Playbook Module
B-2: Intermediate Drone Flight Maneuvers

Level: Intermediate
Objective: Learn & demonstrate intermediate level drone flight maneuvers
Pre-requisites: A-1, A-2, A-3, A-4, A-5, A-6, A-7
Learning Objectives:

- Learn, practice & demonstrate more advanced drone flight control maneuvers
- This can be done individually, or as a group event.

Materials Needed:

a. You will need an operational Drone, its controller, and access to the BSA App on a phone
b. 6 items to mark the reference points for the maneuvers (simple safety pylons work great)
c. A tape measure capable of measuring at least 20 feet (a 50-foot tape measure is helpful)

Space Needed: 40x200+ foot clear area

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Prepare your drone for flight

- **Verify Drone Registration:** Verify that your drone has your FAA registration number clearly marked on the outside of the drone and that it's registered with the BSA Drone system via the app.
- **Review Flight Plan:** Review your flight plan and safety rules before flying.
- You will be flying this set of maneuvers in Line-of-Sight mode. The camera feed should be turned off except for when instructed to turn the camera on. No FPV goggles are allowed. Line of sight is the best way to start learning how to control a drone. Once you get good at line of sight control, transitioning to FPV is easier and you will have better control over your drone. For example, when flying FPV, it is easy to lose track of your altitude and attitude (aircraft 3-D orientation). Try to do as many as possible just in Line of Sight mode. This will help you become a better pilot.

Flying Safely: When you are practicing these flight maneuvers, it is important that you take the proper precautions to avoid any injuries to people or property. Practice these maneuvers in a large, open flat area where there are no people around. Sports fields, large playgrounds, or open parks are good places to practice your flying. The benefit of flying in an open area is that it gives you room to make mistakes. If you try practicing these tricks in your backyard, you will most likely get your quadcopter stuck in a tree or your neighbor's roof.

Fly over an area that has short grass - it will provide some cushion for when your quadcopter crashes… because yes, you will crash! Avoid parking lots with asphalt or concrete surfaces if you can.

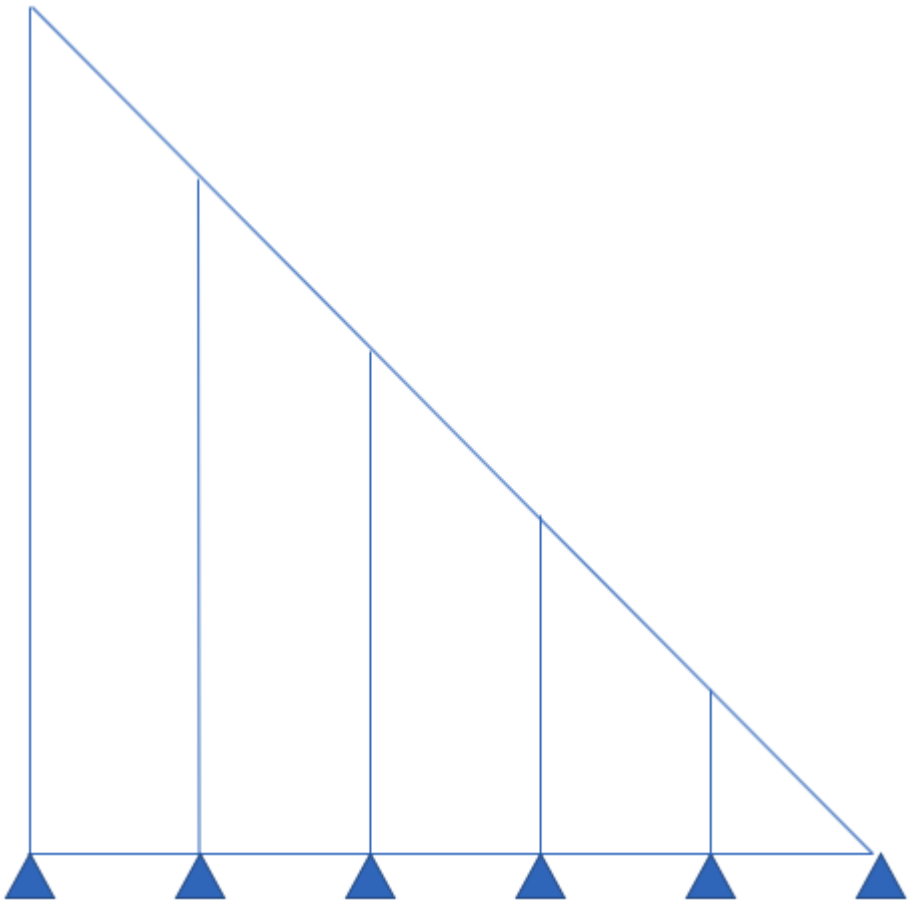
Go through the pre-flight checklist in the App.

Distance Flying Orientation - Line of Sight Mode flying

- As you fly your drone on longer flights, you'll get to the point where your drone is so far away that you can't tell which way it is pointing. This could cause you to accidentally fly your drone out of range and even lose it. Determining the orientation of your drone quickly is an important skill for pilots to learn. An example video for this is shown here: https://www.youtube.com/watch?v=qdYTCfjUVVo
- Do the following steps with your camera turned off. This will help you get good at quickly detecting where your drone is flying when it is at a distance. The radio controlling the drone's flight has a very long range, but the WiFi link sending video to your app has a shorter range. You can fly your drone out far enough to lose the video feed, but you are still controlling it with the radio controller.
- Fly your drone out about 50 feet away from you. Have a friend yaw the drone a bit while you are NOT watching.
- Now, to figure out your drone's orientation, apply forward pitch to give your drone some speed. Look to see which way the drone moves. If it is moving to the left or right, the drone is pointing somewhere to the left or right. Next, apply a little left turn if the drone is moving left, and a little right turn if the drone is moving right. Keep up the turn until the sideways motion stops. Your drone is now flying back towards you.
- If you applied forward pitch and your drone did not move sideways, identify if it is flying away from you or towards you You may be able to see the drone getting larger or smaller, but sometimes this is difficult. If you can't tell, start a left or right turn after applying forward pitch and wait-until you see the drone turning to figure it out. If you apply left yaw, and the drone turns left - it is facing away from you. If it turns right, it is facing toward you. Try it with a right turn.
- Practice this a few times, until you get very quick at recognizing the orientation of your drone.
- Now fly out to about 100 feet away and have a friend yaw the drone a bit while you are NOT watching.
- Apply forward pitch and repeat the identification maneuvers at this distance.
- Last, turn your camera on and repeat the previous 2 steps. You will see how you can use the drone's camera to help find which way the drone is pointing by finding yourself in the camera view.

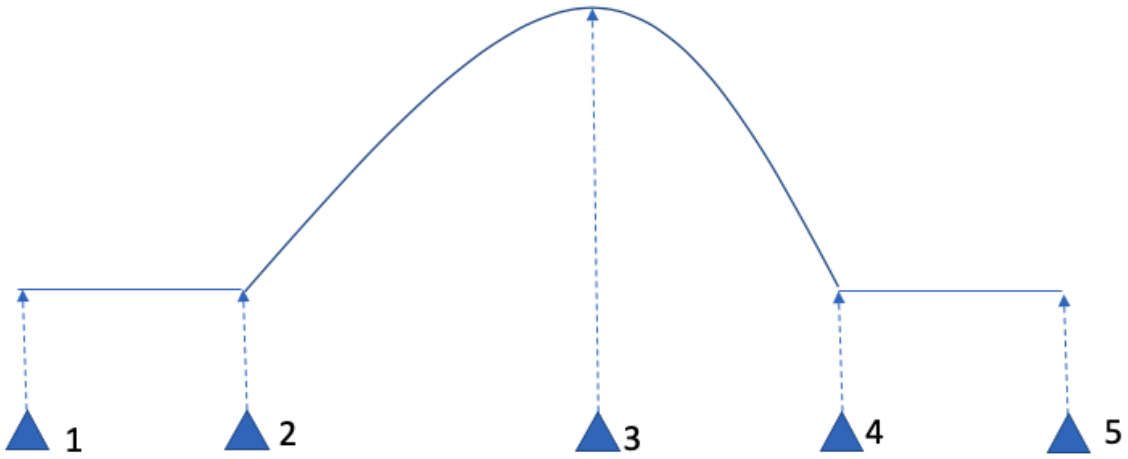
45-degree ascent & Descent - Line of Sight Mode flying with FPV assistance

- This is a maneuver that is used by helicopter pilots when they launch from an airfield to avoid problems with turbulent rotor-wash causing instability. It's also a great way to create an awesome reveal camera shot when shooting video from your drone.
- To get up to altitude, this maneuver is best done outdoors. Place a series of markers in front of you, and moving to the right or left by 20-foot intervals, lay out a ground course 100 feet long.
- Pick a starting point in front of you and then turn to the left or right and push your drone forward and up to achieve a 45-degree flight path. So, for every foot to the right or left your drone travels horizontally, it should rise that same amount. If you put markers at 20-foot intervals, just check your altitude at the start point, and by the 10-foot marker, you should have gained 20 feet of altitude.
- Once you have reached 100-foot altitude above your starting point, turn your drone around by 180 degrees and fly back down the 45-degree angle.



Arch - Line of Sight Mode flying

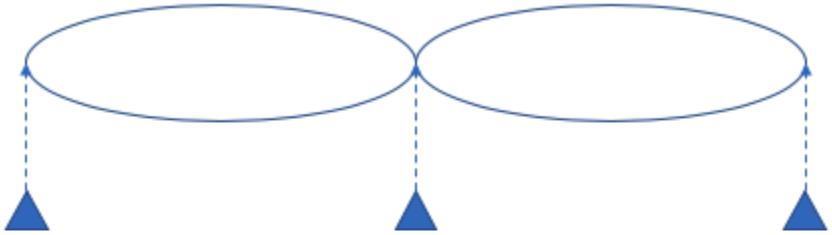
- This maneuver practices using both joysticks at the same time.
- Set up 5 markers in a straight line on the ground as shown below. You should have 20-25 feet between markers.



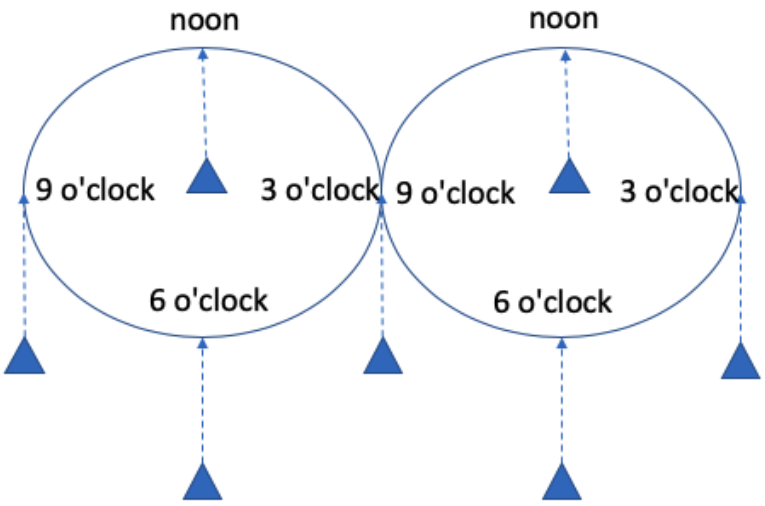
- Start in a hover with your drone about 10 feet above the ground over Marker 1 with the nose pointing to the other markers. Fly level, maintaining 10 feet AGL to Marker 2. Once you hit Marker 2, climb smoothly (20-30 feet or whatever you are comfortable with) while flying forward until you reach Marker 3. Then, start to descend to Marker 4, halting your descent when your drone is again about 10 feet off the ground. Repeat this until you can make a smooth arch.
- Next, start at Marker 5 with your drone pointing away from the markers and fly the arch backwards. Repeat flying backward and forward until you can make smooth arches in both directions.
- Lastly, position your drone again over Marker 1, with the nose facing away from you. Fly the arch sideways, back and forth, and then yaw your drone so that the nose is facing you and again, fly it sideways and back and forth.

Figure 8 - Line of Sight Mode flying with camera assistance

- This maneuver emphasizes yaw control. You will first practice making a stretched out figure 8 (like an infinity symbol), and as you get good at that, you will tighten up to make good circles for a true figure 8.
- First, set up 3 markers/cones about 50 feet apart as shown in the figure below.



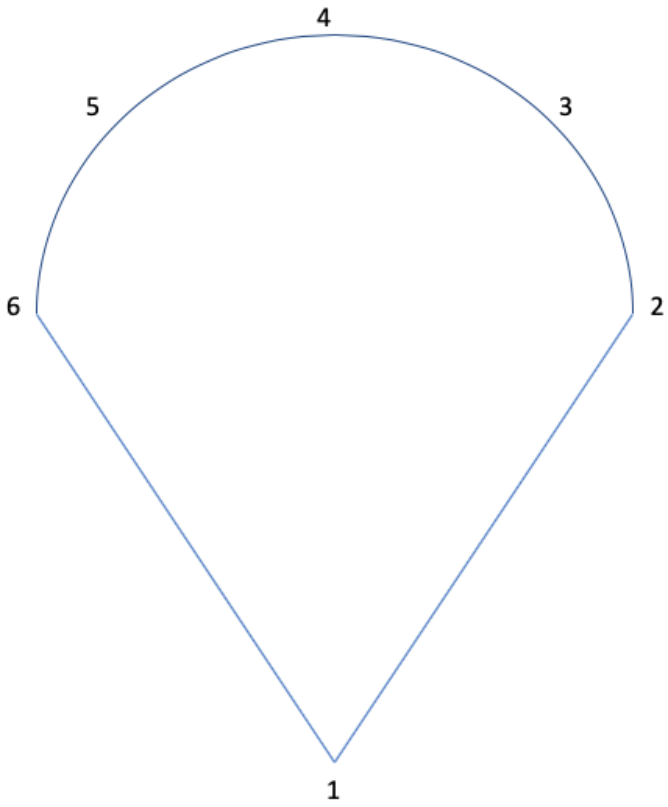
- Fly your drone and make it hover over the center marker, level with your eyes. Turn your drone just a bit past 90 degrees to the right and fly to the right. When your drone is in the area of the right marker, add left yaw to turn the drone 180 degrees and head back to the center marker. Now repeat the maneuver with the left marker. Repeat this a few times until you can make a smooth set of turns, keeping the drone at head height the entire time. Your drone should always be facing in the direction of its travel.
- Now, add markers to outline circle shapes at the noon, 3 o'clock, 6 o'clock and 9 o'clock positions as shown in the figure below.



- Flying around the circular figure-8 is similar to the ovals done previously, but now, you will use the yaw control constantly. First, fly until your drone is over the center marker (where the 9 and 3 o'clock points of the two circles connect, at about eye height. Turn right almost 180 degrees and start to fly forward toward the 6 o'clock position on the right circle, applying left yaw to make a smooth arc from the 9 o'clock to the 6 o'clock position on the right circle. Continue applying left yaw while flying forward to the 3 o'clock, noon, and 9 o'clock points in a counter clockwise circle. As you pass the 9 o'clock position on the circle to the right, start applying right yaw to fly to the 6 o'clock position on the circle on the left, and continue applying right yaw as you fly clockwise around the left circle. Your drone should always be facing in the direction of its travel.
- Repeat this maneuver until you can keep the drone at eye level while making smooth circles. Then, starting back at the center marker, fly the circles in the opposite direction (counter clockwise on the left circle and clockwise on the right circle), until you can do this smoothly.
- Next up, try to fly the same figure 8 with different nose orientations. So far, you have flown these with the nose pointing in the direction of travel. Now try it with the nose always pointing away from you, and again with the nose always pointing towards you. Repeat all of these until you are comfortable and controlled in flying these maneuvers.

Ice Cream Cone - Line of Sight Mode flying

- The Ice Cream Cone helps you learn how to use all the flight axes together in one fluid motion.
- If you need help visualizing the points in the air, set some markers/cones on the ground under points 1, 2, 3. 5, & 6 as reference (see diagram below).



- Start with your drone about 10 feet AGL, facing away from you. Fly your drone to the right, while gaining altitude (how much altitude?) to Point 2. At Point 2, turn 90 degrees left so that the nose is facing toward point 3. Fly a teardrop shape through points 3, 4, 5 and on to 6. At Point 6, yaw right 180 degrees to put the nose of your drone facing away from you and then move right and descend until you get back to Point 1.
- Repeat this until you make a smooth ice cream cone shape, then try varying the height climbed, the size of the teardrop shape, and the direction of turn as you get better and better at this maneuver.

Postflight checklist

- Pull up the post flight checklist in the app and go through it.

