In this activity, students will take the time to develop a cardboard Unmanned Aerial Vehicle, which can deliver “cargo” and perform certain maneuvers. In doing so, students will learn about basic aerodynamics, flight dynamics, the potential of UAVs, and future economic use applications. This activity takes about 10 minutes of prep time, about 15 minutes of construction time and about 20 minutes of activity. The activity does not require any experience, but any homework assignment and lecture requires a basic concept of geometry and unit lengths.

What are Drones?
The Federal Aviation Administration (The Government) calls any drone an airborne vehicle which does not have an on board human operator. The first drones were developed from modifying real airplanes to fly without a pilot. Today, with the miniaturization of technology in smartphones, such as cameras, range finders, batteries, and gyroscopes, drones have become small enough to fit in your hand, powerful enough to fly for days on end, and smart enough to fly without a human at the controls.

Drone Types
Drones appear in a variety of shapes, sizes, materials, and forms. Some drones are small enough to fit in the palm of your hand, while others can carry your entire car. Generally, drones fit into 1 of 2 categories.

1. Fixed Wing
Fixed wing drones fly using wings. Just like the big airplanes, a fixed wing drone uses wings to generate lift. They come in a wide variety of shapes and designs, and have a history dating back to the 1960s. Since fixed wing drones use wings instead of propellers for lift, they are more efficient, meaning they can fly longer and carry more cargo than multirotors. However, fixed wing drones are usually difficult to maneuver, require a lot of space to turn and move, and need runways or landing sites.

From left to right – ZOH Drift, a small glider-like drone around the 1ft wingspan. Skywalker X8, a 2 yard long drone used for mid-range long duration missions. MQ9 Reaper, the #1 military drone with a wingspan of 66 ft.
2. **Multirotors**

Multirotors use propellers and motors to generate the lift needed to fly. You can tell if a drone is multirotor by the number of propellers they have and the direction the propeller is facing. Typically, multirotors have 4 or more propellers, and those propellers are parallel to the ground plane. Multirotors also follow a simple geometric shape, which makes them easy to design and maintain.

![Drone Types](image)

*From left to right – Emax Tinyhawk, a palm sized drone used for training. Diatone Taycan, a 3in drone for indoor usage. Mr. Steele’s Apex, a common 5in drone. DJI Matrice 600, the current industry drone at 21in propellers.*

**Drone Rules**

Remember to always look up the rules for operating drones before you fly. Drone law is very new, so it’s extremely complicated and always changing. For some basics, remember that you can’t fly higher than 400ft, and you can never fly near airplanes, helicopters, or emergency operations. Also, you can never use your drone to harm another person, so don’t launch your drone at friends or at other students.

**MATERIALS**

**Individual Materials** (*Individual materials are set for 1 per student*)

- Cardboard, at least 1 sheet of 8x11 in cardboard plate.
- Scissors, or box cutter, or exacto knife, or other cutting tool.
- A4 paper with printed sheets of Schematics, or a marking tool to replicate the pattern.
- Paper Clips
- 1 Rubber Band

**Optional Tools**

- Ruler
- Hot Glue, Glue or other adhesive.
- Various colored pencils, markers, pens, or other coloring utensils.
- Various stickers and other artistic decals.
- Laser Cutting or other advanced machining tool.
- 2 Band Aids or a sticky note.

**Space Requirements**

A space, approximately 8ft in length and 3ft in width is required for every 5ft from the ground. For an average human height, a hallway or classroom setting will work if you’re willing to deal with cleanup. Outdoor areas can be used for flying the vehicle with low wind and good weather conditions. If you are able to launch from a higher position, such as from soccer stands or from a 2nd floor balcony, you will need another 8 ft of space to prevent crashing.
Notes
Cardboard can be cut from any shipping box, standard trifold poster, or from the top and bottom of a pizza box. The exact shape and material is not required, but it is preferred to use Corrugated Fiberboard (Cardboard Box material). Hot glue is preferred as an adhesive, but usage of a hot glue gun requires parent or teacher supervision. Be sure to ask your parent or teacher before using hot glue. Laser Cutting is a quick and simple way to rapidly manufacture the cardboard “drone” designs without having to provide students with cutting and other equipment. For more information and .exf documents please contact bernardli1998@gmail.com if you have access to a laser cutter.

INSTRUCTIONS
Instructions for assembling and building the drone. See video for more details.

1. Start by drawing or gluing the printed schematics onto the cardboard.
   A. Make sure your cardboard airplane is aligned with the grain of the cardboard.

2. Begin cutting out the general shapes of the cardboard pieces.
   A. Make sure to follow all cut lines, including a small incision on the wing and body for the flaps.
   B. For scissors, you may find it easier to divide the cardboard into sections.
   C. For exacto knives or box cutters, make sure to use the ruler to follow the line perfectly.
   D. For laser cutters, you can laser cut the design and skip steps 1 and 2. Make sure the instructor is the laser cutter operator, and that students are protected.

3. Take the tail piece (the longest airplane part) and the wing (the large trapezoid) and slide them in together at the front section.

4. Attach the tail fin (The smaller trapezoid) to the back of the airplane.

5. Attach the remaining 2 body sections to the left and right of the tail piece.

6. Attach the 3 launcher pieces (the bullet shaped pieces) together.

7. If possible, glue or tape any loose sections.
   A. It is best to glue or tape the launcher together, and the rubber band into the launcher.
   B. It is best to apply glue between the body and the wing of the drone.
   C. It is best to apply glue to the tail section to hold it in place.

CHALLENGE
Now that you’ve created your first unmanned aerial vehicle and test flown it, we have some challenges that you can accomplish with your drone!

1. Deliver Medical Supplies
   A. Load band aids into the drone and deliver them to a friend or destination.

2. Collect Site Data
   A. Make 2-3 loops around a table or obstacle using your drone.

3. Race a fellow Pilot
   A. Find a friend who has also built a drone, and fly to see who can go the farthest and the fastest!
While this is the end of the student activity, it isn’t the end of your career in aviation. Here’s what you can do next to learn more about drones!

**Getting a Multirotor**

If you want to get into the flying and operation of Unmanned Aerial Vehicles, there is no better place to start than to ask your parents for a drone! When you’re looking for a drone in 2021, you’re looking for something with goggles and a camera. Ask around to see if anyone has experience with drones, and can help you get started.

For parents or instructors, we recommend you search “1S brushless whoop kits” and select from your preferred online shop of choice. Make sure the kit you select contains a camera, goggles, and a controller. Our pilots fly the Emax Tinyhawk and the BetaFPV Beta85 as our training drones.

**Motorizing your Current Design**

Adding a motor and a battery would greatly improve the range and capability of your cardboard drone, and get you from gliding to actually “off the ground”! Ask your parents or an upper classman to help you put together a battery and motor system to launch your drone, and get into the air.

For parents or instructors, please contact us for details on support or a follow up lecture if you are interested in your student learning more about UAV electronics.

**Flying a Simulator**

Sometimes, the best way to get good at flying is to play video games. We’re not kidding! Both drone pilots and airplane pilots start their training on simulators to gain the experience they need to fly the plane in the real world. Simulators have become so readily available that anyone with a laptop and a controller can fly. Ask your parents to get you a drone simulator so you can practice your flying in the virtual world.

For parents and instructors, the top 3 drone simulators are, in no particular order, Liftoff FPV, Drone Racing League Simulator, and Velocidrone FPV Simulator. They all range between $10-$25 dollars.

For more detailed lecture plans and homework assignments, please contact bernardli1998@gmail.com for details.