition or having a dialog in a natural language).
41.08	Construct a feature vector representation for a set of objects or word embeddings and explain how distance is used to determine the similarity and difference between objects or words in the feature space.
42.0	Use search algorithms to reason with symbolic representations. The student will be able to:
42.01	Identify types of real-world problems that are search problems and describe their states and operators.

	42.02	Illustrate how a computer can represent the playing of a game (e.g. tic-tac-toe) by drawing the sequence of board positions produced by the players' moves.
	42.03	Describe the search space for graph and tree search algorithms and explain legal and illegal moves.
	42.04	Model the process of solving a graph search problem (e.g., games, mazes, maps, reason about concepts) using breadth-first, depth-first, and best-first search to draw a search tree.
	42.05	Compare and contrast the advantages and disadvantages (e.g., cost, space, time complexity) of using breadth-first, depth-first, and best-first search to solve a problem.
43.0	Explain the relationship between representation and reasoning. The student will be able to:	
	43.01	Describe the ways in which AI uses computer science concepts such as data structures (representations) and algorithms (reasoning methods) to solve problems.
	43.02	Describe the mutual dependence between representation and reasoning-representations support reasoning; reasoning methods operate on representations.
	43.03	Describe how reasoning with symbolic representations is performed using logical inference rules.
	43.04	Describe how reasoning with numerical representations utilizes complex mathematical functions such as neural networks.
44.0	Explain the nature of machine learning. The student will be able to:	
	44.01	Define machine learning as a set of techniques (algorithms) that allow a computer to learn behaviors without explicit programming.
	44.02	Explain that machine learning algorithms are learning "patterns" in data to construct internal representations that encode the relationship between inputs and outputs and result in a model for reasoning (e.g., reasoner).
	44.03	Model and explain how machines learn new behaviors due to changes/adjustments the learning algorithm makes to internal representations of a decision tree or a neural network reasoning model.
	44.04	Illustrate and compare how supervised, unsupervised, and reinforcement learning algorithms adjust internal representations to learn for classification or prediction.
	44.05	Explain the similarities and differences between how humans and machine learning algorithms learn.
45.0	Use and evaluate supervised learning techniques to classify or predict outputs. The student will be able to:	
	45.01	Research and present real-world problems and applications of supervised learning.
	45.02	Describe how supervised learning algorithms find relationships between feature values and class labels in labeled data to create classification or prediction models.
	45.03	Explain how supervised learning models use features to predict or label new data.

CTE Standards and Benchmarks	
	45.04 Describe how supervised learning algorithms adjust the parameters of a mathematical model (selected in advance by a human) to create models that make correct classifications or predictions.
	45.05 Evaluate the results of a supervised learning model by measuring the percent of items in a test set that are labeled correctly.
	45.06 Describe the types of algorithms that are used for classification (e.g., decision trees, NN, logistic regression).
	45.07 Describe the types of algorithms that are used for regression (e.g., decision trees, NN, linear regression).
	45.08 Evaluate the accuracy of a classification model using root mean squared error.
	45.09 Describe the benefits and limitations of supervised learning algorithms for solving problems.
46.0	Use and evaluate unsupervised learning techniques to solve problems. The student will be able to:
	46.01 Research and present real-world problems and applications of unsupervised learning (e.g., anomaly detection in fraud and medical images, groups of customers who buy similar products, recommender systems).
	46.02 Describe how unsupervised learning algorithm finds patterns in unlabeled data by looking for data grouped into clusters.
	46.03 Explain how an unsupervised learning models is trained to assign each input to a cluster of similar inputs.
	46.04 Explain how unsupervised learning differs from supervised learning and how this difference allows unsupervised learning algorithms to solve more complex problems than supervised learning algorithms.
	46.05 Distinguish between data that are appropriate for supervised versus unsupervised learning based on its structure, particularly the presence and roles of inputs and outputs.
	46.06 Explain how clustering works and the types of problem clustering algorithms solve.
	46.07 Use clustering algorithms (e.g., K-Means, hierarchical clustering, principal component analysis) to solve a problem.
	46.08 Use an unsupervised learning algorithm to generate a decision tree to predict numerical outcomes using 1 or 2 features/variables. Fit and interpret a regression tree using software.
	46.09 Evaluate the results of an unsupervised learning model by examining the clusters to see if they capture useful distinctions in the dataset (e.g., If the clustering algorithm separates dissimilar observations apart and similar observations together, then it has performed well).
	46.10 Describe the limitations of clustering algorithms (e.g., identification of clusters even if the data does not contain any clusters, unable to understand why elements are clustered together).
47.0	Use and evaluate reinforcement learning techniques to solve problems. The student will be able to:
	47.01 Research and present real-world problems and applications of reinforcement learning (e.g. self-driving cars, walking, learning a new skill, video games, question answering, machine translation, medical diagnosis, sequential decision making problems).

47.02	Explain that reinforcement learning models focus on how machines can learn to act in a particular way (e.g., robots learning to walk, or chatbots learning to better answer customer problems).
47.03	Describe how reinforcement learning generally works: the learning algorithm uses trial and error to find a policy for choosing actions that maximizes the reinforcement signal.
47.04	Model the ways that reinforcement learners update value predictions or policies (e.g., internal representations).
47.05	Use reinforcement algorithms to solve a problem (e.g., Deep Adversarial Networks, Q-learning).
47.06	Describe the benefits and limitations of reinforcement learning.
48.0	**Use and evaluate different types of neural network architectures and their applications. The student will be able to:**
48.01	Illustrate the two main components of a Generative Adversarial Network's (GAN) architecture (i.e., generator and discriminator models) and explain how each component works to create realistic images and audio.
48.02	Illustrate the architecture of a convolutional neural network (CNN) and explain the motivation for the model and how it is optimized for computer vision tasks (e.g., image processing, natural language processing, and recommendation systems).
48.03	Illustrate the architecture of a recurrent neural network (RNN) and explain how it is optimized for time-series forecasting (e.g., weather prediction, stock predictions, etc.).
48.04	Describe the purpose of ensemble learning methods and how they are used to improve the performance of machine learning models and identify examples in the real-world.
48.05	Describe the purpose of transfer learning methods and how it is used to decrease the amount of training time for new tasks and identify examples in the real-world.
49.0	**Illustrate Neural Networks and their components. The student will be able to:**
49.01	Describe and illustrate the fundamental components of a neural network (e.g., input, hidden layers, output) and their purpose.
49.02	Explain the roles hyperparameters, activation functions, learning rules, and transfer functions play in the development of a machine learning model.
49.03	Illustrate and explain how backpropagation works to improve how machines learn.
49.04	Illustrate and explain how stochastic gradient descent works.
49.05	Research and explain how deep neural networks work.
49.06	Illustrate and explain how Feedforward multi-layer work.
49.07	Illustrate and explain how a perceptron work.
50.0	**Recognize and identify mathematical principles upon which machine learning and AI are built such as calculus, linear algebra, probability, statistics, and optimization partial derivatives. The student will be able to:**

CTE Standards and Benchmarks	
50.01	Explain how machine learning uses statistics to find patterns in data to make predictions about future values, identify the relationship between features, and make improvements.
50.02	Identify the type of mathematical functions machine learning models use (e.g., a simple linear equation, a high-degree polynomial, or an even more complex nonlinear equation such as a deep neural network).
50.03	Recognize that neural networks are non-convex function composed of many multi-variable functions.
50.04	Illustrate and explain the role of gradient based algorithms for training neural networks and related issues.
50.05	Use a linear regression model and then adjust its parameters to fit a set of data points and use the model to predict a y value for any x value.
50.06	Model polynomial or logistic regression by using tools to manually adjust the parameters to reach what they perceive as a best fit to the data.
50.07	Evaluate the quality of fit of a machine learning model using the mean squared error to determine if they have been over-fitted or under-fitted and explain the implications for future predictions or classifications made by the model.
50.08	Utilize visual reporting and statistical tools to perform, understand, and interpret statistics such as regression analysis, ANOVA, hypothesis testing, and sampling distributions.
51.0	Use the most common machine learning algorithms to solve a problem. The student will be able to:
51.01	Construct a decision tree to solve a classification or prediction problem and explain the pros and cons of using this approach to solve the problem.
51.02	Construct a neural network to solve a classification or prediction problem and explain the pros and cons of using this approach to solve the problem.
51.03	Construct a linear regression model to predict a time-series value and explain the pros and cons of using this approach to solve the problem.
51.04	Use K nearest neighbor algorithm to solve classification and regression problems and explain the pros and cons of using this approach to solve the problem.
51.05	Construct machine learning using a naïve Bayes algorithm to solve a classification problem and explain the pros and cons of using this approach to solve the problem.
51.06	Construct machine learning using support vector machines (SVM) algorithm to solve a classification or regression problem and explain the pros and cons of using this approach to solve the problem.
52.0	Identify the types of problems that can be solved with machine learning algorithms. The student will be able to:
52.01	Describe the kinds of reasoning problems machine learning algorithms can solve (e.g., classification, prediction, sequential decision making, regression, search, heuristic search, logical deduction, statistical inference).
52.02	Categorize real-world problems as classification, prediction, sequential decision problems, combinatorial search, heuristic search, adversarial search, logical deduction, or statistical inference.

	52.03	Describe the kinds of reasoning problems and the machine learning algorithms that can be used to solve them (e.g., supervised learning, used for classification and prediction; unsupervised learning, used for clustering; and reinforcement learning, used for sequential decision making.
	52.04	Select the appropriate type of machine learning algorithm (supervised, unsupervised, or reinforcement learning) to solve a reasoning problem and explain why this algorithm is most appropriate for this type of problem.
	52.05	Evaluate the pros and cons between two approaches to solving a reasoning problem (e.g., decision tree vs visual classifier).
53.0	Evaluate the sources of bias in machine learning/AI and identify appropriate mitigation strategies. The student will be able to:	
	53.01	Recognize that machine learning models and AI systems are inherently socio-technical system that have requirements spanning hardware, software, personal, and community aspects. Thus, an incident in a socio-technical system is not just a technical problem but also a social problem between humans that requires coordination.
	53.02	Examine the role and importance of taking a human-in-the-loop approach to the training of machine learning models and deployment and use of AI-driven automation of systems.
	53.03	Identify the critical points of machine learning model and AI system design (e.g., goals, purposes, and risks) that are not easily identified by automation itself and require human-in-the-loop decision making.
	53.04	Identify and address bias in the machine learning and AI system development lifecycle.
	53.05	Evaluate flaws in the model of the world due to sample bias, prejudicial bias, and measurement bias.
	53.06	Examine the ways in which biases and preferences of those who are designing, building, or testing the system may contribute to the systems behaviors or decisions.
	53.07	Evaluate how the system is used in decision making and by whom.
	53.08	Evaluate the role the motivation and purpose for the system or model to be developed influences the system design and behavior.
	53.09	Research proxies in data for race, ethnicity, socio-economic status, gender, or context that can lead to disparate accuracy and impacts on different people groups.
	53.10	Identify characteristics that indicate a problem is framed in a fundamentally problematic way.
	53.11	Determine whether characteristics of dataset (e.g., incomplete, imbalance, and selected inappropriately) are contributing bias to a machine learning model.
	53.12	Evaluate machine learning model for characteristics of measurement bias as a result from faulty measurement (e.g., sources sensors such as camera color filters and distance, data collection instruments, data labeling).
	53.13	Argue for and against the accuracy of the claim that AI can produce more fair results than human.
	53.14	Recognize the many roles that humans play in development of AI models, algorithms, data collection and preparation, model training and use, and decision making.

	53.15	Investigate the ways that prejudice and stereotyping can make their way into data and strategies for mitigating prejudicial bias.
	53.16	Evaluate the goals and acceptable behavior of a particular AI application.
	53.17	Research the ethical, security, and privacy issues that affect data gathering and quality that can contribute to bias in a model.
	53.18	Explain the need for models to be regularly evaluated and updated to best represent the model of current world.
	53.19	Explain the concerns that designers and users of AI systems should have AI is being used in context where there is no objective answer.
	53.20	Explain how accuracy and impact of algorithms cause algorithmic bias.
54.0	Program machine learning algorithms to train a model on real world data, then evaluate the results. The student will be able to:	
	54.01	Identify real world data sets that are appropriate to solve a problem of interest.
	54.02	Use either a supervised or unsupervised learning algorithm to train a model on real world data, then evaluate the results.
	54.03	Quantitatively measure the performance of a trained model on a nontrivial test set.
	54.04	Learning an assortment of machine learning algorithms and understand how to implement them in real-world scenarios.
	54.05	Explain the importance of considering the nature of your dataset when deciding which algorithm to use.
	54.06	Explain and model the use of a cross-validation data sets to evaluate the best model for a problem that avoids overfitting and under-fitting.
	54.07	Describe the role of training data in determining the accuracy and margin of error of the model
	54.08	Evaluate the bias-variance trade-off as an estimation of error of a model and explain the implications for future predictions or classifications made by the model.
55.0	Identify different kinds of data, sources, and how they might be used in decision making. The student will be able to:	
	55.01	Explain why data is the fuel of machine learning and the importance of quality data for gaining insights.
	55.02	Identify and describe sources of company data such as basic information (search trends), economic information, technology information (e.g., website traffic and trends), and reviews-based information (e.g., business rating and reviews).
	55.03	Identify and describe sources of people data such as Internet behavior: web presence score, social networks and social mentions, search engine results, proxy usage, economic information, interests and, spending.
	55.04	Identify and describe sources of geospatial data such as location-specific alternative data such as demographic information, property information, purchasing behavior, business information.

	55.05	Identify and describe sources of time-based data such as real-time information surrounding events, politics, internet trends behavior (e.g., trending keywords and subjects, foot traffic, web traffic), and financial trends: Company share price, GDP, debt history, unemployment trends.).
	55.06	Explain how different kinds of data can be used in decision-making and the form/type (text, numerical, time series, image, categorical) data may be represented in.
56.0		Explain the characteristics, collection, storage, and uses of datasets in AI. The student will be able to:
	56.01	Explain the relationship between the size of a data set needed and the type of problem it is trying to solve.
	56.02	Identify and utilize existing datasets from reliable sources (e.g., Kaggle) to train machine learning models.
	56.03	Collect data from APIs, RSSs, and web scraping
	56.04	Use SQL and NoSQL databases to store and retrieve data and to work with large datasets
	56.05	Explore data wrangling methods such as data inspection and cleaning to prepare data for processing.
	56.06	Use excel or spreadsheet software to view, organize, filter, and clean or separate data.
	56.07	Use programming tools and processes to clean and transform data (e.g., Pandas, Spark, Dask, SQL, Spark SQL, and/or ScrappingHub).
	56.08	Develop an understanding of data management issues in the context of the data science learning cycle.
57.0		Work with datasets to gain insight, using data analysis and visualization tools. The student will be able to:
	57.01	Use good practices for statistical sampling and testing and incorporation of uncertainties in estimation using margins of error or interval estimates to accurately analyze data.
	57.02	Uses statistics to find patterns in data and create a computer algorithm that improves the more it is implemented.
	57.03	Use data analysis techniques to useful discover new or information, guide decision-making, power an application, or be used to tell a story.
	57.04	Explore and utilize packages from a data analysis and manipulation tool when training a machine learning model (e.g., Pandas).
	57.05	Use basic techniques for exploration and analysis of single, pair, and multi-feature models.
	57.06	Build a ML model based on a dataset that trains the computer on how to make decisions.
	57.07	Tell a data story using appropriate visualizations that are clear, compelling and accessible for the audience (e.g., interactive dashboards, static infographics, charts, graphs, etc.).
58.0		Critique data and data-based claims to avoid being misled by data through identifying bias, confounding and random error. The student will be able to:

	58.01	Provide examples of the social and personal consequences of predictions derived from models built on data.
	58.02	Identify and describe errors in decisions and predictions owing to faulty use of data.
	58.03	Describe issues of privacy and security with respect to data collection, storage, analysis, and insights.
	58.04	Discuss how and when data can support making decisions.
59.0		Apply the machine learning life cycle in the development and use of a machine learning model. The student will be able to:
	59.01	Identify a problem to solve and write a problem definition.
	59.02	Evaluate the problem and identify the data needed to solve the problem.
	59.03	Find, convert, clean, and prepare the data for use in constructing a machine learning model.
	59.04	Evaluate, select, and test an appropriate model using the hold-out dataset method.
	59.05	Select and justify the appropriateness of the learning algorithm for your problem and data.
	59.06	Experiment by adjusting hyper-parameters to tune the model.
	59.07	Use a cross-validation set to determine when training should stop to avoid overfitting.
	59.08	Use a test set to measure performance of the machine learning model.
	59.09	Evaluating success of model: setting criteria, what to do when it fails in lab; fails in field. This can be done by an independent group for high-stakes applications.
	59.10	Use appropriate tools to deploy and use the machine learning model.
	59.11	Monitor model use over a span to time to evaluate its effectiveness on unseen data and make improvements.
60.0		Design and develop AI systems to solve a problem or design solutions for social and ethical issues. The student will be able to:
	60.01	Define and research a real social or ethical problem in the community that could be enhanced or solved with AI.
	60.02	Use a problem-solving process (e.g., design thinking) to collaboratively investigate the identified problem and identify requirements.
	60.03	Analyze the requirements and translate the vision to build complete end-to-end AI solutions.
	60.04	Define and apply a team-based software development process to collaboratively design a solution that uses AI for the problem.
	60.05	Identify and use IDEs, APIs, and packages in program development to build and train machine learning models.

	60.06	Design and develop an AI software solution that addresses a researched interest or problem that could be enhanced or solved with AI.
61.0	**Understand how machine learning is applied to solve problems. The student will be able to:**	
	61.01	Name common computer vision tasks (e.g., image classification, object detection, semantic segmentation, image analysis, face detection, analysis, and recognition; optical character recognition (OCR)) and how they might be used to solve problems.
	61.02	Understand the ways natural language processing can be used to create software to solve a wide range of problems related to written and spoken language.
	61.03	Research the current applications of machine learning in innovations in science, medicine, healthcare, banking and investment, engineering, building and construction, education, and criminal justice.
	61.04	Evaluate an AI systems and identify all the forms of machine learning or AI sub-systems contribute to the systems behavior(s).
62.0	**Describe the limitations of machine learning and the decisions that can be made with data. The student will be able to:**	
	62.01	Describe the principle of garbage in/garbage out in relationship to data used to train and evaluate the machine learning model and its accuracy and impact.
	62.02	Demonstrate and understanding of the inverse relationship between model complexity and transparency and the impact this has on decision making.
	62.03	Research and evaluate the limitations of machine learning and AI and the impact this has on decision-making with AI.
	62.04	Research the security vulnerabilities of a machine learning model and ways to mitigate them.
	62.05	Research the potential failure modes of AI and evaluate how, when, and why things can go wrong.
	62.06	Research and evaluate the sensitivity of machine learning models to understand how and why it is likely to break.
63.0	**Evaluate societal impacts of AI on individuals, society, and the environment. The student will be able to:**	
	63.01	Explain the implications of Amara's Law in our ability to, which observes that we over-estimate the impact of any given technology in the short term, and under-estimate it in the long term.
	63.02	Evaluate the beneficial and harmful effects of AI and machine learning on the environment.
	63.03	Evaluate all the ways that you interact with AI directly and indirectly (e.g., use AI-enable system, contribute data to a dataset, trade privacy and security for access to an AI-tool).
	63.04	Research and identify the different ways AI impacts individuals, people groups, and communities in different ways.
	63.05	Research and identify the policies and laws companies and government adhere to when developing and using AI systems.
	63.06	Research and identify the characteristics of jobs/careers that are created and eliminated by AI.

63.07	Research and evaluate the need for continuing education for all careers and age groups impacted by AI.
63.08	Research and evaluate the security issues relevant to machine learning model creation, storage, and usage.
63.09	Research and evaluate the privacy issues relevant to machine learning model creation, storage, and usage.
63.10	Research and illustrate the potential harms and benefits of a specific machine learning model or AI system.
64.0	Evaluate AI applications to ensure they provide solutions to difficult problems without any unintended negative consequences. The student will be able to:
64.01	Use machine learning tools to evaluate the level of fairness a machine learning model has by quantifying the extent to which each feature of the data influences the model's prediction.
64.02	Research and explain the importance of reliability and safety metrics and procedures used in evaluating the level of risk an AI system may pose to human life.
64.03	Research and evaluate the security issues relevant to machine learning model creation, storage, and usage.
64.04	Evaluate the level of Inclusiveness an AI system demonstrates through investigating the degree to which it empowers and engages people, and bring benefits to all parts of society, regardless of physical ability, gender, sexual orientation, ethnicity, or other factors.
64.05	Evaluate the level of transparency an AI system demonstrates through investigating the degree to which users are made fully aware of the purpose of the system, how it works, and what limitations may be expected.
64.06	Research and identify the strategies individuals, companies, and governments use to demonstrate accountability in AI.
65.0	Research and explain the advancements in computing hardware that make AI possible. The student will be able to:
65.01	Explain the original purpose of Graphical Processing Units (GPUs) and their role in advancing the field of deep learning.
65.02	Explain the purpose and function of GPUs in decreasing the training time of machine learning and identify applications that use this approach in the real world.
65.03	Explain the purpose and function of Tensor Processing Unit (TPU) as an AI accelerator application-specific integrated circuit (ASIC) for neural network machine learning and identify applications that use this approach in the real world.
65.04	Explain why CPUs are not sufficient for training most machine learning models.
65.05	Compare and contrast the pros and cons of using GPUs, TPUs, and FPGAs in data processing and performance improvements of AI-based applications.
66.0	Create a portfolio of AI projects that demonstrate ability to program machine learning models using a wide range of AI algorithms. The student will be able to:
66.01	Identify common vendors and range of AI, cognitive services, machine learning, and knowledge mining available to architect and implement AI systems involving natural language processing, speech, computer vision, and conversational AI.

	66.02	Analyze requirements for AI solutions, recommending the appropriate tools and technologies to solve a problem.
	66.03	Develop and explain the development process and architecture of a chatbot.
	66.04	Develop and explain the development process and architecture of a recommender system.
	66.05	Develop and explain the development process and architecture of an application that uses natural language processing.
	66.06	Develop and explain the development process and architecture of an application that uses computer vison.
	66.07	Use regression modeling with linear and logistical regression to make a time series prediction model.
	66.08	Use naive bayes, k-nearest neighbor, and support vector machines to develop a classification model.
	66.09	Use random forest and the accompanying boosting algorithms such as XGBoost and CatBoost to develop a Decision tree model.
	66.10	Use isolated forests, PCA or K-Means clustering to develop an Anomaly detection model.
	66.11	Demonstrate the ability to use regularization, dimension reduction, and cross-validation in the processes of model selection, evaluation, and interpretation.
	66.12	Engage in continuous learning to upgrade skills and adapt to change to complete portfolio projects.
	66.13	Execute projects that demand critical and creative thinking, planning and problem-solving using research and investigation skills.
	66.14	Apply multiple literacies (data, information, historical, etc.) to identify and understand problems; ask appropriate questions; and design an appropriate solution.
	66.15	Explain the usefulness of the AI models they create to a wide range of stakeholders.
67.0		Research and evaluate various AI careers involved in AI system usage, design, development, deployment, and maintenance. The student will be able to:
	67.01	Explain the roles, responsibilities, tools, skills, expertise, and education needed for AI researchers to develop new machine learning algorithms, architectures, applications, and approaches to solve challenging problems.
	67.02	Explain the roles, responsibilities, tools, skills, expertise, and education needed for AI or machine learning engineers to architect and implement AI algorithms, models, and systems.
	67.03	Explain the roles, responsibilities, tools, skills, expertise, and education needed for AI solutions architect to design AI systems that meet the business needs for customers.
	67.04	Explain the tools, skills, expertise, and education needed for data scientists to train machine learning models that can make predictions and inferences based on the relationships they find in the data.
	67.05	Explain the roles, responsibilities, tools, skills, expertise, and education needed for data engineers to design and implement the management, monitoring, security, and privacy of data solutions.

CTE Standards and Benchmarks
67.06   Explain the roles, responsibilities, tools, skills, expertise, and education needed for database administrators to implement and manage cloud and on premises databases that work with AI-base data services.

Additional Information

Laboratory Activities

Laboratory investigations that include scientific inquiry, research, measurement, problem solving, emerging technologies, tools and equipment, as well as, experimental, quality, and safety procedures are an integral part of this career and technical program/course. Laboratory investigations benefit all students by developing an understanding of the complexity and ambiguity of empirical work, as well as the skills required to manage, operate, calibrate and troubleshoot equipment/tools used to make observations. Students understand measurement error; and have the skills to aggregate, interpret, and present the resulting data. Equipment and supplies should be provided to enhance hands-on experiences for students.

Academic Alignment

Secondary Career and Technical Education courses are pending alignment to the B.E.S.T. (Benchmarks for Excellent Student Thinking) Standards for English Language Arts (ELA) and Mathematics that were adopted by the State Board of Education in February 2020. Academic alignment is an ongoing, collaborative effort of professional educators that provide clear expectations for progression year-to-year through course alignment. This initiative supports CTE programs by improving student performance through the integration of academic content within CTE courses.

Florida Standards for English Language Development (ELD)
English language learners communicate for social and instructional purposes within the school setting. ELD.K12.SI.1.1

English Language Development (ELD) Standards Special Notes:
Teachers are required to provide listening, speaking, reading and writing instruction that allows English language learners (ELL) to communicate for social and instructional purposes within the school setting. For the given level of English language proficiency and with visual, graphic, or interactive support, students will interact with grade level words, expressions, sentences and discourse to process or produce language necessary for academic success. The ELD standard should specify a relevant content area concept or topic of study chosen by curriculum developers and teachers which maximizes an ELL's need for communication and social skills. To access an ELL supporting document which delineates performance definitions and descriptors, please click on the following link: http://www.cpalms.org/uploads/docs/standards/eld/SI.pdf.
For additional information on the development and implementation of the ELD standards, please contact the Bureau of Student Achievement through Language Acquisition at sala@fldoe.org.

Special Notes

The occupational standards and benchmarks outlined in this secondary program correlate to the standards and benchmarks of the postsecondary program with the same Classification of Instructional Programs (CIP) number.

Cooperative Training – OJT

On-the-job training is appropriate but not required for this program. Whenever offered, the rules, guidelines, and requirements specified in the OJT framework apply.

Accommodations

Federal and state legislation requires the provision of accommodations for students with disabilities as identified on the secondary student's Individual Educational Plan (IEP) or 504 plan or postsecondary student's accommodations' plan to meet individual needs and ensure equal access. Accommodations change the way the student is instructed. Students with disabilities may need accommodations in such areas as instructional methods and materials, assignments and assessments, time demands and schedules, learning environment, assistive technology and special communication systems. Documentation of the accommodations requested and provided should be maintained in a confidential file.

In addition to accommodations, some secondary students with disabilities (students with an IEP served in Exceptional Student Education (ESE)) will need modifications to meet their needs. Modifications change the outcomes or what the student is expected to learn, e.g., modifying the curriculum of a secondary career and technical education course. Note: postsecondary curriculum and regulated secondary programs cannot be modified.

Some secondary students with disabilities (ESE) may need additional time (i.e., longer than the regular school year), to master the student performance standards associated with a regular Occupational Completion Point (OCP) or a Modified Occupational Completion Point (MOCP). If needed, a student may enroll in the same career and technical course more than once. Documentation should be included in the IEP that clearly indicates that it is anticipated that the student may need an additional year to complete an OCP/MOCP. The student should work on different competencies and new applications of competencies each year toward completion of the OCP/MOCP. After achieving the competencies identified for the year, the student earns credit for the course. It is important to ensure that credits earned by students are reported accurately. The district's information system must be designed to accept multiple credits for the same course number for eligible students with disabilities.

Additional Resources

For additional information regarding articulation agreements, Bright Futures Scholarships, Fine Arts/Practical Arts Credit and Equivalent Mathematics and Equally Rigorous Science Courses please refer to:
http://www.fldoe.org/academics/career-adult-edu/career-tech-edu/program-resources.stml