**Flying Drones**

Students will be able to:

1. Explain drone safety.
2. Define yaw, pitch, and roll.
3. Identify parts of the drone
4. Fly drones in a certain flight path.

Interest Approach

Today we are going to spend our time flying drones. When you hear the term “drone”, what does the term “drone” mean to you? Who uses drones and for what purpose?

Define: Roll, Pitch, and Yaw

Imagine three lines running through a drone and intersecting at right angles at the drone’s center of gravity.

* Rotation around the front-to-back axis is called **roll**.
* Rotation around the side-to-side axis is called **pitch**.
* Rotation around the vertical axis is called **yaw**.

Safety with drones

* Always fly below 400 feet.
* Always fly within visual line of sight.
* Be aware of airspace requirements.
* Never fly over groups of people.
* Never fly over stadiums and sports events.
* Never fly with 5 miles of an airport without contacting air traffic control and airport authorities.
* Never fly near emergency response efforts such as fires.
* Never fly near other aircraft.
* Never fly under the influence of drugs or alcohol.

Parts of a quadcopter

Chasis

* The skeleton of a quadcopter is the frame (chassis), some motors and propellers attached to the chassis.  Let’s look at the frame first.  Quadcopter frames come in a variety of sizes and weight ratings. Most have the same basic appearance – a vague X shape. For hobbyists wishing to mount something with additional weight such as a camera, a sturdier frame rated for more weight is recommended.  However, adding a sturdier material typically creates more weight itself, causing you to require longer propellers and a stronger motor to create the lift necessary to pull up the weight.  There’s always a delicate balance played by the manufacturers between flight speed, maneuverability, and flight.

Motor

* The next and probably most important component is the motor.  Motors are rated in “Kv” units, which equate to the number of revolutions per minute a motor can achieve when a 1v current is introduced to it unhindered.  The higher the Kv, the faster the motor can spin.  However, faster is not always better.  A faster motor spin requires much more power from the battery, causing your flight times to decrease.  More RPMs also decrease the life of the motor over the long run.  You’ll see this typically referred to as ‘burn out’.

Propellers

* Propellers largely effect the speed at which the quadcopters fly, the load that they can carry, and the speed at which they can maneuver.  To effect these various attributes you can increase or decrease the length of the propellers and the pitch of the propeller.  The pitch is the shape and slant of the propeller.
* Longer propellers can achieve stronger lift at lower RPM than a shorter propeller, but take longer to speed up and slow down.  Beyond a certain size, they’re literally unable to fly.  For heavier weights, you’ll typically see manufacturers add more arms onto the frames (hexacopters/octocopters).
* Shorter propellers allow the quadcopter to change speed quickly and do tend to produce better maneuvering capabilities, however they require more energy to spin them.  This causes excess strain on the motors, which may lead to shorter life span for the motors.   If you put everything together, an efficient quad will have properly sized, low RPM motors with very large props.
* The faster you want to go, the more aggressive a pitch you want.   If you want to go somewhere fast a higher pitch might be appropriate. However, since quadrotors are generally hovering this means you want the lowest pitch available.  Most quadcopter propeller pitches are typically the same.

Electronic Speed Controller (ESC)

* So far, we have the most obvious components of the quadcopter – a chassis, motors and propellers for lift. But, a machine of this sophistication does have more to it than that. Yet, you’d be surprised at how little more there actually is.  The next part needed is an electronics component called an electronic speed control, or ESC.  There’s an ESC for each of the four motors of the quadcopter.
* An ESC supplies the proper modulated current to the motors, which in turn produce correct rates of spin for both lift and maneuvering. There are fewer things to consider with an ESC than with other components since they’re a fairly standard part, but there are two small factors.  Most ESCs come with the SimonK firmware, which is designed for the precision timing of multiple rotors which a quadcopter uses. Tthis is a standard feature in most ESC designs now.  Usually ESCs also come with a battery eliminator circuit (or BAC), which allows the flight control and transceiver components to connect to the ESC rather than directly to the battery.

Flight Receiver

* Next, comes the brains of the quadcopter, the flight controller. The flight controller is basically the little computer which controls the craft, and interprets the signals the transceiver sends to guide the quadcopter.  For builders of quadcopters, choosing a flight controller is more of a personal choice in many ways, not unlike choosing from various PC processors in the same power range.   Each have various options that each manufacturer wants and may or may not be customizable.  If this is something that needs to be fixed, start reading the forums and listen to hobbyists who recommend affordable, reliable controllers which work with most components easily.

Radio Receiver

* So how does the flight controller receive signals from the transmitter (the remote control)?  That’s the radio receiver’s job.  This consists of a component which connects to the flight controller, to receive signals, and a controller to transmit them.  There are a lot of very slick receivers which work quite well with standard quadcopter flight controllers. However the key is to be sure that it supports at least four channels if not as high as eight or nine.
* A channel is a control input.  If your quadcopter had no channels, it would just hover in place.  A minimum of 4 channels is required to get the quadcopter to move.  2 channels would be available for each stick on the transmitter.    Each additional channel allows you to add controls for accessories (like gimbal control) onto the transmitter.  If you’re going to stay with this hobby for a while, then it makes sense to invest in a good transmitter now, something that has up to 8 or 9 channels.

Battery and Battery Charger

* Finally, to power the quadcopter you’ll a power source, which is typically a LiPo (Lithium Polymer) battery.  LiPo batteries use a C rating, which stands for it’s capacity to discharge.  You’ll typically see a LiPo battery have “20C”.   So if you see a 25C 4000mAh LiPo battery, it means that you can get a maximum of 25C \* 4 = 100A (A standing for Amps).  The power of the battery is usually dictated by the energy draw required from the ESCs.  For example if you motor’s maximum draw is 19A, at the very least you’ll want a 30A ESC to be safe.  Now multiply that by the number of propellers you have (4 in this case) and you’ll get the maximum draw for your entire quad – 4 \* 19A = which is 76A. Your 4000mAh 25C LiPo would definitely be enough for this quadcopter.
* A lot of battery types can be fully discharaged, but the LiPos have a minimum voltage requirements, which if gone beyond can cause damage to the battery.  In most cases it’s 3.0 volts, but can vary from battery to battery.  This is generally about 80 – 85% usage of your battery.   Once past this mark, battery power drops fairly quickly.  So make sure you’re landing or are about to land when you hit this mark.
* You’ll also notice that most quadcopters come with a battery charger specially designed for the battery.  It’s important to use the one they supply you with.  It controls how much current is sent to the battery.  Charging a LiPo battery past 100% could actually cause a fire.  Make sure to charge batteries in a fire safe area (away from things that are flamable).  Allow your battery time to cool before charging again.

Activity 1

**Practice Taking Off and Landing**

1. Always remember, push the control sticks gently and avoid sharp movements.
2. To take off, the only control needed is the throttle.
3. Use the left stick to control the throttle. When the left stick is moved up, the drone will increase throttle. When the left stick is moved down, the drone will reduce throttle.
4. Push the throttle up very slowly, just to get the propellers going then pull back on the throttle to stop.
5. Repeat this multiple times until you are comfortable with the throttle’s sensitivity.
6. Slowly push the throttle further than before, until the drone lifts off the ground. Then pull the throttle back down to zero and let the drone land.
7. Practice taking off and landing by moving throttle up and down slowly.

**Practice Taking Off, Hovering, and Landing**

1. Always remember, push the control sticks gently and avoid sharp movements.
2. Use the left stick to control the throttle. When the left stick is moved up, the drone will increase throttle. When the left stick is moved down, the drone will reduce throttle.
3. To hover, you will use the throttle to get airborne. You will then use small adjustments of the left stick to keep the drone hovering in place.
4. When you’re ready to land, cut back the throttle slowly.
5. When the drone is an inch or two off the ground, go ahead and cut the throttle completely and let the drone drop to the ground.
6. Repeat this until you get comfortable hovering off the ground and landing gently.

**Practice Yaw**

1. Always remember, push the control sticks gently and avoid sharp movements.
2. Use the left stick to control the throttle. When the left stick is moved up, the drone will increase throttle. When the left stick is moved down, the drone will reduce throttle.
3. To hover, you will use the throttle to get airborne. You will then use small adjustments of the left stick to keep the drone hovering in place.
4. Move the left stick to the left for yaw left
5. Move the left stick to right to yaw right.
6. Repeat this until you get comfortable with yaw right and yaw left.
7. When you’re ready to land, cut back the throttle slowly.
8. When the drone is an inch or two off the ground, go ahead and cut the throttle completely and let the drone drop to the ground.

**Practice Pitch**

1. Always remember, push the control sticks gently and avoid sharp movements.
2. Use the left stick to control the throttle. When the left stick is moved up, the drone will increase throttle. When the left stick is moved down, the drone will reduce throttle.
3. To hover, you will use the throttle to get airborne. You will then use small adjustments of the left stick to keep the drone hovering in place.
4. Move the right stick up to pitch down.
5. Move the right stick down to pitch up.
6. Repeat this until you get comfortable with pitch up and pitch down.
7. When you’re ready to land, cut back the throttle slowly.
8. When the drone is an inch or two off the ground, go ahead and cut the throttle completely and let the drone drop to the ground.

**Practice Roll**

1. Always remember, push the control sticks gently and avoid sharp movements.
2. Use the left stick to control the throttle. When the left stick is moved up, the drone will increase throttle. When the left stick is moved down, the drone will reduce throttle.
3. To hover, you will use the throttle to get airborne. You will then use small adjustments of the left stick to keep the drone hovering in place.
4. Move the right stick to the right to roll right.
5. Move the right stick to the left to roll left.
6. Repeat this until you get comfortable with roll right and roll left.
7. When you’re ready to land, cut back the throttle slowly.
8. When the drone is an inch or two off the ground, go ahead and cut the throttle completely and let the drone drop to the ground.

**Free Flight**

1. Always remember, push the control sticks gently and avoid sharp movements.
2. Now fly around the room practicing your yaw, pitch and roll. Remember to keep the drone in your sight and if you crash, wait until the area is clear before retrieving.