Framework Articulation for Common Core Math & Next Generation Science

STEM Integrated Robotics: Drones Curriculum

STEM Integrated Robotics: Drones		
Course: STEM Integrated Robotics: Drones		**Total Framework Hours up to: 90**
CIP Code:	☒**Exploratory** ☐**Preparatory**	**Date Last Modified:**
Career Cluster: Science, Technology, Engineering and Mathematics		**Cluster Pathway: Engineering and Technology**

Curriculum Overview
The following is a STEM Integrated Robotics: Drones curriculum outline for an exploratory elective, focusing on the use of MINDS-i Robotics within an elective curriculum. Integrated in the outline are the essential components of four core foundational areas: State Standards, National Standards, STEM Education, and CTE inclusion. The described outline is a brief, linear sequence of units in how they would flow during the contact period.

The overall focus of the curriculum is to seamlessly integrate the interdependent disciplines of Science, Technology, Engineering and Math (STEM) into a focussed and invigorating real-world relevant Robotics curriculum. Also embedded are engineering (mechanical, electrical, & software), design, innovation, communications, small group collaboration, and 21st century critical thinking skills and knowledge relevant for student success in college, career and the community.

Course Units
Unit 1: "Introduction to Drone Robotics"
Unit 2: "UGV - Unmanned Ground Vehicles"
Unit 3: "Electrical Engineering & Energy Transfer"
Unit 4: "Drone Code & Technologies"
Unit 5: "Applied Systems Thinking"
Unit 6: "Physics of Flight"
Unit 7: "UAV – Unmanned Arial Vehicles"
Unit 8: "Culminating Project"

Resources
MINDS-i STEM Integrated Robotics: Drones Lab
PC Work Stations; spreadsheet program capable of graphing (must be provided by school)

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Unit 1: "Introduction to Drone Robotics" **COMPONENTS AND ASSESSMENTS**
Performance Assessments: • Student will be able to describe the many applications of Drones and the use of related technologies in today's society including possible future applications • Student will be able to describe STEM education as a system and learn about 21st century skills
Standards and Competencies
Standard/Unit: ISA (International Society for Automation) Certified Automation Professional (CAP) – (http://www.isa.org/)

Competencies	Total Learning Hours for Unit:
• Describe (UGV) Unmanned Ground Vehicles, (UAV) Unmanned Aerial Vehicles, and (AUV) Autonomous Underwater Vehicles • Exercise recognizing and identifying the use of Drones • Student Performance Development System based on 21st Century Skills • Curriculum Overview	

Alignment with Standards	
Science	Modern civilization depends on major technological systems (HS-PS4-2),(HS-PS4-5),(HS-PS3-3) Engineering continuously modify these technological systems (HS-PS4-2)

Unit 2: "UGV - Unmanned Ground Vehicles" **COMPONENTS AND ASSESSMENTS**	
Performance Assessments: • Describe and understand in-depth applications of ground Drones (UGVs) • Select and build and troubleshoot a UGV Drone chassis both in transmitter to receiver mode, and transmitter to micro-controller mode	
Standards and Competencies	
Standard/Unit: NCSA (National Computer Science Academy) C-Programming Certification (http://www.ncsacademy.com/)	
Competencies	**Total Learning Hours for Unit:**
• Describe and understand in-depth UGV and their applications such as; office, distribution, farming, national defense, planetary exploration, and transportation • Select and build (as a shared team responsibility) one of two Drone chassis designs (4x4 4-link or 6x6 independent) and will wire, and effectively navigate the Drone frame through the transmitter and receiver • Troubleshoot the Drone chassis and suspension system using the PDSA cycle	
Alignment with Standards	

Unit 3: "Electrical Engineering & Energy Transfer" **COMPONENTS AND ASSESSMENTS**	
Performance Assessments: • Students will be able to demonstrate understanding of electrical energy, electrons, energy storage, and the principles of energy transfer within a system • Students will be able to identify and describe Drone components associated with energy transfer, such as; battery, ESC, motor, servos, drive train, and friction, and will explain their relationship to energy transfer	
Standards and Competencies	
Standard/Unit: IEEE (Institute of Electrical and Electronics Engineering) (http://www.ieee.org/index.html)	
Competencies	**Total Learning Hours for Unit:**

- Demonstrate understanding of the principles of energy transfer, and apply them to the paths of energy transfer within the Drone, such as; chemical, electrical, mechanical and heat
- Identify and describe the Drone components and paths of energy transfer between; battery, ESC, motor, servos, drive-train, etc.
- Demonstrate understating of an electric motor, describe and understand the components that make it operate (e.g. stator, rotor, brushes, etc.)
- Build an electric motor, describe and understand the components and forces that make it operate (e.g. stator, rotor, brushes, magnetic fields, etc.)
- Calculate relationships between amps, volts and watts, through the utilization of division and multiplication of fractions and decimals
- Determine and compare the amount of amps (electrons) needed to propel the Drone under "no-load" and with drive train "simulated-load" and calculate battery life and charge time

Alignment with Standards	
Math	**6.EE Expressions and Equations** 6.EE1 Write and evaluate numerical expressions involving whole-number exponents. 6.EE2 Write, read, and evaluate expressions in which letters stand for numbers. 6.EE2a Write expressions that record operations with numbers and with letters standing for numbers. **HS Quantities** N-Q1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N-Q2. Define appropriate quantities for the purpose of descriptive modeling **HS Creating Equations** A-CED2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
Science	**MS-PS2 Motion and Stability: Forces and Interactions** MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. Cause and effect relationships may be used to predict phenomena in natural or designed systems. MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). Cause and effect relationships may be used to predict phenomena in natural or designed systems. **HS-PS2 Motion and Stability: Forces and Interactions** HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields (HS-PS2-5) "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (HS-PS2-5) **HS-PS3 Energy** HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2), (HS-PS3-3) Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system (HS-PS3-3)

	Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3) HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-5) When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

Unit 4: "Drone Code & Technologies"
COMPONENTS AND ASSESSMENTS

Performance Assessments:

- Understand and describe the various capabilities that support autonomous Drones; including internal measurement unit (IMU) and external measurement unit (EMU) technologies.
- Design, create, test and modify various Drone programming syntax and language components, and the various Drone inputs and outputs in which they control
- Understand the science, technology, engineering and math behind the various Drone technologies including; information transmission through to waves, and the physics of an objects orbiting a planetary body (e.g. satellite orbiting earth).

Standards and Competencies

Standard/Unit: NCSA (National Computer Science Academy) C-Programming Certification (http://www.ncsacademy.com/)
Standard/Unit: ISA (International Society for Automation) Certified Automation Professional (CAP) – (http://www.isa.org/)

Competencies	**Total Learning Hours for Unit:**

- Install Arduino software and gain familiarity with the various functions of the programming environment.
- Identify and describe various Drone components, including but not limited to; controller, compass, gyro, accelerometer, GPS, encoder, etc.
- Remote Navigation through the Drone Board; Test, experiment with and understand a basic program capable of manually driving the UGV chassis through a simple obstacle course with the end goal of precision vs speed.
- Describe and understand Drone sensing technologies, including power level monitoring, and self-orientation.
- Understand the different types of self-orientation, including directional, rotational, and linear orientation; and the technologies that make it possible (compass, gyro, accelerometer, and altimeter).
- Power Level Monitoring; Test, experiment with and understand a basic program capable of live monitoring of UGV voltage power levels while determining the effect of various terrain.
- Compass Heading; Construct and compass platform to test, experiment with and understand a basic program capable of maintaining a specific heading.
- Orientation; Construct a Gimbal and test, modify and understand a basic program capable of maintaining level orientation.
- Describe and understand Drone sensing technologies (GPS) including longitude and latitude location and heading (including the orbital science and math behind GPS satellite systems).
- Describe and understand UGV Drone sensing technologies (encoder) utilized for maintaining a constant speed (cruise-control) within the context of varying terrain.
- Describe and understand Drone object detection, recognition and mapping capabilities and technologies.
- GPS; Test, experiment with and understand a basic program capable of remotely relaying GPS information to a serial terminal, using the information to pilot and autonomously navigate the UGV.
- Describe and understand the behaviors and properties of mechanical waves (such as sound) and electromagnetic waves (such as light), and their utilization in Drones for information transfer technology (telemetry).

- Write, experiment with, and optimize a multi-ultrasound sensor UGV program for alternate speeds and reaction times.

Alignment with Standards	
Science	**HS-ESS1 Earth's Place In the Universe** HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4) **HS-PS2 Motion and Stability; Forces and Interactions** HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. Use mathematical representations of phenomena to describe explanations. (HS-PS2-2) Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) **HS-PS4 Waves and Their Applications in Technologies for Information Transfer** HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5) HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)

Unit 5: "Applied Systems Thinking"
COMPONENTS AND ASSESSMENTS

Performance Assessments:

- Using a variety of technologies, students will demonstrate understanding of systems thinking applied to Drone operating and navigation components and sub-systems.

Standards and Competencies

Standard/Unit: ASQ (American Society for Quality) - Six Sigma Black Belt Certification – CSSBB (http://prdweb.asq.org/certification/control/six-sigma/index **)**

Competencies	**Total Learning Hours for Unit:**

- Demonstrate understanding of systems thinking definitions and principles, such as; energy flow, sub-systems, boundaries, interdependence, and systems optimization.
- Identify and label the various components, sub-systems, and boundaries of a simple electromechanical device (servo)
- Demonstrate understanding of systems thinking definitions and principles, such as; inputs, outputs, open and closed systems, and constraints
- Create inter-relationship diagrams demonstrating the interconnectedness and interdependencies between the various Drone operating and navigation systems components and sub-systems, labeling inputs, outputs and constraints.

Alignment with Standards	
Science	Develop a model to describe unobservable mechanisms. (MS-PS1-5) Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4),(MS-PS3-2)

	The total amount of energy in a closed system is conserved (HS-PS1-7) The total amount of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system (HS-PS1-4) Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)(HS-PS2-4) Science and engineering complement each other in the cycle known as research and development (R&D) (HS-PS4-5) Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6) Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2), (HS-PS3-5) When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) When investigating or describing a system, boundaries, inputs and output analyzed (HS-PS3-4)

Unit 6: "Physics of Flight" **COMPONENTS AND ASSESSMENTS**	
Performance Assessments: • Describe and understand of how changes in propeller geometry, such as angle of attack, effect lift, force, and lift to weight ratio, etc. • Build and troubleshoot a AUV Drone chassis	
Standards and Competencies	
Standard/Unit:	
Competencies	**Total Learning Hours for Unit:**
• Understand the factors and principles of flight dynamics including; lift, airfoils, flow deflection, angle of attack, pitch, airfoil shape, the Coanda effect and Camber, and Bernoulli's principle and pressure. • Understand the principles and math of thrust-to-weight-ratio and vertical take-off lift capacity. • Demonstrate understand of the math and science behind factors of angle of attack, pressure, and pitch; and predict it effects on lift (airfoil) and thrust (propeller), trust to weight ratio and lift capacity. • Build (as a shared team responsibility) an UAV airframe and transfer Drone Controller, GPS, and Telemetry on to AUV airframe.	
Alignment with Standards	
Math	**6.RP Ratios and Proportional Relationships** 6.RP1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. 6.RP2 Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. 6.RP3 Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. a. Make tables of equivalent ratios relating quantities with whole number measurements, find missing values in the tables, and plot the pairs of values on the coordinate plane. Use tables to compare ratios. b. Solve unit rate problems including those involving unit pricing and constant speed. c. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problem involving finding the whole, given a part and the percent. d. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities. **HS Quantities**

	N-Q1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N-Q2. Define appropriate quantities for the purpose of descriptive modeling. **HS Reasoning with Equations and Inequalities** A-REI1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

.Unit 7: "Unmanned Arial Vehicles (UAV) Development"
COMPONENTS AND ASSESSMENTS

Performance Assessments:

- Students will be able to demonstrate understanding of various autopilot functions relate forces to stability and responsiveness and explain the relationship among them
- Perform Various Integrated Autonomous tasks with UAV

Standards and Competencies

Standard/Unit: ASME (American Society of Mechanical Engineers) - Certifications (http://www.asme.org/kb/courses)
Standard/Unit: IEEE (Institute of Electrical and Electronics Engineering) (http://www.ieee.org/index.html)
Standard/Unit: NCSA (National Computer Science Academy) C-Programming Certification (http://www.ncsacademy.com/)
Standard/Unit: ISA (International Society for Automation) Certified Automation Professional (CAP) – (http://www.isa.org/)

Competencies	**Total Learning Hours for Unit:**

- Describe and understand in-depth UAV and their applications such as; commercial, distribution, farming, national defense, communications and space exploration.
- Describe and understand the dynamics of multi-rotor flight dynamics, contra and counter rotation, and quad-copter flight and motion.
- Practice and refine MultiRotor manual flight skills and technique in a simulated flying environment.
- Describe and understand the Individual functions of autopilot and P-I-D (Proportional Integral-Derivative), and the principles behind tuning each factor (P-I-D) individually, and as a system to optimize flight satiability and responsiveness.
- Build Tuning Rack, and utilize PDSA cycle to optimize P-I-D settings for stable and responsive flight.
- Manual Flight and Calibration, including take-off, forward motion (negative pitch), reverse motion (positive pitch), rotation on axis (yaw), side to side motion (roll), and landing.
- For autonomous flight, see curriculum for more details on acquiring airman's license.

Alignment with Standards

Science	**HS-PS2 Motion and Stability; Forces and Interactions** HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) Systems can be designed to cause a desired effect. (HS-PS2-3) **HS-PS3 Energy** HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

	At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2), (HS-PS3-3) Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3) Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)

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Unit 8: "Culminating Project"
COMPONENTS AND ASSESSMENTS

Performance Assessments:

- By applying a variety of technologies, students will be able to demonstrate an understanding of the basics of Drone design, operation, programming and application.

Standards and Competencies

Standard/Unit: ASME (American Society of Mechanical Engineers) - Certifications (http://www.asme.org/kb/courses)
Standard/Unit: IEEE (Institute of Electrical and Electronics Engineering) (http://www.ieee.org/index.html)
Standard/Unit: NCSA (National Computer Science Academy) C-Programming Certification (http://www.ncsacademy.com/)
Standard/Unit: ISA (International Society for Automation) Certified Automation Professional (CAP) – (http://www.isa.org/)

Competencies | **Total Learning Hours for Unit:**

- Demonstrate understanding and utilization of units 1 through 7 by demonstrating their application within the "Culminating Project".
- Develop a project plan with specific goals and responsibilities and apply what has been learned to design, build and program a Drone (UGV or UAV) capable of performing a specific classroom challenge(s) outlined in curriculum.
- Or, develop a project plan with specific goals and responsibilities and apply what has been learned to design, build and program a Drone (UGV or UAV), and compete in one of many autonomous Drone competitions listed (or not listed) in the curriculum.

Alignment with Standards

Science	**HS-ETS1 Engineering Design** HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2) HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3) When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and

	constraints on interactions within and between systems relevant to the problem.