Unit Plan: Cross-Curricular Drone Technology Project

Unit Title: Design, Build, and Fly: A Cross-Curricular Drone Technology Project

Courses: Aviation and Robotics Classes

Duration: 12 Weeks (Mid-January to the End of April 2025)

Subject Areas: STEM, Aviation Technology, Aerodynamics, Robotics, 3D Printing, Engineering Design, Electronics, Arduino Programming

Overview:

This unit plan engages students from both the aviation and robotics courses at Moriarty High School to collaboratively design, build, code, and test a drone that addresses a real-world need in the Moriarty, New Mexico community. Students will identify the local need, develop a technical specification sheet, design a drone using 3D printing technology, program the flight control system using Arduino, and conduct test flights. This unit will also focus on applying aerodynamic principles, regularly reviewed by aviation students, to the design and flight testing of the drone. The unit culminates in a drone demonstration for middle school students, with plans for long-term educational use of the drone.

Unit Goals:

By the end of this unit, students will:

1. **Research and Identify Real-World Needs:** Research and assess a local community need for drone technology.
2. **Apply STEM and Arduino Programming Skills:** Utilize engineering and coding principles, 3D printing technology, and Arduino programming to design and build a functional drone.
3. **Master Arduino and Flight Control:** Develop proficiency in Arduino programming, sensor integration, motor control, and real-time flight control systems.
4. **Incorporate Aerodynamic Principles:** Review and apply principles of flight mechanics (lift, drag, thrust, stability) to ensure drone efficiency and stability.
5. **Collaborate Across Disciplines:** Work collaboratively between aviation and robotics to design, build, and test the drone.

6. **Present to Younger Students**: Present the completed project and demonstrate the drone to middle school students.
7. **Evaluate and Reflect:** Assess the performance of the drone through test flights and make iterative design improvements.

Academic Standards

1. **Next Generation Science Standards (NGSS)**:
   - **HS-ETS1-1**: Define criteria and constraints of a design problem.
   - **HS-ETS1-2**: Design a solution to a complex real-world problem.
   - **HS-PS3-3**: Apply scientific principles to design, construct, and test a device.
2. **Common Core Mathematics Standards**:
   - **HSG.MG.A.3**: Solve design problems using geometric methods (e.g., frame design, propeller sizing).
   - **HSN.Q.A.1**: Use quantities and units to solve engineering problems (e.g., power and thrust calculations).
3. **International Society for Technology in Education (ISTE):**
   - **4a**: Use design processes to test engineering solutions.
   - 5c: Break down problems into parts and use technology to solve them (e.g., Arduino coding for drone control).

Unit Timeline

Phase 1: Research and Needs Assessment (Weeks 1-4, Mid-January to Mid-February)

- **Objective**: Aviation students identify a local community need for drone technology, and robotics students begin reviewing Arduino fundamentals.
- **Skills**:
  - **Arduino Setup**: Introduction to Arduino hardware, including setting up an Arduino Nano/Uno, understanding the pins, and basic wiring for sensors and motors.
  - **Digital and Analog 1/O Basics**: Learn how to use digital and analog pins for basic input/output functionality (e.g., controlling LEDs or reading sensor data).
- **Aviation Focus**: Monthly review of **aerodynamic principles** (lift, drag, thrust, and balance) to inform the design specifications.
- **Product**: **A** formal "spec sheet" outlining the identified local need, technical requirements, and aerodynamic considerations for the drone.

Phase 2: Design and Development (Weeks 5-8, Mid-February to Late March)

- **Objective**: Robotics students will 3D design and print the drone's frame, assemble the motors and electronics, and begin programming the flight control system using Arduino.
- **Skills**:
  - **PWM and Motor Control**: Program PWM signals on the Arduino to control brushless motor speeds and adjust motor outputs for balance.
  - **ESC Integration**: Learn how to connect and control ESCs with the Arduino for motor management.
  - **Gyroscope and Accelerometer Integration**: Program the Arduino to read data from the MPU6050 gyroscope/accelerometer and stabilize the drone's flight by adjusting motor speeds.
  - **Serial Communication**: Debugging through Serial Monitor to ensure correct sensor readings and motor outputs.
- **Aviation Focus**: Continual review of how **aerodynamic principles** affect drone performance, with adjustments made based on real-world considerations.
- **Product:** A 3D-printed, assembled drone frame with basic Arduino motor control and sensor integration.

Phase 3: Testing, Flight Operations, and Demonstration (Weeks 9-12, Early April to Late April)

- **Objective**: Test and refine the drone's flight, making necessary adjustments to the Arduino code and hardware. Prepare to demonstrate the drone to middle school students.
- **Skills**:
  - **Flight Stabilization Algorithms**: Implement advanced stabilization algorithms using data from the gyroscope and accelerometer.
  - **Transmitter/Receiver Integration**: Program the drone to respond to inputs from a 2.4GHz transmitter/receiver for manual flight control.
  - **Safety Protocols**: Program fail-safe mechanisms (e.g., auto-landing or buzzer alerts) in case of low battery or signal loss.
  - **Sensor Calibration and Tuning**: Fine-tune sensor inputs and outputs for smooth flight and adjust the Arduino code as needed.
- **Aviation Focus**: Final aerodynamic assessments, examining the drone's **flight characteristics** based on real-time flight data.
- **Product:** A fully functional, flight-tested drone capable of responding to manual controls and achieving stable flight. Ready for presentation.

Assessment:

- **Research & Needs Assessment:** Evaluate aviation students' ability to research and identify a relevant community need for drone technology, as well as the thoroughness of the spec sheet. Evaluate how well aerodynamic principles are incorporated.
- **Design & Development**: Assess robotics students' proficiency in 3D printing, assembly, and Arduino programming. Measure their ability to implement motor control and sensor feedback.
- **Testing & Demonstration**: Assess both classes on their ability to collaborate, refine the design based on flight test results, and successfully demonstrate the drone to middle school students.

Instructional Strategies:

- **Collaborative Learning**: Students from aviation and robotics courses work together in interdisciplinary teams. Aviation focuses on research and aerodynamic design, while robotics focuses on design, programming, and assembly.
- **Project-Based Learning (PBL)**: Students will solve a real-world problem through hands-on project work, with specific milestones to track progress.
- **Inquiry-Based Learning**: Students will make data-driven decisions during design iterations and testing phases based on the results of flight tests and evaluations.
- **Peer Teaching**: High school students will present the drone project to middle school students, encouraging interest in STEM fields.

Reflection and Evaluation:

- **Reflection**: Students will participate in group discussions and journaling activities to reflect on their learning experiences, challenges they encountered, and the real-world application of STEM skills.
- **Evaluation**: Students will be asked to assess how well the drone met the defined need and how their interdisciplinary collaboration contributed to the success of the project.

Extensions:

- **Long-Term Use**: After the unit, the drone can continue to be used as a teaching tool for future aviation and robotics students. Modifications can be made to improve the drone or repurpose it for different applications, such as advanced sensor integration or obstacle avoidance.
- **Sustainability**: The unit can be repeated with new students, and new community needs can be identified to ensure the project remains relevant and impactful.

NGSS Cross-Curricular Connections:

- **Science and Engineering Practices**: Students engage in defining problems, designing solutions, testing, and refining those solutions throughout the unit.
- **Crosscutting Concepts**: Structure-function relationships are highlighted in drone design, with an emphasis on how design decisions impact aerodynamics and flight.
- **Disciplinary Core Ideas**: The unit addresses core concepts in engineering design, technology, and physics (force, motion, and energy).

This unit provides students with an in-depth, hands-on opportunity to apply aviation, robotics, and Arduino programming skills to solve a local community problem. It fosters interdisciplinary collaboration, while also allowing students to master essential STEM and Arduino concepts. This unit will not only have immediate educational impact but will also be sustainable for future learning.

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Item	Quantity	Estimated Cost	Description
3D Printing Materials	1 set	$50	Filament for custom drone frame (PLA or PETG), covering extensive 3D printing.
Arduino Nano/Uno	1 unit	$15	Flight controller for the drone, used for motor and sensor control.
MPU6050 Gyro/Accelerometer	1 unit	$8	Sensor to track the drone's orientation and stabilize its flight.
Brushless Motors (2204/2205)	4 units	$60	Motors to power the drone's propellers, providing thrust and control.
ESCs (Electronic Speed Controllers)	4 units	$40	Devices to regulate the power supplied to the motors, allowing for speed control.
Propellers (CW & CCW)	2 pairs	$10	Propellers to provide lift and control.
LiPo Battery (3S 11.1V or 4S)	1 unit	$40	Power source for the drone.
LiPo Battery Charger	1 unit	$30	Charger for the drone battery.
Power Distribution Board	1 unit	$15	Distributes power from the battery to the ESCs and other components.
2.4GHz Transmitter/Receiver	1 set	$60	Remote control system to operate the drone from a distance.

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Voltage Regulator	1 unit	$10	Regulates the voltage going to the motors and other components.
Jumper Wires & **Connectors**	1 set	$20	Wiring and connectors needed for assembling the electronics and components.
Buzzer	1 unit	$5	Audible warning system to signal low battery or crashes.
Soldering Kit	1 set	$30	For assembling and connecting the electronic components.
Miscellaneous Tools & **Accessories**	1 set	$30	Additional tools and supplies (e.g., zip ties, heat shrink tubing) for assembly.