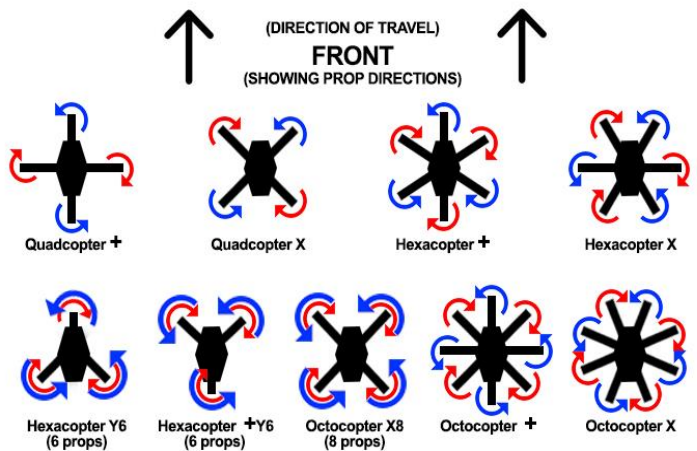


Curriculum/Units

- 1: Design & Documentation
- 2: Safety Considerations
- 3: Introduction to Drones
- 4: Fundamentals of Flight
- 5: Airframes
- 6: Electric Motors
- 7: Propellers
- 8: Electronic Speed Controllers (ESCs)
- 9: Flight Controllers
- 10: Batteries, Charges & Connectors
- 11: Transmitters & Receivers
- 12: Cameras, Gimbals & Other Payloads
- 13: Ground Control Stations & FPV
- 14: Regulations & The FAA
- 15: Drone Maintenance & Battery Care
- 16: Efficiency vs. Performance



| FTW Curriculum | FTW-007 |
|----------------|----------|
| 30 Seats | \$999.99 |

Each Unit Includes:

Lesson Plan – Teacher Prep

Activity – Student Activity

Student Reading – Take home reading


PowerPoint Presentation – In Class Presentation

Unit Quiz

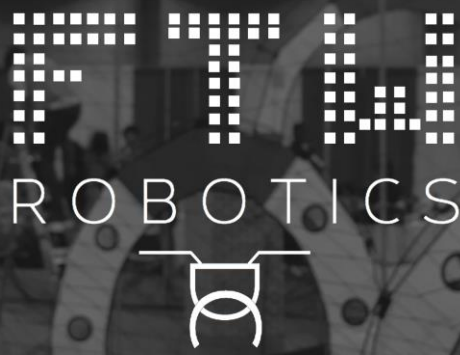
Vocab

Vocab Quizzes

FTU ROBOTICS



| | Description | Minimum # days (if some activities are skipped) | Maximum # days (if all activities completed) |
|--|---|--|---|
| Unit 1: Design & Documentation | Introduces the engineering design process and stresses the importance of cooperation, teamwork, and documentation to solve problems. | 3 | 7 |
| Unit 2: Safety Considerations | Stresses the importance of adopting a “safety attitude” when building and flying a drone. Covers workshop safety and outdoor flying. | 3 | 7 |
| Unit 3: Introduction to Drones | Covers nomenclature, history of aerial drones, reputation, airframe, configurations, basic components, and current/future uses of drones. | 4 | 7 |
| Unit 4: Fundamentals of Flight | Introduces aerodynamics, history of flight, Newton’s Laws of Motion, Bernoulli’s Principle, four forces of flight, three axes of flight, how they apply to drone flight. Reveals issues aircraft pilots encounter including airspace, traffic patterns, and safe altitudes. | 4 | 7 |
| Unit 5: Airframes | Covers history of helicopter design, early multirotor design, various configurations, airframe sizes, and construction materials. | 3 | 5 |
| Unit 6: Propellers | Covers history of propeller design, fixed-pitch and constant speed blades, airfoil design, size, pitch, and blade-count. Includes balancing tips and construction materials | 3 | 5 |
| Unit 7: Ground Control Stations & FPV | Introduces telemetry, data tracking, mission planning, and 3D mapping and modeling. Covers first-person-view flying safety and drone racing options. | 3 | 5 |
| Unit 8: Common Sense Flying | Discusses responsibility of flying and being “neighborly.” Discusses building or buying a drone. | 3 | 5 |
| Unit 9: Regulations & The FAA | Covers role of the FAA and NTSB. Stresses importance of regulation, and lists registration and recreational use of drones. Section 333 Exemptions and Part 107 Rules are explained. | 2 | 3 |
| | TOTAL | 28 | 51 |



Unit 1: Design & Documentation

Unit 1 Vocabulary

Unit 1 Concepts

Unit 1 Performance Objectives

1.1 - What is Engineering?

1.2 – Engineering Design

1.3 – The Design Process

1.4 – Importance of Documentation

1.5 – Working in Teams

1.6 – Effective Team Practices

1.7 - Quantitative vs. Qualitative Arguments

1.8 – Engineering Notebooks

1.9 – Software and Tools for Drone Design

Unit 1 Summary

Unit 2: Safety Considerations

Unit 2 Vocabulary

Unit 2 Concepts

Unit 2 Performance Objectives

2.1 – Safety First

2.2 – Your Safety Responsibility

2.3 – Establishing a Safety Culture

2.4 – Workshop Safety Issues

2.5 – Workshop Safety Rules

2.6 – Soldering Safety Rules

2.7 – Increase Your Drone Design Knowledge

2.8 – Increase Your Flight Skills

2.9 – Flight Safety Organizations

2.10 – Educational Regulations

2.11 – Drone Registration

2.12 – Definition of Recreational Use

2.13 – Safety Guidelines for sUAS Recreational Users

2.14 – Privacy Policy

2.15 – Safe Flying Locations

2.16 – No-Fly Zones

2.17 – Safe Weather Conditions

2.18 – Safe Flight Clearance

2.19 – Visual Line of Sight

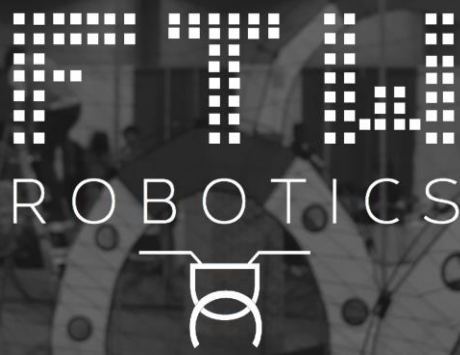
2.20 – Start Out Slowly

2.21 – Ground Effect & Prop Wash

2.22 – Propeller Dangers

2.23 – Pre-Flight Inspection

Unit 2 Summary



Unit 3: Introduction to Drones

Unit 3 Vocabulary
Unit 3 Concepts
Unit 3 Performance Objectives
3.1 – What is a Drone?
3.2 – Drone Uses Besides Aerial
3.3 – Brief History of Aerial Drones
3.4 – Drone Reputation
3.5 – Development of Small UAVs
3.6 – What's in a Name?
3.7 – Types of Small UAVs (sUAV)
3.8 – Choosing a Multicopter Configuration
3.9 – Drone Components
3.10 – Current Uses and Future Potential
Unit 3 Summary

Unit 4: Fundamentals of Flight

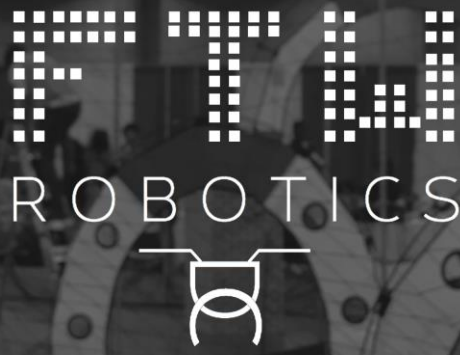
Unit 4 Vocabulary
Unit 4 Concepts
Unit 4 Performance Objectives
4.1 – What is Aerodynamics?
4.2 – Brief History of Flight
4.3 – Newton's Laws of Force and Motion
4.4 – Bernoulli's Principle
4.5 – Airfoils
4.6 – Four Forces of Flight
4.7 – Mechanical Design of an Airplane
4.8 – Three Axes of Flight
4.9 – Airspace
4.10 – Traffic Patterns and Minimum Safe Altitudes
4.11 – Weather Factors for Drone Flight
4.12 – Pilot-in-Command/Remote Pilot-in-Command
4.13 – How Multicopters Fly
4.14 – Vectors Applied to Flight Physics
4.15 – Calculating Values of Combined Maneuvers
Unit 4 Summary

Unit 5: Airframes

Unit 5 Vocabulary
Unit 5 Concepts
Unit 5 Performance Objectives
5.1 – Airframe Characteristic
5.2 – History of Helicopter Design
5.3 – Early Multirotor Aircraft Design
5.4 – Advancements in Control and Design
5.5 – Multirotor Configurations
5.6 – Choosing/Building a Multicopter Configuration
5.7 – Airframe Sizes
5.8 – Airframe Materials
5.9 – Tensile Strength
Unit 5 Summary

Unit 6: Propellers

Unit 6 Vocabulary
Unit 6 Concepts
Unit 6 Performance Objectives
6.1 – Introduction to Propellers
6.2 – History of Propeller Design
6.3 – Propeller Design Theory
6.4 – Fixed Pitch, Variable-Pitch, and Constant Speed Blades
6.5 – Size, Pitch, Direction, and Blade-count
6.6 – Safety and Use of Prop Guards
6.7 – Balancing Your Propellers
6.8 – Materials Used in Prop Construction
6.9 – Choosing Your Propellers
6.10 – Using eCalc© to Determine Best Prop Selection
Unit 7 Summary



Unit 7: Flight Skills

Unit 7 Vocabulary

Unit 7 Concepts

Unit 7 Performance Objectives

7.1 – First Things First

7.2 – Working with Lightweight Drones

7.3 – Recreational Use Laws Summarized

7.4 – Propeller Awareness

7.5 – Other Safety Issues

7.6 – Ground Effect & Prop Wash

7.7 – Controller Basics

7.8 – Ready, Set, Go ...!

7.9 – Beginning Flight Skills

SKILL 1

SKILL 2

SKILL 3

SKILL 4

7.10 – Advanced Flight Skills

- SKILL 5

- SKILL 6

- SKILL 7

- SKILL 8

- SKILL 9

Unit 7 Summary

Unit 8: Common Sense Flying

Unit 8 Vocabulary

Unit 8 Concepts

Unit 8 Performance Objectives

8.1 – Being Responsible

8.2 – “No-Fly” Zones vs. “Notify” Zones

8.3 – Be “Neighborly”

8.4 – Get It Registered!

8.5 – Revisiting Common Sense Safety

8.6 – Revisiting Educational and Recreational Use

8.7 – Determining Your Purpose

8.8 – Configuration Considerations

Unit 8 Summary

Unit 9: Regulations & The FAA

Unit 9 Vocabulary

Unit 9 Concepts

Unit 9 Performance Objectives

9.1 – The Need to Regulate Airspace

9.2 – The NTSB (National Transportation Safety Board)

9.3 – The FAA (Federal Aviation Administration)

9.4 – UAS Incidents and FAA Response

9.5 – Regulation of UAS Operations

9.6 – Recreational Use of Drones

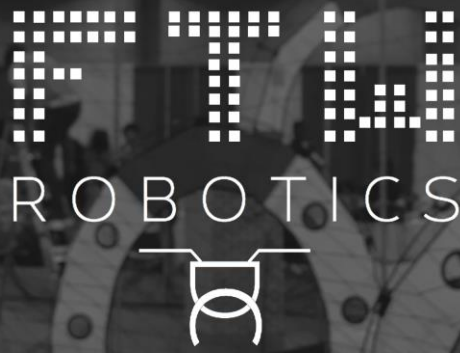
9.7 – sUAS Registration

9.8 – Section 333 Exemptions

9.9 – Summary of Small Unmanned Aircraft Rule (Part 107)

9.10 – Future Challenges for Regulation

Unit 14 Summary



Drone Theory & Design: Unit 3 v1.1 Page | 1

Curriculum Designed for the S.T.E.M. Classroom

Unit 3: Introduction to Drones – Lesson Plan

NOTE: Activity 3.4 is in the form of a Design Challenge. It does NOT require supplies. Students should have an engineering notebook or paper to document all activities.

1. You have the option to copy and distribute the **Unit 3 Handout** for student binders or use it solely as a teacher reference.
2. Copy and distribute the **Unit 3 Vocabulary Definitions**. There are 68 vocabulary terms. Review the first 34 terms and definitions at this time (“2.4 GHz” thru “Kettering Bug”).
3. Teach the lesson using the **Unit 3 PowerPoint** up through and including **Section 3.8**.
4. Students complete **Activities 3.1 & 3.2**.

Activity 3.1: Unit Comprehension (3.1-3.8)

No supplies needed. The students write subjective responses to questions dealing with the first half of the Unit presentation (3.1 – 3.8). They will need to use their engineering notebooks or paper for the responses. Following the written portion, lead the class in a discussion encouraging every student to participate and share their responses. You have the option of collecting their responses when finished.

Activity 3.2: Configuration Suggestions

No supplies needed. The students write subjective responses to a scenario dealing with drone configurations. They will need to use their engineering notebooks or paper for the responses. Following the written portion, lead the class in a discussion encouraging every student to participate and share their responses. You have the option of collecting their responses when finished.

5. Review the first 34 vocabulary terms again. Students should take the **Vocabulary Quiz – Part 1 (matching)**. (Note: You can have the students grade their own quiz or exchange papers and grade each other’s – unless you prefer grading them yourself).
6. Review the next 34 vocabulary terms/definitions from **Unit 3 Vocabulary Definitions** (“Kv rating” thru “yaw”).
7. Return to the lesson using the **Unit 3 PowerPoint** beginning at **Section 3.9: “Drone Components.”**

3.1 Activity

Unit Comprehension (3.1-3.8)

Using your engineering notebook or regular paper, respond to the following questions. Each response should be a minimum of three paragraphs (a paragraph is defined as at least three sentences):

Question #1

Describe the brief history of drones and major developments that led to the development of small UAVs.

Question #2

Explain why drones were greeted with resistance and disapproval when first introduced to the consumer and commercial markets.

Question #3

Describe the various configurations of multicopters including quadcopters, hexacopters, and octocopters.

Question #4

Explain why a bicoter, tricopter, and V-Tail configuration is less desirable.

Question #5

Describe some factors to consider when choosing a multicopter configuration.

Following the activity, you will participate in a class discussion of the responses. Be sure to share your responses and be involved in the group. Turn in your responses to your teacher if required.

Unit 3: Introduction to Drones

Unit 3 Vocabulary

| | | |
|-----------------------------------|---------------------------------|-------------------------------|
| 2.4 GHz | flight controller | payload |
| accelerometer | FPV (first-person view) | pitch |
| airfoil | frequency | quadcopter |
| airframe | gimbal | racing drones |
| algorithm | GCS (ground control station) | R/C (radio control) |
| autonomously | GPS (Global Positioning System) | ROV (remote operated vehicle) |
| autopilot | hexacopter | sensor |
| barometric sensor | IR (infrared) camera | servo |
| bicopter | receiver | stator |
| bind | jumper | submersible |
| brushed DC motor | Kettering Bug | sUAV |
| brushless DC motor | Kv rating | telemetry |
| carbon fiber | LED (light-emitting diode) | terrestrial |
| chassis | LiPo (lithium polymer) | torque |
| CW (clockwise) | mAh | tricopter |
| CCW (counter-clockwise) | magnetometer | UAS (unmanned aerial system) |
| channel | microcontroller | UAV (unmanned aerial vehicle) |
| compass | micro SD | UGV (unmanned ground vehicle) |
| constant | Mode 2/Mode 1 | V-tail |
| current | modem | VLOS (visual line-of-sight) |
| datalogger | multicopter | waypoint |
| DIY (do-it-yourself) | multirotor | yaw |
| ESC (electronic speed controller) | nano drones | |
| | octocopter | |

Unit 3 Concepts

1. A **drone** or **UAV (unmanned aerial vehicle)** is the label given to an unmanned aircraft that navigates by either human remote control (R/C) or autonomously by its own onboard microcontroller.
2. As drones were introduced to the public for consumer use, they were first greeted with resistance and disapproval largely due to controversy surrounding their **military use** abroad, **privacy concerns**, and nuisance flying by "**irresponsible hobbyists**."
3. Fueled by continuing advancements in **miniaturization** and the availability of the **Global Positioning System (GPS)**, consumer and commercial drone production has grown drastically in the past few years.
4. **Multicopter** and **multirotor** are interchangeable terms, and both are used as the generic name for a drone with multiple propellers.
5. A **quadcopter** has 4 rotors positioned on a horizontal plane like a helicopter, a **hexacopter** is a multirotor aircraft that has six rotors, and an **octocopter** is a small UAV that has eight rotors.
6. Multirotors with a **high number of rotors** are typically larger and designed to carry a heavier payload.

Unit 3: Introduction to Drones

Unit 3 Vocabulary

| | |
|--------------------------------|---|
| 2.4 GHz | 2.4 GHz, a frequency designated by the FCC as the industrial, scientific, and medical radio bands, is utilized by many sUAV operators for their transmission control. |
| accelerometer | An accelerometer is an instrument for measuring acceleration, typically that of an automobile, ship, aircraft, or spacecraft, or that involved in the vibration of a machine, building, or other structure. |
| airfoil | An airfoil is the shape of a wing or blade of a propeller as seen in cross-section. An airfoil-shaped body moving through a fluid produces lift, an aerodynamic force that is perpendicular to the direction of motion. |
| airframe | An airframe of an aircraft is its mechanical structure. |
| algorithm | An algorithm is a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer. |
| autonomously | Autonomously refers to being navigated and maneuvered by a computer, without a need for human control or intervention under normal conditions. |
| autopilot | An autopilot is a system used to control the trajectory of a vehicle without constant 'hands-on' control by a human operator being required. |
| barometric sensor | A barometric sensor is a device that is responsible for measuring the atmospheric pressure of the environment. |
| bicopter | A bicopter is an unmanned multicopter having two rotors. |
| bind | Binding is the simple process by which you program the receiver in an aircraft to respond to a specific aircraft transmitter. |
| brushed DC motor | A brushed DC motor is an internally commutated electric motor designed to be run from a direct current power source. |
| brushless DC motor | A brushless DC (BLDC) motor is powered by direct current and has electronic commutation systems instead of the mechanical brushes and commutators used in brushed dc motors. |
| carbon fiber | Carbon fiber is a material which is created using carbon fibers bonded by a resin. The binding polymer is often a resin such as epoxy, and the bonding alignment gives the fiber high strength-to-volume ratio. |
| chassis | A chassis is the base frame of a vehicle or aircraft. |
| CW (clockwise) | A clockwise (CW) motion is one that proceeds in the same direction as a clock's hands, from the top to the right, then down and then to the left, and back up to the top. |
| CCW (counter-clockwise) | A counter-clockwise (CCW) motion is one that proceeds in the opposite direction as a clock's hands, from the top to the left, then down and then to the right, and back up to the top. |
| channel | A channel refers to the number of actions that the R/C transmitter controls such as for the throttle and for steering. |
| compass | A compass is an instrument containing a magnetized pointer that shows the direction of magnetic north and bearings from it. |
| constant | In mathematics, the term constant refers to a fixed and well-defined number or another mathematical object. |
| current | An electric current is a flow of electric charge. In electric circuits this charge is often carried by moving electrons in a wire. It can also be carried by ions in an electrolyte, or by both ions and electrons such as in a plasma. |

3.5 – Development of Small UAVs

Fueled by continuing advancements in **miniaturization** and the availability of the **Global Positioning System (GPS)**, consumer and commercial drone production has grown drastically in the past few years. Numerous companies are developing hundreds of commercial drone systems and products. Companies like Amazon, Wal-Mart, and Google are developing drone delivery systems, and the hobby market has exploded with models of all sizes and capabilities. It's estimated that over 100,000 drone-related jobs will be created in the next 10 years, and sales of drones will reach over 125,000 by the year 2020.

3.6 – What's in a Name?

What's the difference between a **drone**, a **UAV** and a **UAS**? These terms are often used interchangeably to describe unmanned aircraft however there are some distinctions to be made. The most common term being used to describe an unmanned aircraft is a **drone**. However, because of its associated reputation from controversial military applications, those in the "drone industry" prefer the more descriptive reference of **Unmanned Aerial Vehicle (UAV)**. The terms **UAV** and **drone** are now essentially used interchangeably. According to the FAA, a UAV or drone is an aircraft without an onboard human pilot, controlled either autonomously or by remote control. Another term, **sUAV** is used to identify "small" UAVs ("s" meaning *small*) that weigh less than 55 pounds.

Unmanned Aerial Systems (UAS), on the other hand is a reference term that by definition is clearly distinguished from a drone or UAV. The term refers to the unmanned aircraft **AND all of its components** including, but not limited to:

- Ground control stations and software
- Radio-frequency linkage
- Remote controls
- Payloads
- Launch and recovery equipment.

3.7 – Types of Small UAVs (sUAV)

Multicopter and **multirotor** are also interchangeable. Both are used as the generic name for a drone with multiple propellers. There are a variety of multicopters classified as drones. Here are the most common configurations:

- **Quadcopter:** As the most popular configuration for small UAVs, a quadcopter has **4 rotors** positioned on a horizontal plane like a helicopter.
- **Hexacopter:** A hexacopter is a multirotor aircraft that has **six rotors** which gives it the advantage that it can lose any single engine and still maintain control to land.
- **Octocopter:** An octocopter is a small UAV that has **eight rotors**.

Multirotors with a high number of rotors are typically larger and designed to carry a heavier payload. For example, because of their increased flight range, stability, and ability to carry moderate amounts of weight, octocopters are preferred by many of the businesses developing UAVs to deliver packages.