

INTRODUCTION



Welcome to the Wild West of winged robotics! Drones help fight wildfires, perform at the Super Bowl, inspect hundreds of miles of pipelines, film stunning moments of movie-making magic, thrill spectators in FPV racing, bring crucial supplies to hard-to-reach areas and even deliver pizzas in New Zealand. The world has fallen in love with them, and we're sure your students will too.

This educator guide is here to help as you launch your program, guide your students through the curriculum and maybe even build a drone racing team. Before getting started, you first need to introduce yourself to your drone, RubiQ, (**R**obotic-**U**nmanned-**B**ird), who joins RiQ, the Arduino-based PCS robot, and the EiQ engineering kit as the latest addition to the PCS Edventures iQ series. You and RubiQ will be getting very close over the course of *Discover Drones!* Additional details on RubiQ's flight control configuration, troubleshooting and more can be found at rubiq.edventures.com, as well as in the printed RubiQ Flight Manual that comes with each set of RubiQ parts.

If you ever need additional guidance or want to share the awesome work your students are doing, send us a message at rubiq.edventures.com/support. We'd love to hear from you!



PRE-IMPLEMENTATION GUIDELINES



Bookmark this page and return to it as you work through the checklist, ensuring you're fully prepared to give your students the best introduction to the world of drones. The time to complete each step varies from person-to-person and site-to-site, but general estimates are listed below to help with planning:

- 1 Inventory your hardware (30 min)** using the packing slip included with your original *Discover Drones* shipment.
- 2 Review your print materials (25 min)** using the guide included with your expanding Instructor Folder.
- 3 Ask your IT department to whitelist edventures.com and droneology.tech (5 min)** to ensure access to your digital materials. Without whitelisting, you may not receive critical emails and content.
- 4 Email your Digital Resource License Key to rubiq@edventures.com (5 min)**. Then look for an email from PCS providing access to your digital materials, such as the FPV Freerider flight simulator software or Droneology EDU online video courses. Be sure to check both your inbox and spam folder for emails with your digital materials. *The Digital Resource License Key is listed on a printed page included in the expanding Instructor Folder.*
- 5 Download the RubiQ Configurator (10 min per device*)**. The RubiQ Configurator is a downloadable application required to complete RubiQ's pre-flight configuration. To use it, you'll need to download the configurator directly from the RubiQ website at rubiq.edventures.com/file-downloads. *RubiQ's firmware is only compatible with the RubiQ Configurator available for download directly from the RubiQ website NOT the INAV Configurator.* The RubiQ Configurator needs to be downloaded to each student's computer. *Note: if your site has tight security protocols, you may need to enlist the help of the IT department to complete the software installation.
- 6 Install FPV Freerider (10 min per device*)**. You will be emailed access links for FPV Freerider when you redeem your Digital Resource License Key. Installation and use instructions can be found in the *Flight Simulator Guide* in your Instructor Folder. The FPV Freerider software is compatible with Macs and Windows PC's, but NOT Chromebooks or tablets. Each license is per computer and can be used by any number of different pilots, no login required. *Note: if your site has tight security protocols, you may need to enlist the help of the IT department to complete the software installation.
- 7 Set up Droneology EDU (2 hr)**, the online component of the *Discover Drones* curriculum. You will be emailed a login and password for your Droneology EDU account when you redeem your Digital Resource License Key. Installation and use instructions can be found in the *Droneology EDU Guide* in your Instructor Folder. Droneology is a web-based platform at droneology.tech, so learners will need access to Internet-connected devices. If this is not an option for your students, printable versions of the Droneology quizzes are included in the Appendix for students to take on paper after watching the videos all together from your instructor account.
- 8 Review the most recent drone regulations (15 min)** by visiting the FAA (Federal Aviation Administration) website at https://www.faa.gov/uas/educational_users/. The recommendations in this Educator Guide are designed to help you run a safe and lawful drone program, but the drone laws may have changed since this guide was printed. Look for email updates from PCS Edventures and check the FAA website regularly to stay up-to-date.



- 9 **Practice, practice, practice (3+ hr).** Start putting in training hours on the flight simulator as early as possible — we recommend completing at least the first six challenges on the Flight Simulator Checklist (see p. 84) before you start flying. For the best experience, use a mini-USB cable to connect the Taranis radio to use as your controller. Review the *Discover Drones Flight Simulator Guide* included in your print materials for guidance on setting up the flight simulator software.
- 10 **Pass The Recreational UAS Safety Test (TRUST).** Unless you are a Part 107 Certified Remote Pilot, you are required by the FAA to pass TRUST and carry your printed certificate during all outdoor flight operations. Visit the website of an approved test administrator such as UAV Coach: <https://uavcoach.com/faq-recreational-drone-training/>.
- 11 **Register and label your drones (15 min).** Go to <https://faadronezone.faa.gov> and be prepared for a \$5 fee. The registration number that you'll receive is valid for three years and must be clearly marked on all drones before operation. (RubiQ's base plate is a great option.) Unless you have Part 107 certification, choose the option to *Fly under The Exception for Recreational Flyers*.
- 12 **Build RubiQ (1 hr).** Read the *RubiQ Flight Manual* for step-by-step instructions and review Yellow LABCards 2, 3 and 4 for information on each subsystem.
- 13 **Review LiPo safety protocols and charge your batteries (1 hr).** You must charge your batteries before you can configure or fly RubiQ, as they arrive at a safe storage level. Consult the *LiPo Battery Charger Guide for RubiQ* in your Instructor Folder for safe charging instructions.



Do not use your batteries until you have charged them. Using batteries at storage level will cause permanent damage.

- 14 **Configure RubiQ (2 hr).** Visit the Configuration section at rubiq.edventures.com for step-by-step instructions and review Orange LABCard 2, 3 and 4 and Purple LABCard 1 and 2 for a briefing on flight configuration.
- 15 **Secure a safe place to fly (30 min).** To see if there are airspace restrictions in your area, visit <https://b4ufly.kittyhawk.io/>. Authorization to fly in controlled airspace can be requested through a LAANC (Low Altitude Authorization and Notification Capability) supplier such as **Airmap** or **Aloft**.
- 16 **Learn how to use your radio controller and FPV goggles (1 hr)** by reading the instructions in the *FPV Goggle Guide for RubiQ* and *Radio Controller Guide for RubiQ* that are included with your Instructor Folder.
- 17 **Go out and fly! (3+ hr)** Bring the pre-flight checklist in your *RubiQ Flight Manual* and start with line-of-sight (LOS) flight challenges in Purple, then move on to First-Person View (FPV) challenges in Blue. Be sure to find a drone-loving friend to serve as your spotter when you start FPV. Read through each Purple and Blue LABCard for step-by-step coaching.
- 18 **Tether your radios (10 min).** Now that you've mastered the switch settings and feel comfortable piloting RubiQ, follow the steps in the separate printed *Radio Controller Guide for RubiQ* to set up and tether the radios together for the safest flight experience for your students.
- 19 **Review the pacing guide and LABCard curriculum (3+ hr).** *Discover Drones* is designed to be flexible. Read through the options and decide what makes the most sense for your program.
- 20 **Reset RubiQ for your students (1 hr).** When you're done preparing, the settings on RubiQ's flight controller can be reset to default by clicking the Reset Settings button in the RubiQ Configurator and RubiQ can be disassembled back to her original set of parts. She'll be back to brand new for students.

CURRICULUM OVERVIEW



The *Discover Drones* program breaks down into five main pieces: build and configure RubiQ, learn the basics of UAV operations through Droneology, train on the flight simulator, go out and fly and understand the STEM that makes it all possible. Rather than working through each part of the program sequentially, the LABCard curriculum takes an integrated approach, so, plan to dedicate at least this much time for each piece:

- Build and configure RubiQ: 3+hr
- Complete Droneology: 3-5 hr
- Train on the flight simulator: 7-9 hr
- Fly: At least 30 min per student
- Explore STEM: 2-3 hr

Note: The 2-3 hours estimated for STEM will give you just enough time to cover the material written into the LABCard curriculum. As students start asking their own questions, you'll probably end up wanting more time, and that's where you and your students can really make the program your own. Check out the Explore More sections in the Instructor Version of the LABCards (later in this guide) for resources and ideas to go deeper into STEM and UAV technology.

In its simplest form, *Discover Drones* is a 25-30 hr (depending on the size of your group) introduction to the world of UAVs. To go through the full curriculum outline in the pacing guide, plan on 50 hours for a smaller group of 10 or closer to 100 hours for a full class of 25. If you have more time, check out the optional End Design Projects at the end of each level for additional extension ideas, or consider expanding the time for student flight practice. The full curriculum breakdown includes 7 hours of simulator time and 3 hours of flight time for each student, but pilots will only keep improving with more time, whether on the flight simulator or with RubiQ. However, depending on how much time you have to work with, don't feel like you have to complete every project and every flight challenge. The end of the third level, Purple, is one natural stopping point. Each card of the fourth level, Blue, extends the curriculum further, but depending on the length of your program and the size of your group, it's okay if you don't get through them all. The most important thing is that your students have enough training to fly safely and have a positive experience with drones.

The following pages include a pacing guide for the entire curriculum, as well as several examples of how the *Discover Drones* resources could be adapted for several different teaching scenarios.

PACING GUIDE



YELLOW: 5 hr

Build RubiQ

Register for Droneology

Droneology: Introduction, Essential Knowledge & Laws, Regulations and Coordinating Groups

- **Card 1:** 90 min
- **Card 2:** 60 min
- **Card 3:** 60 min
- **Card 4:** 90 min
- **End Design Project & Extensions** (optional)

ORANGE: 7 hr

Configure RubiQ's radio controller and LED's

Droneology: Basic Piloting Skills & Ethical Operation

Begin flight simulator training

- **Card 1:** 90 min
- **Card 2:** 90 min
- **Card 3:** 120 min
- **Card 4:** 120 min
- **End Design Project & Extensions** (optional)

PURPLE: 5 hr + 1 hr per student

Configure RubiQ's motors and sensors

Droneology: Drones and the Future & Flight Safety

Continue flight simulator training

Begin RubiQ flight practice

- **Card 1:** 90 min
- **Card 2:** 90 min
- **Card 3:** 60 min + 30 min per student
- **Card 4:** 60 min + 30 min per student
- **End Design Project & Extensions** (optional)

BLUE: 5.5 hr + 2 hr per student

Aeronautics flight experiments

Continue flight simulator training

Continue RubiQ flight practice

- **Card 1:** 60 min + 30 min per student
- **Card 2:** 90 min + 15 min per student
- **Card 3:** 120 min + 15 min per student
- **Card 4:** 60 min + 60 min per student
- **End Design Project & Extensions** (optional)

EXAMPLE CURRICULUM MAPS



45-HR UAV UNIT (1 hour a day Mon-Fri for 9 weeks)

The first three weeks of *Discover Drones* are primarily small-group, in-class activities as students build and configure their drones and progress through *Droneology*. Outdoor line-of-sight (LOS) piloting begins in Week 4. This activity is much easier to manage if you're able to bring out one student group at a time. If possible, partner with a librarian, aid or even administrator who would be willing to supervise the students who stay inside as they log time on the flight simulator and work on their end design projects. Check out the End Design Projects on the Overview card for each level and choose the one that best fits your program's objectives.

Week	Topics	Curriculum
1	RubiQ Build	Yellow Cards 1-4
2	RubiQ Configuration & Flight Simulator	Orange Cards 1-3
3	RubiQ Configuration & Flight Simulator	Orange Card 4, Purple Cards 1, 2
4	Flight Simulator & LOS Piloting	Purple Cards 3, 4
5	Flight Simulator, LOS Piloting (5 students) & End Design Project	Purple Cards 3, 4
6	Flight Simulator, LOS Piloting (5 students) & End Design Project	Purple Cards 3, 4
7	Flight Simulator, LOS Piloting (5 students) & End Design Project	Purple Cards 3, 4
8	Flight Simulator, LOS Piloting (5 students) & End Design Project	Purple Cards 3, 4
9	Flight Simulator, LOS Piloting (5 students) & End Design Project	Purple Cards 3, 4

FULL SEMESTER UAV COURSE (1 hour a day Mon-Fri for 18 weeks)

The first three weeks of *Discover Drones* are primarily small-group, in-class activities as students build and configure their drones and progress through *Droneology*. Outdoor line-of-sight (LOS) piloting begins in Week 4. This activity is much easier to manage if you're able to bring out one student group at a time. If possible, partner with a librarian, aid or even administrator who would be willing to supervise the students who stay inside as they log time on the flight simulator and work on their end design projects.

Week	Topics	Curriculum
1	RubiQ Build	Yellow Cards 1-4
2	RubiQ Configuration & Flight Simulator	Orange Cards 1-3
3	RubiQ Configuration & Flight Simulator	Orange Card 4, Purple Cards 1, 2
4	LOS Piloting, Flight Simulator & Video Project	Purple Card 3/EDP
5	LOS Piloting, Flight Simulator & Video Project	Purple Card 3/EDP
6	LOS Piloting, Flight Simulator & Video Project	Purple Card 4/EDP
7	LOS Piloting, Flight Simulator & Video Project	Purple Card 4/EDP
8	Video Project	Purple EDP
9	FPV Piloting, Flight Simulator & FAA Project	Blue Card 1/Yellow EDP
10	FPV Piloting, Flight Simulator & FAA Project	Blue Card 1/Yellow EDP
11	FPV Piloting, Flight Simulator & FAA Project	Blue Card 2/Yellow EDP
12	FPV Piloting, Flight Simulator & Careers Project	Blue Card 2/Orange EDP
13	FPV Piloting, Flight Simulator & Careers Project	Blue Card 2/Orange EDP
14	FPV Piloting, Flight Simulator & Lab Reports	Blue Card 3
15	FPV Piloting, Flight Simulator & Lab Reports	Blue Card 3
16	FPV Piloting, Flight Simulator & Lab Reports	Blue Card 4
17	FPV Piloting, Flight Simulator & Lab Reports	Blue Card 4
18	Capstone Projects	Race or Alternate Ending (see Appendix)

Drones

CARD 2 OVERVIEW

Electrical Subsystem

Drones are high-speed racing machines, but did you know “danger” is their middle name? Full throttle propellers can slice through skin and eyes, and batteries can burst into flames unexpectedly. That’s why drone assembly requires skill and attention to detail. Attach the motors in the wrong configuration and RubiQ will act more like a mole than a drone. Plug in the battery before attaching the antenna, and you risk permanently frying the video transmitter (VTX). So buckle up, read carefully and build methodically!

MATERIALS LIST:

- Droneology
- RubiQ Kit
- RubiQ Flight Manual

SAFETY PRECAUTIONS:

Keep LiPo batteries stored in the fireproof container.



P1

Safety: It's No Accident

Learn to stay out of harm's way by navigating the Droneology safety briefing before beginning to attach RubiQ's electronic components.

Open up Droneology *Flight Safety* and watch *Intro to Flight Safety*. (File this info away for the Flight Safety test in Purple!)

Your first safety lesson begins during drone construction:

- Leave the battery unplugged and in the LiPo safe storage container.
- Leave the props off the drone whenever working indoors.
- Wear safety goggles whenever the battery or props are attached to the drone.

With safety taken care of, it's time to dive in! Grab the parts and the *RubiQ Flight Manual* and follow Steps 1-4 to attach the antenna tubes and the camera to RubiQ's Power Distribution Board (PDB).

The power distribution board (PDB) is like the motherboard of a computer — it routes power and data to the interconnected electronic components. On some drones, the PDB is an external circuit board that's bolted to the frame. Others, like RubiQ, have their printed circuit boards etched into the drone's frame, allowing the PDB to integrate other parts like the LEDs or VTX.



P2

Hang 10

Explore the data transmission and telemetry that makes FPV piloting possible.

Power isn't the only thing that needs to travel through RubiQ's board! Her circuits are basically information highways. Learn more by watching *Flight Dynamics and Data* in *Droneology Essential Knowledge*.



RubiQ is a hobby grade drone equipped with a barometer, compass, accelerometer, gyroscope and GPS sensor, allowing her to hold a position and return home. Coupled with the camera, video transmitter and video antenna, this complex array of sensors creates her first-person view (FPV) system. This system allows the pilot to become a modern-day pod-racer, seeing the real-time video feed from the drone's point of view.

So how does it work? Well, let's think about light as a type of wave — it makes it easier to imagine sunlight's 8-minute journey from the Sun to the Earth. Sunshine contains the full electromagnetic spectrum of **wavelengths**: radio waves longer than a football field, x-rays shorter than a single atom, infrared, ultraviolet and every visible color from blood red to eggplant purple. The Earth is constantly bombarded with these waves, absorbing some and allowing others to bounce off.

Project continues on next page...



KEEP IT SAFE:

Keep batteries stored in LiPo-safe bags.



CONSIDER THE FOLLOWING

How will you flow between the activities? Start with a whole group safety briefing and watch the Droneology videos all together on the projector. Break into teams to build, then come back together in P2 to talk through flight dynamics and essential terminology. Split to individual computers to take the Lesson 2 Quiz in C1. Come back together to watch the next batch of videos in C2.



CHECK FOR UNDERSTANDING

What does FPV stand for? (First-Person View.)

How does a camera capture visual data? (When light hits the pixels in a camera, it knocks electrons loose and creates an electric current that the camera detects and interprets as an image.)

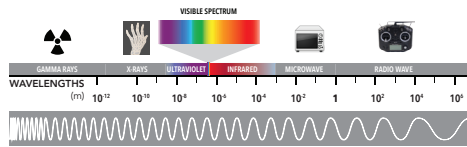
Why are most FPV systems based on purely analog data? (To reduce the delay of data transmission.)

Drones

P2 *Continued...*

When the lights hit the proteins in our eyes or the pixels in a camera, it knocks electrons loose and creates an electric current that the eye or camera can detect and interpret as an image. But, according to the wave concept, electromagnetic waves in the visible light spectrum shouldn't have enough energy to knock those electrons off. In order to explain that, we have to think of light as particles, called photons. This discovery, known as the photoelectric effect, won Albert Einstein the 1921 Nobel Prize in physics. Light behaves in both wave-like and particle-like manners, and to fully understand it, we have to consider both aspects.

ELECTROMAGNETIC SPECTRUM



When you're flying FPV, the camera in your drone is interpreting light just like your eyes. In order to reduce the delay of data transmission from camera to goggles, RubiQ's signal conversion circuitry runs on purely analog data. While HD video feed would be awesome, a delay of even a hundredth of a second could spell disaster for a high-speed drone racer! For now, most FPV pilots sacrifice resolution to reduce lag time.

DRONEOLOGY
CHECKLIST

- ESSENTIAL KNOWLEDGE:**
- Flight Dynamics and Data.
 - Review Essential Terminology
 - Essential Knowledge Quiz

C1 *DRONEOLOGY*
Essential Knowledge

Time to wrap up Essential Knowledge and move on in your Droneology journey. Review *Essential Terminology* and bring your A-game to the *Essential Knowledge* quiz.

C2 *DRONEOLOGY*
Laws, Regulations & Coordinating Groups

Every Droneologist needs to be well versed in the current UAS legislation to know how, when and where to fly. Open *Laws, Regulations & Coordinating Groups* in Droneology and watch *Regulations & Laws Introduction* and *Coordinating Groups*.

KEY TERMS

- **FPV (first-person view):** a flying style that leverages technology to allow the pilot to see from the perspective of the drone.
- **PDB (power distribution board):** a circuit board with embedded wires that routes power from the battery to connected electrical components.
- **VTX (video transmitter):** an electronic component that converts the analog signal from the camera to a radio frequency to send to the goggles through the antenna.
- **Wavelength:** the distance between two peaks of a wave; the defining property of different types of electromagnetic radiation, such as visible light or radio waves.

- FLIGHT SAFETY:**
- Intro to Flight Safety

- LAWS, REGS & GROUPS:**
- Regulations & Laws Introduction
 - Coordinating Groups.



EXPLORE MORE

FIRE! Find the first-aid kit, fire extinguisher and safety goggles and practice acting out what to do if your drone catches fire. How will you respond to the emergency? (Remember, this is a simulation. Your instructor really won't like it if you unload the fire extinguisher into an invisible fire. Practice the safety procedures, but wait for a real emergency for your complete run-through.)

How can light turn into electricity?

<https://phet.colorado.edu/sims/cheerpj/photoelectric/latest/photoelectric.html?simulation=photoelectric>

How does a camera capture an image?

<http://www.cambridgeincolour.com/tutorials/camera-sensors.htm>

How can a radio wave possibly carry all the data captured by a camera?

<http://electronics.howstuffworks.com/radio.htm>

What exactly is analog data?

<http://www.explainthatstuff.com/analog-and-digital.html>