Flight Guide: Drone Competition Curriculum Teacher Guide
# Table of Contents

**Getting Started**.......................................................................................................................................................................................2-22  
**Activity 1 – Drone Control**........................................................................................................................................................................23-24  
**Activity 2 – Experienced Drone Control**..............................................................................................................................................25-26  
**Activity 3 – Navigating Various Obstacles**......................................................................................................................................27-28  
**Competition 1 – Construction Zone**.....................................................................................................................................................29  
**Activity 4 – No-Fly Zone**........................................................................................................................................................................30-31  
**Activity 5 – Picture Perfect**.................................................................................................................................................................32-33  
**Activity 6 – Beyond Visual Line of Sight**......................................................................................................................................34-35  
**Competition 2 – Air Traffic Heavy**.....................................................................................................................................................36  
**Activity 7 – Traffic Jam**........................................................................................................................................................................37-38  
**Activity 8 – Power Grid Off**.................................................................................................................................................................39-40  
**Activity 9 – Make a Map**........................................................................................................................................................................41-42  
**Competition 3 – Construction Inspection**........................................................................................................................................43  
**Activity 10 – Wildlife**...........................................................................................................................................................................44-45  
**Activity 11 – Off to the Races**...............................................................................................................................................................46-47  
**Activity 12 – Disaster Strikes**...............................................................................................................................................................48-49  
**Competition 4 – Help Is on the Way!**.....................................................................................................................................................50  
**Standards**.....................................................................................................................................................................................................51-53  
**Field Element Assembly**.........................................................................................................................................................................54-96  
**Notes**.............................................................................................................................................................................................................97-98
Purpose
The Drone Competition guide was developed to introduce students to the many uses drones have in today’s world in a fun, exciting, and competitive way. Each activity has a drone connection to a career the students can explore that utilizes drones in some fashion. Students also learn about how that career uses drones to accomplish their job. Then, students are given a situation that simulates the real-world experience of someone in that field utilizing a drone to complete various tasks. These activities build in complexity as the guide continues. Competitions are placed after every three activities; these incorporate the skills the students have learned along the way. A scoring system is provided, but you as the teacher know your situation the best, so feel free to make adjustments to the scoring system and tasks for your individual classroom.

This curriculum is designed so that you can utilize any drones you have available to you in your classroom. It has been designed and tested with the Tello EDU drone. Any examples included in this curriculum of hardware or software will use the Tello EDU.

Manual Operation vs Coding
Each activity has similar task lists that guide the students to complete the activities using manual or coded flight. Be sure to familiarize yourself with the coding platform you will utilize in your classroom for your drones. You may have students complete the activities using both manned and coded drones or choose just one option.

There are several coding options for drones. Be sure to familiarize yourself with the capabilities and limitations for the one you plan to use in your situation. Common problems can be tolerance for measurements in movements, accessing functions and sensors on the drone can be limited, and device compatibility issues.

Student familiarity with the coding platform used will likely affect the amount of time you will need to allow for the coding portion of activities. You will need to allow sufficient time for students to test and debug the code they create to control the drone.

Preparation
Before you begin, the class must complete the following:
1. Assemble the Pitsco Drone Arena. Be sure to follow the instructions included in the user guide.
2. Locate and become familiar with the field elements and obstacles that you will use inside the arena.
3. Decide on the team sizes for the students in your classroom. We recommend teams of two or a maximum size of teams of four. Possible roles for team members:

- **Pilot** – Operate the drone.
- **Spotter** – Keep eyes on the drone and relay information back to the pilot who is in a fixed location; one to three spotters can be utilized during any drone mission around the drone arena.
- **Air Traffic Controller** – If multiple drones are in the drone arena at one time, instruct the pilots where they are clear to fly and at what altitudes within the arena.
- **Emergency Dispatcher** – Send drones to specific locations within the arena to complete certain tasks as they are made available; as the instructor, you can give the dispatcher real-time tasks that they must relay to the pilot and spotters during drone operation.

4. Before the first class begins, ensure that all batteries for the drones are charged.

5. Create a schedule of time allotted to each team inside the arena for flying their drone and stick to the schedule to ensure all students have the opportunity to fly.

6. Beginning with Activity 2 students will need to develop a flight plan before flying the drone. You may provide them with a copy of the drone arena map for that activity, or a blank map, to create their flight plan.

7. Visibly mark the drones so that they are distinguishable from the other drones in the classroom. You may assign drones and devices, if possible, to groups to expedite the pairing process.

8. Determine how you want the students to create a flight plan before the first activity begins. Options include:
   a. Providing them with a blank arena map and having them create a map of the arena with their flight plan marked.
   b. Providing them with a map with the elements marked in advance and having them indicate their flight plan.

### Arena

The arena will need to be set up before each activity. Maps have been provided at the end of the Getting Started section as examples of ways in which the arena can be arranged. Be sure you are familiar with all the activities.

At times, there will be multiple drones in the arena simultaneously. Students are instructed to communicate with one another during these events and others, so the noise level might be rather high. You will want to take this into consideration when deciding on a location for the drone arena.
Field Element Parts

- MDF Base
- Cardboard Square
- MAS Platform
- Pipe (5')
- Pool Noodle (52'')
- Pipe (3')
- Pipe (16'')
- Pipe (12'')
- Pipe (8'')
- Pipe (4'')
- Pipe Tee
- Pipe Elbow
- Pipe Table Cap
- Hook-and-Loop Fastener
- Screw
- Binder Clip
- Pan Head Machine Screw
- Hex Nut
- Launch Pad
### Field Elements Key for Maps

<table>
<thead>
<tr>
<th>Field Element</th>
<th>Map Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Hoop</td>
<td><img src="image" alt="Large Hoop Symbol" /></td>
</tr>
<tr>
<td>Wide Arch</td>
<td><img src="image" alt="Wide Arch Symbol" /></td>
</tr>
<tr>
<td>Small Hoop</td>
<td><img src="image" alt="Small Hoop Symbol" /></td>
</tr>
<tr>
<td>Tower</td>
<td><img src="image" alt="Tower Symbol" /></td>
</tr>
<tr>
<td>Panel Gate</td>
<td><img src="image" alt="Panel Gate Symbol" /></td>
</tr>
<tr>
<td>Narrow Arch</td>
<td><img src="image" alt="Narrow Arch Symbol" /></td>
</tr>
<tr>
<td>Raised Landing Platform</td>
<td><img src="image" alt="Raised Landing Platform Symbol" /></td>
</tr>
<tr>
<td>Box Tower</td>
<td><img src="image" alt="Box Tower Symbol" /></td>
</tr>
<tr>
<td>Launch Pad</td>
<td><img src="image" alt="Launch Pad Symbol" /></td>
</tr>
</tbody>
</table>
Introduction

The history of aviation includes many different types of flying machines – kites, parachutes, hot-air balloons, gliders, propeller-powered airplanes, jet airplanes, helicopters, and rockets. Most recently, remote-controlled vehicles, commonly known as drones, have joined the vast array of flying machines.

Find a very good time line of aviation here: Pitsco.com/c-aero-history.

Drones belong to a class of aircraft known as UAVs. A UAV is an Unmanned Aerial Vehicle that is piloted via remote control. The control can be a human behind the controls, or the control can be autonomous. Autonomous control indicates that the UAV is controlled by digital code – a series of instructions for the drone to follow.

Drones are most closely related to helicopters; drones have motors that spin propellers and push air downward, offsetting the force of gravity. Some drones are known as quadcopters, a name that hints at the relationship between drones and helicopters. Quadcopters have four motors and propellers that work together to cause the drone to fly.

Rules/Regulations

Even within the educational realm, regulations for drones must be followed. Since the drones recommended for this curriculum weigh less than 0.55 lb, they do not have to be registered with the FAA (Federal Aviation Administration). This also means that they can be flown under Part 107 of the Small Unmanned Aircraft Rule.

For a current summary of Part 107, follow this link: Pitsco.com/c-uas-107.

This curriculum is intended for indoor flying; a number of the limitations within Part 107 are moot as long as flights are kept indoors.

If larger drones are used, all FAA regulations governing those drones will need to be adhered to – including registering the drone with the FAA. Current FAA regulations for UAS (Unmanned Aircraft Systems) can be found here: Pitsco.com/c-faa-uas.

There might also be specific regulations based on your location. You should become familiar with these regulations if your drone program includes outdoor activities or larger drones.

Safety

Read and follow all safety and operational recommendations included with the drone you will be using. The latest versions of these documents are available here: Pitsco.com/c-tello.

Pay particular attention to the Disclaimer and Safety Guidelines document and go through the guidelines with your students to ensure safe drone flights.

Read and follow safety recommendations for the Pitsco Drone Arena and associated accessories.
**Principles of Flight**

In general, flight is governed by four forces: lift, drag, thrust, and gravity. When these four forces are balanced (or in equilibrium), the vehicle is at a stationary point – it is not moving in any direction. This is known as hovering. When the forces are not balanced, the vehicle will move in one or more of the following directions: up, down, forward, back, left, or right. On airplanes, these forces are controlled by the thrust of the engines, lift from the wings, and control surfaces such as vertical and horizontal stabilizers and flaps.

**Principles of Quadcopter Flight**

The same four forces that govern flight in general govern drone flight as well. However, drones use completely different mechanisms to hover and move through the air. A drone's motion can be described in terms of the following movements.

- **Vertical movements** include climbing, hovering, and descending.
- **Rotational movements** involve the drone turning.
- **Horizontal movements** include actions to the left, right, forward, and backward.

The four motors of a quadcopter turn very fast. Two of the motors are spinning their propellers clockwise while the other two motors are turning their propellers in the opposite direction, counterclockwise.

Notice in the pictured diagram how the motors are oriented – like directions are diagonally across from each other. The propellers diagonally across from one another (1 and 3; 2 and 4) should match and be opposite the other set of propellers on the drone.

The movements of the drone (rotational, vertical, and horizontal) are controlled by the speeds of the various motors. Changing one or more motor speeds (and each motor speed may change to be faster or slower) will affect the flight of the drone.

The physics behind the cause and effect due to changes in motor speed is a little complex. The complexity increases as the drone does maneuvers that combine two or more movements simultaneously. In fact, controlling the motor speeds to obtain any of the desired actions requires the use of a microcontroller that can handle multiple motor speeds in very short time frames.

Fortunately, drones have built-in microcontrollers to take care of the hundreds of changes of motor speeds that occur during a flight. If you listen closely, you can hear the changes occurring in motor speeds as the drone changes its flight pattern. Some motors are increasing in speed while others are decreasing in speed – but the outcome is a change in the movement of the drone.

There are a few terms associated with drone flight that you will need to know:

- **Throttle** controls up and down movement.
- **Yaw** controls rotation, determining the direction the drone is facing.
- **Pitch** controls the forward and backward movement.
- **Roll** controls the sideways (left and right) movement.
Visualizing Drone Flight

To help you see and understand a drone’s flight more clearly, place a drone (keep the switch in the off position) on a table directly in front of you with the front of the drone pointed away from you. Leave the drone turned off as you perform the movements described here.

Throttle – This causes the drone to go straight up or straight down. Under positive (+) throttle, the drone ascends. Under negative (-) throttle, the drone descends. Get the feel for throttle by simply picking the drone straight up about a foot and then setting it back down.

Yaw – This causes the drone to rotate in place. Keeping the drone in the same location on the table, rotate the drone so the front of the drone is pointing right. Then, rotate the drone so that the front of the drone is facing you. Keep in mind that the position of the drone on the table does not change; only the direction the front of the drone is facing changes.

Pitch – This causes the drone to move forward or backward. With the drone on the table positioned with the front of the drone away from you, lift the back of the drone up about an inch as you slide the drone forward about a foot. Now set the back of the drone down and pick up the front of the drone about an inch as you slide the drone backward about two feet. Keep in mind that the direction the front of the drone is facing does not change – the drone just slides forward or backward.

Roll – This causes the drone to move sideways – left or right. With the drone on the table positioned with the front of the drone away from you, lift up the right side of the drone and slide the drone directly to the left about a foot. Now pick up the left side of the drone and slide the drone to the right about two feet. Keep in mind that the direction the front of the drone is facing does not change – the drone just slides left or slides right.
Other Drone Terminology

**autonomous flight** – the use of a set of digital instructions for controlling the drone via an electronic controller

**axis** – one plane of several that the drone might move through

**BVLOS** – beyond visual line of sight – the pilot operates the drone beyond his or her visual line of sight or the sight of an observer; the FAA has issued very few licenses for BVLOS operators

**FPV** – first-person view – the use of an onboard camera for controlling the drone from the viewpoint of the drone

**no-fly zone** – an area where drone flying is not allowed

**payload** – an object or additional mass that a drone carries in addition to its own mass, including batteries

**prop** – short for propeller

**prop guard** – the cage surrounding props that protects the props from damage or entanglement; also protects users from being injured by prop rotation

**quadcopter** – an aerial drone with four propellers

**R/C** – remote controlled

**remote-controlled flight** – the use of analog controls for controlling the drone using a radio transmitter

**trim** – an adjustment to how a drone hovers

**VLOS** – visual line of sight – the pilot operates the drone within his or her visual line of sight or the sight of an observer

**VO** – visual observer – an optional person serving as a second set of eyes while the drone is in flight

**waypoint** – a point in space defined by coordinates in three-space (three-dimensional space)
**Career Connection: Air Traffic Controller**

Air traffic controllers manage the air space and all the air traffic in that space over a specified land area. They monitor several aircraft in an area, both those they are directing and the aircraft being controlled by other air traffic controllers. In addition to this, they monitor several areas of restricted airspace called no-fly zones. In no-fly zones, pilots are not allowed to operate any aircraft whether they are manned or unmanned. For drones, no-fly zones are set up around airports, over certain government facilities, and in places where large numbers of people can be found such as sports stadiums. These no-fly zones are intended to keep everyone safe and free from injury. Penalties for entering no-fly zones can be severe, including fines and imprisonment, if you violate the no-fly zones flagrantly or repeatedly. You can explore careers for air traffic controllers and regulations about no-fly zones further here:

- OOH – [Pitsco.com/c-ooh-53-2021-00](Pitsco.com/c-ooh-53-2021-00)
- CareerOneStop – [Pitsco.com/c-cos-53-2021-00](Pitsco.com/c-cos-53-2021-00)

**Objective**

Complete a basic drone obstacle course as quickly as possible while avoiding flying into a designated no-fly zone.

**Overview**

Many drone operators must navigate areas and obstacles within those areas to complete tasks while avoiding no-fly zones to prevent injury or damage to property. Sometimes, they must do this with several drones in the air at the same time. Communication between the drone pilot and the controller is very important during these times.

**Preflight Check**

Before you begin flying your drone in a set boundary, you should be familiar with the following:

- The area or arena in which you will be operating the drone, its boundaries, and how the drone will interact with those boundaries.
- The obstacles and their placement inside the flight area.
- The location of no-fly zones.
- The flight plan for the drone.
- Who your flight controller is and how you will communicate when other controllers and drones will be operating within the same airspace.

**Teacher Note:** Use the map on page 9 titled Activity 4 – No-Fly Zone Course Map. The no-fly zones can be marked on the floor using masking tape, and observers should monitor the no-fly zone during the activity.
Manned Flight Operations
Each member of the team should use manual flight operation to complete the following tasks.

- Complete the course by successfully navigating all obstacles.
- Establish clear communication with your flight controller.
- Avoid flying the drone into no-fly zones.
- Avoid colliding with other drones in the airspace.

Autonomous Flight Operations
Each member of the team should program the drone to complete the following tasks.

- Complete the course by successfully navigating all obstacles.
- Establish a protocol with the other drone operators in the same airspace.
- Avoid flying the drone into no-fly zones.
- Avoid colliding with other drones in the airspace.
<table>
<thead>
<tr>
<th>Standard ID</th>
<th>Standard</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Students will develop an understanding of the characteristics and scope of technology.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>1.f</td>
<td>New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>1.g</td>
<td>The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>1.h</td>
<td>Technology is closely linked to creativity, which has resulted in innovation.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>2</td>
<td>Students will develop an understanding of the core concepts of technology.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>2.m</td>
<td>Technological systems include input, processes, output, and at times, feedback.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>2.n</td>
<td>Systems thinking involves considering how every part relates to others.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>2.q</td>
<td>Malfunctions of any part of a system may affect the function and quality of the system.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>2.u</td>
<td>Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>3</td>
<td>Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>3.d</td>
<td>Technological systems often interact with one another.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>4</td>
<td>Students will develop an understanding of the cultural, social, economic, and political effects of technology.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>4.d</td>
<td>The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>5</td>
<td>Students will develop an understanding of the effects of technology on the environment.</td>
<td>x x</td>
</tr>
<tr>
<td>5.e</td>
<td>Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.</td>
<td>x x</td>
</tr>
<tr>
<td>6</td>
<td>Students will develop an understanding of the role of society in the development and use of technology.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>6.d</td>
<td>Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>6.e</td>
<td>The use of inventions and innovations has led to changes in society and the creation of new needs and wants.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>10</td>
<td>Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>10.f</td>
<td>Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.</td>
<td>X X X X X X X X X X X X X X X X</td>
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<tr>
<td>12</td>
<td>Students will develop abilities to use and maintain technological products and systems.</td>
<td>X X X X X X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>12.h</td>
<td>Use information provided in manuals, protocols, or by experienced people to see and understand how things work.</td>
<td>X X X X X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>12.i</td>
<td>Use tools, materials, and machines safely to diagnose, adjust, and repair systems.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>12.j</td>
<td>Use computers and calculators in various applications.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>12.k</td>
<td>Operate and maintain systems in order to achieve a given purpose.</td>
<td>X X X X X X X X X X X X X X X X</td>
</tr>
<tr>
<td>15</td>
<td>Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.</td>
<td>X</td>
</tr>
<tr>
<td>15.f</td>
<td>Technological advances in agriculture directly affect the time and number of people required to produce food for a large population.</td>
<td>X</td>
</tr>
<tr>
<td>15.g</td>
<td>A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.</td>
<td>X</td>
</tr>
<tr>
<td>16</td>
<td>Students will develop an understanding of and be able to select and use energy and power technologies.</td>
<td>X X</td>
</tr>
<tr>
<td>16.h</td>
<td>Power systems are used to drive and provide propulsion to other technological products and systems.</td>
<td>X X</td>
</tr>
<tr>
<td>17</td>
<td>Students will develop an understanding of and be able to select and use information and communication technologies.</td>
<td>X</td>
</tr>
<tr>
<td>17.h</td>
<td>Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.</td>
<td>X</td>
</tr>
<tr>
<td>17.i</td>
<td>Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.</td>
<td>X</td>
</tr>
<tr>
<td>17.j</td>
<td>The design of a message is influenced by such factors as intended audience, medium, purpose, and the nature of the message.</td>
<td>X</td>
</tr>
<tr>
<td>17.k</td>
<td>The use of symbols, measurements, and drawings promotes a clear communication by providing a common language to express ideas.</td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>Students will develop an understanding of and be able to select and use transportation technologies.</td>
<td>X X</td>
</tr>
<tr>
<td>18.f</td>
<td>Transporting people and goods involves a combination of individuals and vehicles.</td>
<td>X X</td>
</tr>
<tr>
<td>18.g</td>
<td>Transportation vehicles are made up of subsystems, such as structural propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.</td>
<td>X X</td>
</tr>
<tr>
<td>18.h</td>
<td>Governmental regulations often influence the design and operation of transportation systems.</td>
<td>X X</td>
</tr>
<tr>
<td>Standard ID</td>
<td>Standard</td>
<td>Activity</td>
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<td>------------</td>
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<td>----------</td>
</tr>
<tr>
<td>18.i</td>
<td>Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.</td>
<td>X</td>
</tr>
<tr>
<td>20</td>
<td>Students will develop an understanding of and be able to select and use construction technologies.</td>
<td>X</td>
</tr>
<tr>
<td>20.f</td>
<td>The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.</td>
<td>X</td>
</tr>
</tbody>
</table>
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HAVE QUESTIONS?
There are a variety of ways to get in touch with us:

Call us at 800-358-4983.
Email us at orders@pitsco.com.
Chat with us on Pitsco.com/support.