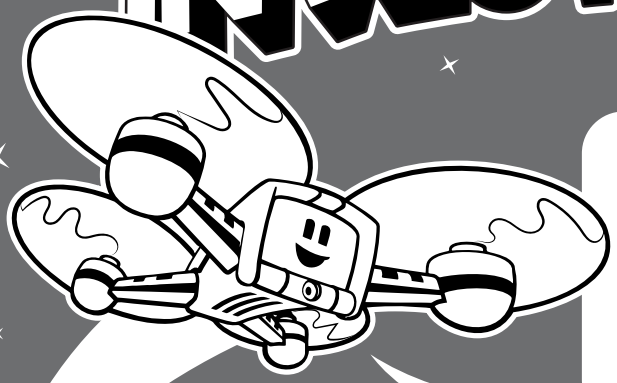
INGENUITY INVESTIGATION



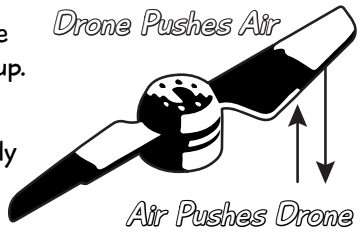
A team of NASA engineers has been working for months to design and build a drone, Ingenuity, that can fly on Mars!
The Perseverance rover just landed and dropped Ingenuity on the surface.
NASA wants you to take Ingenuity through its first 3 test flights in the Jezero Crater on Mars's surface.

Getting a drone to fly on Mars, like Ingenuity can, is hard work! Mars has extremely thin air (just 1/60 the density of Earth's air). Air is essential for flight. Let's rewind to 1686 so Newton can explain some physics.

Every time you push or pull an object (action), that object pushes or pulls you back (reaction). So if you are standing, your feet are pushing down on the ground and the ground is pushing up on you with the same amount of force. If you push harder on the ground, the ground will push harder on you. That's how you jump: try it!

Flight works the same way. When the propeller blade spins, it pushes air downward. The air will push the propeller blade upward with the same amount of force. The faster the propeller blade turns, the more air it pushes down and the more the air pushes the propeller (and the whole drone) up.

But what if there is not much air? Now you see the problem. The propellers on Ingenuity have to spin incredibly fast - about 60 times faster than propellers on Earth because there is only 1/60 as much air. That's tricky.



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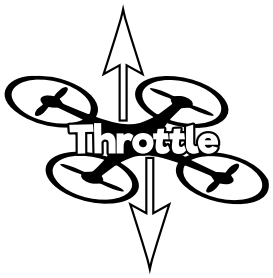
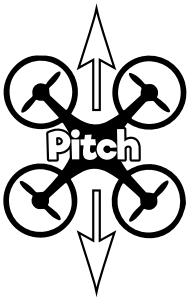
Getting Started

Most Drone Legends missions are designed specifically for the DJI Tello, but this mission can be used with any drone, even if they have different features than the Tello. When you first start flying, one of the biggest challenges is that joysticks vary in sensitivity, so it is helpful to use really gentle movements at first while you figure it out. Another challenge is knowing which direction your drone is flying. Because the drone's direction changes when it yaws, sometimes your forward direction and the drone's forward direction are different. For that reason, it is helpful to fly without yawing during your first few flights.

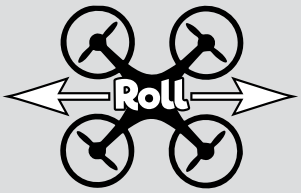


Throttle: Move the drone up (away from the ground) or down (toward the ground). This is the up and down arrows on the left joystick.

Yaw: Rotate the drone left or right. This is the left and right arrows on the left joystick.

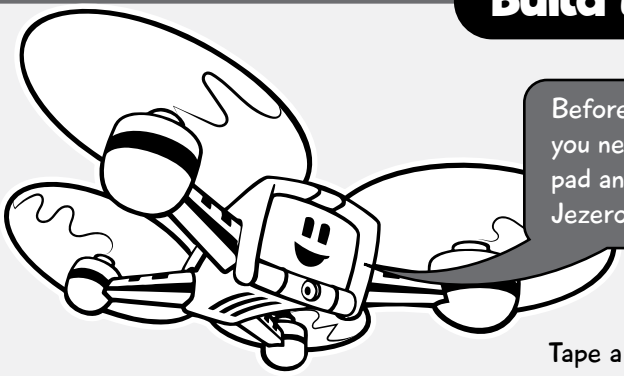


Pitch: Move the drone forward or backward. This is the up and down arrows on the right joystick.



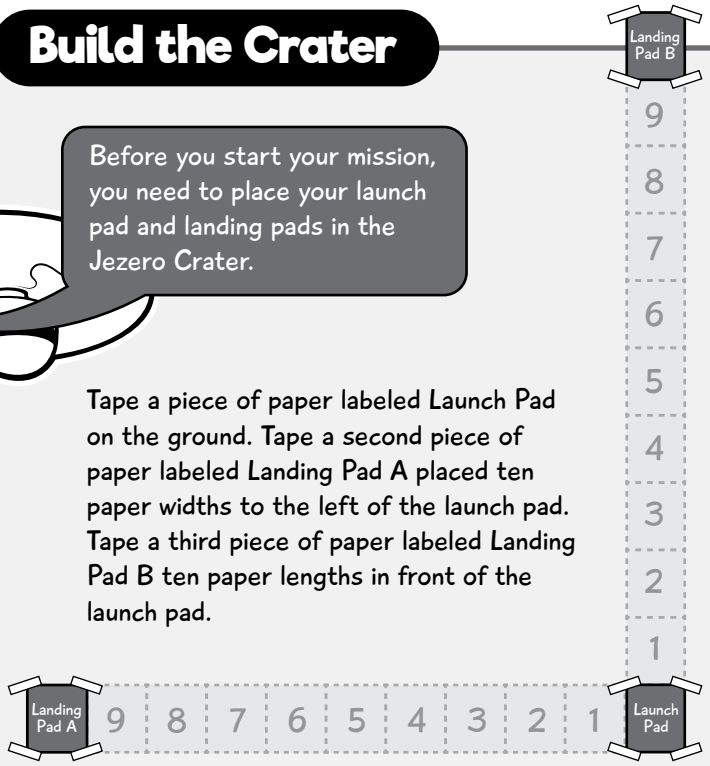
Roll: Move the drone right or left. This is the left and right arrows on the right joystick.

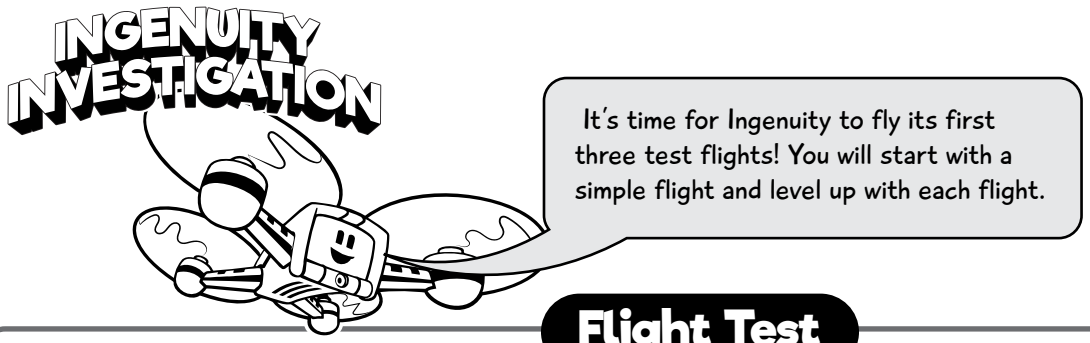
Build the Crater



Before you start your mission, you need to place your launch pad and landing pads in the Jezero Crater.

Tape a piece of paper labeled Launch Pad on the ground. Tape a second piece of paper labeled Landing Pad A placed ten paper widths to the left of the launch pad. Tape a third piece of paper labeled Landing Pad B ten paper lengths in front of the launch pad.





Flight Test

Your first Ingenuity test flight is to practice taking off and throttling. You will take off, hover, throttle up 2 meters off Mars's surface, and land.

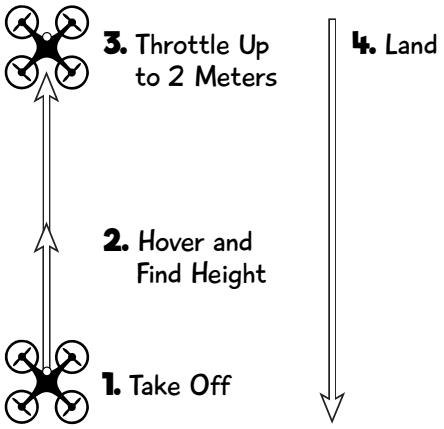
1. Place Ingenuity on the launch pad and take off.

2. Hover and find the height reading on your controller screen.

3. Throttle up until the height reads 2 meters (6.56 feet) off the ground.

4. Land on the launch pad.

Ingenuity's real first flight was to take off, throttle up until it was 3 meters off Mars's surface, hover, and land. It was 39 seconds of scientific glory!



Time to Fly

Your second Ingenuity test flight is to practice rolling. You will take off, roll left 2 meters, yaw 360°, roll right 2 meters, and land.

1. Place Ingenuity on the launch pad and take off.

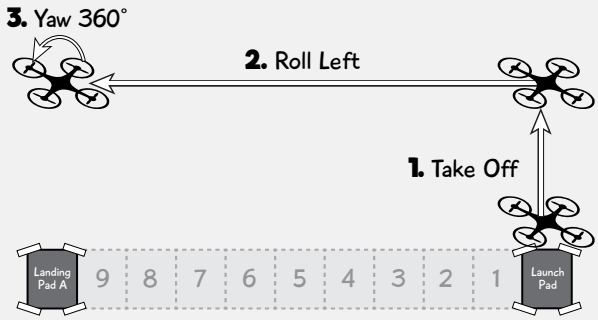
2. Roll left until Ingenuity is hovering directly above landing pad A.

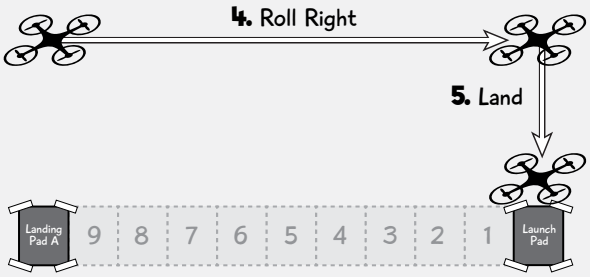
3. Yaw left 360° so Ingenuity returns to its original orientation.

4. Roll right until Ingenuity is hovering directly above the launch pad.

5. Land on the launch pad. If you don't get on the launch pad the first try, take off and correct your position before landing again.

Ingenuity's real second flight was to take off, roll westward 2 meters, yaw back and forth while recording the landscape, roll eastward 2 meters, and land.





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Time to Compete

In your third Ingenuity flight, you will practice recording video and yawing. If your drone does not have a video or photo function, simply complete the mission without it. To start, you will take off, pitch forward about 3 meters, and land on Landing Pad B. Next, you will launch, yaw 180 degrees, pitch forward 3 meters (about 10 feet), and land back on the launch pad.

If you record your flight, you can submit your video to compete with other Drone Legends for the fastest time.

1. Place Ingenuity on your launch pad and read through the safety tips. Then start video recording.

2. Take off.

3. Pitch forward until Ingenuity is directly above landing pad B.

4. Land so that Ingenuity lands on the landing pad. If you don't get it the first time, take off and correct your position before landing again.

5. From landing pad B, take off again.

6. Yaw left 180 degrees (so Ingenuity is facing the launch pad).

7. Pitch forward until Ingenuity is directly above the launch pad.

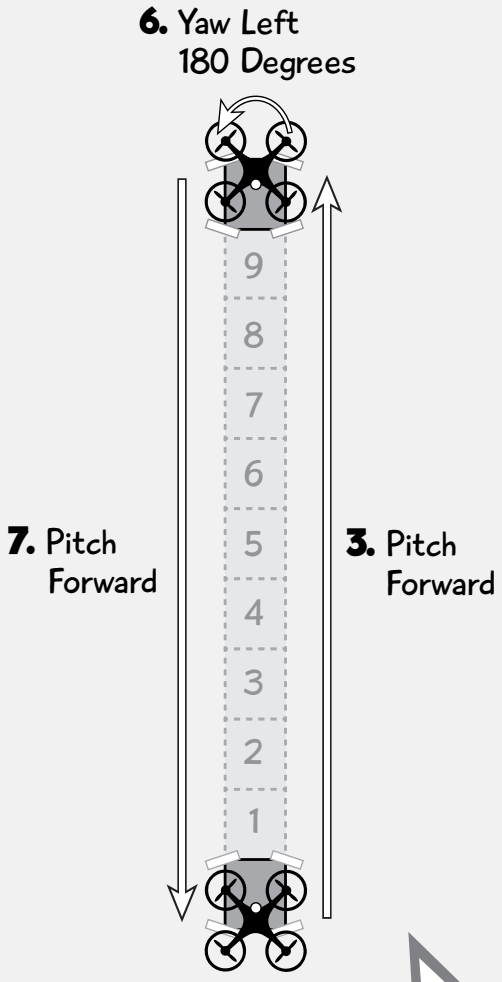
8. Land so that Ingenuity lands on the launch pad. If you don't get it the first time, take off and correct your position before landing again.

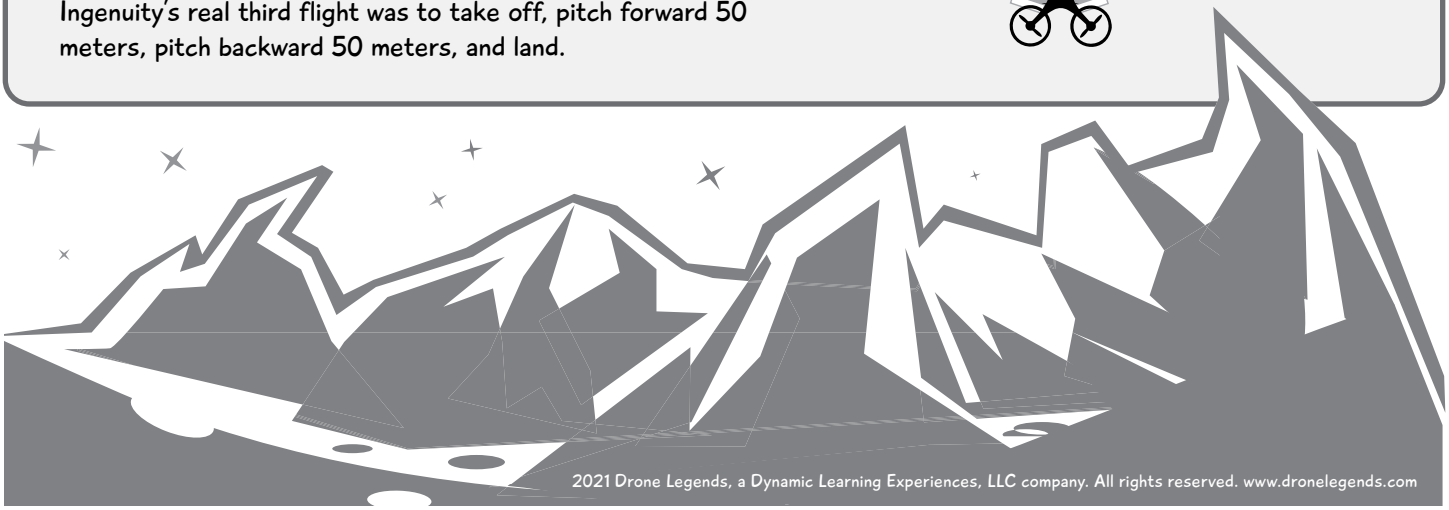
9. Turn off video.

10. Repeat to get a faster time if you want, and upload your video and tag us:

TikTok: @wearedronelegends
Facebook: @wearedronelegends
Instagram: @wearedronelegends
Twitter: @Drone_Legends

Ingenuity's real third flight was to take off, pitch forward 50 meters, pitch backward 50 meters, and land.





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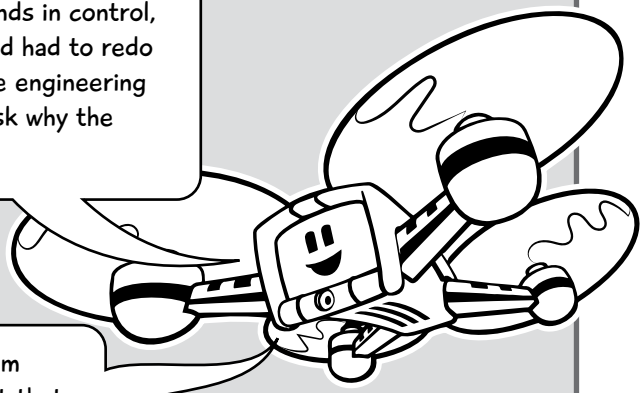
Wrap Up

At the time this mission was written, Ingenuity had completed 18 successful flight missions. Instead of having a live pilot flying Ingenuity, NASA[1] coded its missions so Ingenuity could complete them autonomously, which means without human intervention. Ingenuity's farthest flight was 625 meters, nearly half a mile! NASA compares Ingenuity's success with the Wright brothers' first flight on Earth - truly momentous!

Even with some of the brightest minds in control, Ingenuity failed 4 of its missions and had to redo them. Failure is a normal part of the engineering process and led the engineers to ask why the mission failed and how to fix it.



Just like scientists and engineers, when we fail, we can move from discouragement to curiosity by asking questions like, "Why didn't that work?" and "How can I look at the problem in a different way?" Keep practicing. Keep failing. Keep asking questions. You are on your way to your very own "Wright brothers' moment!"

1. Information cited from https://mars.nasa.gov/technology/helicopter/

Optional STEM Challenges

Science Challenge:

Make a paper helicopter spinner and roll up a piece of paper. Drop each from equal heights and time how long it takes for each of them to hit the ground. What is the ratio of their fall times? Why? What effect would dropping them on Mars have on each of their fall times? Why?

Technology Challenge:

Start at the launch pad, fly to landing pad A, then straight to landing pad B, and back to the launch pad.

Engineering Challenge:

If you have a DJI Tello drone, download the DroneBlocks app (iOS or Android) and try to code the three missions (and the challenges) that you just completed so that your drone can complete the flights autonomously, just like Ingenuity did on Mars.

Math Challenge:

The real 3rd flight of ingenuity was 50 meters. If your paper models the real flight, what length does each piece of paper represent?

Calculate the length from the launch pad to landing pad A, and the length from the launch pad to landing pad B. Calculate the length from landing pad A to landing pad B using the Pythagorean Theorem. Which distance is longest and why?

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Adult Instructions

Introduction

Drone Legends uses the magic of drones to help prepare students for the 21st Century. Our mission is to blend science, technology, engineering, arts, and math (STEAM) with social and emotional learning (SEL) to develop tomorrow's legends today!

In this mission, 8 to 12 year old students will learn and practice drone-flying skills to complete three test flights that mirror the first thre e actual flights of the Ingenuity drone on Mars. They will also learn flight physics and apply their knowledge to science, technology, engineering, and math challenges.

This Drone Legends sample lesson is designed for the DJI TELLO but can be used with any drone. Other drones may not have the same functionalities, such as a camera, a vision positioning system, or a height indicator. The joystick may also function differently, but the lesson can be adapted to accommodate these differences.

Using the Mission

Read through the mission together with your learner, and then complete each section. When the learner has completed the mission and practiced their flight skills, record their final test flight mission. To enter the community competition, upload the video to TikTok, Facebook, Instagram, or Twitter, and tag us!

Differentiation for Age Groups

A 6- to 8-year old can:

- read the mission out loud but may need help defining advanced words.
- tape 21 pieces of paper to the ground rather than the 3 pieces indicated in the mission.
- decorate the pages. Coloring and writing are good practice for fine motor skills.
- think about units of measurement, where paper length is one unit and paper width is another unit. This can help students understand the difference between any two units of measure.

A 13+ year old can:

- research more about the Ingenuity drone and Mars exploration at the NASA or Drone Legends website.
- build complex courses for their drone to practice flying or coding their drone.
- explore other science concepts related to flight physics such as Bernoulli's Principle, lift and drag, Newton's laws of motion, combined forces, etc.
- investigate other math concepts such as the distance, time, and speed of their drone; the volume of the 3-D triangular prism space enclosed by the drone flight path; and the percent of the battery used in each test flight.

Standards Alignment	Common Core Math Standard 1.MD.A.2	Next Generation Science Standard K-PS2-1	Next Generation Science Standard 3-5-ETS1-3

If you enjoyed this

FREE Mission

and want to learn how to bring the

Drone Legends Experience

to your child's school or your classrooms, email us at info@dronelegends.com!