



Flying Machines Playbook

Flying Machines Spark: Comprehensive Educator's Guide

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One-Page Quick Start

What's the big idea?

Learners in grades K and up can design and build a wind-up flying machine using stored potential and released kinetic energy. This project takes a minimum of 10 minutes, if at an event activity station, 30 minutes in a single classroom session, or up to 60 minutes if you use our recommended extensions. Please refer to the full guide for details.

What's in the kit?

- Propeller
- Fuselage stick
- A latex-free rubber band
- Card stock instruction & fuselage design sheet
- Marker set
- Sticky strips



You may have access to an older version that includes two craft sticks and a rectangle of card stock. This guide covers both versions.

Are any extra materials needed?

Yes! Students will need access to **scissors** to design and create a fuselage for their flying machine. You may want to make additional scrap or construction paper available if they want to make an alternate “wing”.

With older version, you will need to provide drawing materials.

How can I lead my students with confidence?

These slide decks prepare you to communicate the big ideas and pro

tips for activating the materials. The English version has been updated to include two versions of the project – new style (Q1 2025) and old style. This guide covers both.

Slides – English:  **Flying Machines**

Slides – Spanish:  **Flying Machines – ESP**

Watch this awesome video guide!

[Flying Machines Educator Guide](#)

Build Your Confidence – Make a Flying Machine!

Educators are most confident and successful when they **build an example before using it with learners**. You'll need about fifteen minutes to tackle this activity, and those will be minutes that you'll thank yourself for taking later. By investing in practice you'll learn how the project connects to your learning objectives, some challenges to anticipate, and develop your own pro tips to help learners know where to start based on what challenged you.

Here's a text overview of the build process to help you get started. We encourage you to use the Flying Machines [slide deck](#) as well to help with the build process.

Newest version (Q2 2025 and later)

1. Gather Materials:

Review the Spark components: One fuselage stick, 7" plastic propeller, rubber band, sticker strips, instruction sheet with two fuselage design sections.

2. Create the Engine:

Connect your propeller to one end of the fuselage stick. Align the metal hook with the wooden hook on the opposite end of the stick. Attach rubberband to the propeller and fuselage hooks.

3. Store Energy

Hold the fuselage stick and turn the propeller clockwise (to the right) at least 50 times to tighten the rubber band, storing elastic potential energy. Observe the rubber band winding up and forming bumps. This is stored energy.

4. *Test Without a Wing*

When you're ready to test fly, use the "LIFT-OFF" technique.

- Hold the base of the fuselage stick, and release the propeller so it starts to spin (LIFT).
- Once it's spinning, release the fuselage (OFF) and it will... lift off!

You'll notice that the machine flies better once the propeller is able to generate lift. If you release both at the same time, the propeller and fuselage will twist in opposite directions and fall.

Pro Tip: You may need to review the difference between clockwise and counterclockwise.

3. *Test With a Practice Wing*

Using the test shape on the left side of the instruction guide, encourage learners to draw, cut, and attach a wing to the fuselage. Focus on symmetry - use any colors you want, and be sure to cut the wing along the dotted lines. Attach the wing to the wooden fuselage stick with sticky strips. Be careful not to cover the rubber band with sticky strips.

Use the same LIFT-OFF technique

4. *Connect the Rubber Band:*

Hook one end of the rubber band to the paper clip and the other to the small hook on the propeller. This can be challenging, so encourage patience. Pro Tip: Twist the propeller *clockwise* multiple times to tighten the rubber band, storing elastic potential energy. You may need to review the difference between clockwise and counterclockwise.

7. *Prepare for Launch:*

Demonstrate the "tick-tock technique" to allow the propeller to generate *momentum and lift* prior to launching your flying machine. It's a quick maneuver, and takes as long as it does to say "tick-tock"! With one hand on the propeller and the other holding near the paperclip, release the propeller ("tick") to let it spin very briefly - then lightly launch the fuselage ("tock"). This takes practice, and many attempts will be required to get great results - and this is all about practicing technique. Lots of spins of the propeller will be used up practicing - but don't be discouraged! By practicing the tick-tock

technique, learners will be more successful in allowing the propeller to spin up prior to flight, like a real flying machine!

8. Test and Iterate:

Have learners test their flying machines in a safe, open area. Encourage them to tweak wing shapes, sizes, and number of rubber band twists to observe different flight outcomes. Use our [Flying Machines Extension](#) document and its [printable wing evolution worksheet](#) to support the testing and iteration.

Older version: (Q1 2025 and earlier)

1. Gather Materials:

Review the Spark components: One fuselage stick, 7" plastic propeller, rubber band, sticker strips, instruction sheet with two fuselage design sections.

Q1 2025 and earlier: 2 craft sticks, sticky foam strips, a paper clip, a propeller, a latex-free rubber band, and cardstock. You'll need to supply scissors and drawing materials.

2. Start with Stick:

Align the craft sticks at the center and secure them using two sticky foam strips. The foam wraps tightly around the overlap to form the main body (fuselage) of the flying machine.

3. Create the Engine Hook:

Bend the paper clip into an "L" shape. Attach it to one end of the fuselage using another foam strip. This will serve as the hook for the rubber band, acting as the engine of the flying machine.

4. Attach Your Propeller:

On the opposite end of the fuselage, attach the propeller securely. This step forms the flying machine's propulsion system.

5. Add the Wing:

Using the cardstock, encourage learners to draw, cut, and attach a wing to the fuselage. Highlight that larger wings might add weight, affecting flight. Pro Tip: Test different wing shapes and sizes to explore aerodynamics.

6. Connect the Rubber Band:

Hook one end of the rubber band to the paper clip and the other to the small hook on the propeller. This can be challenging, so encourage patience. Pro Tip: Twist the propeller *clockwise* multiple times to tighten the rubber band, storing elastic potential

energy. You may need to review the difference between clockwise and counterclockwise.

7. *Prepare for Launch:*

Demonstrate the “tick-tock technique” to allow the propeller to generate *momentum and lift* prior to launching your flying machine. It’s a quick maneuver, and takes as long as it does to say “tick-tock”! With one hand on the propeller and the other holding near the paperclip, release the propeller (“tick”) to let it spin very briefly – then lightly launch the fuselage (“tock”). This takes practice, and many attempts will be required to get great results – and this is all about practicing technique. Lots of spins of the propeller will be used up practicing – but don’t be discouraged! By practicing the tick-tock technique, learners will be more successful in allowing the propeller to spin up prior to flight, like a real flying machine!

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Have learners test their flying machines in a safe, open area. Encourage them to tweak wing shapes, sizes, and number of rubber band twists to observe different flight outcomes. Use our [Flying Machines Extension](#) document and its [printable wing evolution worksheet](#) to support the testing and iteration.

Facilitate With Confidence

Classroom Planning

This is a 30 minute activity, and can be extended with the use of our extension plan. Organize your workspaces with access to additional paper, tape, scissors and drawing materials if possible. Encourage experimentation by supplying extra cardstock for wing modifications.

Facilitation Tips

Reinforce the importance of letting learners take ownership of their designs, offering support without leading. Use open-ended questions to guide learners through troubleshooting, fostering a student-centered, inquiry-driven environment.

- Promote student-led inquiry: ask learners how they might modify their wings for better flight or what changes to the rubber band tension could do.
- Teach SEL skills by emphasizing perseverance and teamwork, especially during the “tick-tock” testing phase.

FAQ's

1. What if the machines just won't fly?

Biggest culprit – not allowing the propeller to build momentum and lift prior to launching. Try adjusting the timing of the release using the “tick-tock” technique. Second biggest culprit – just not enough stored potential energy. Have learners turn the propeller until they can see many bumps in the rubber band.

2. It seems that this is for young learners. How can I adapt this project for older students?

Incorporate the iterative design process using different wing and fuselage designs, as outlined in the [Flying Machines Extension](#) document and explore how each iteration impacts flight. Older learners are all for testing and repeating, instead of one and done!

3. Is this project reusable/extendable?

Yes! By using masking tape to attach different wing designs, learners can iterate on their designs without damaging the core fuselage, enabling a deeper exploration of the engineering design process. Each learner will keep their flying machine – so it's a perfect “make-and-take” activity for further playful engineering at home.

4. How do I facilitate the engineering design process in this activity?

Use the [wing evolution worksheet](#) to guide learners through an iterative process: draw a wing design, test it, analyze the results, and make improvements. This allows students to practice critical thinking and refine their flying machines using the EDP.

Troubleshooting Tips

- If the flying machine flies down instead of up or away, change the direction of rotation – it needs to turn clockwise to fly forward / up!
- Ensure the rubber band is wound tightly enough (at least 70 twists, but 100 is better!)
- For improved flight, experiment with the “tick-tock” technique to master propeller momentum before full release.
- Pro Tip: Remind students to focus on iterative testing and peer feedback.

Early Finisher / Post-Build Exploration

Have learners experiment with new wing shapes, combining multiple designs to observe different flight patterns. Use prompts like, “What happens if we make the wings larger?” to spark curiosity. Encourage students to disassemble their flying machines and rebuild them using new designs, emphasizing the iterative nature of engineering.

Reflective / Exit Questions

“What’s the difference between potential energy and kinetic energy? Give me examples.”

“What challenges did you encounter, and how did you solve them?”

“What changes would you make if you could, and why?”

“What pro tips would you offer to other learners so they’re successful?”

“How does this project connect to something you’ve experienced before?”

“Are there ways your flying machine could be modified to fly longer / farther / faster?”

Vocabulary:

Propeller

Definition: A device with blades that spins to move the flying machine through the air.

Context: The propeller is powered by the twisted rubber band, which makes the flying machine fly.

Fuselage

Definition: The main body of the flying machine.

Context: The fuselage holds all the components together and keeps the machine balanced during flight.

Elastic Potential Energy

Definition: The energy stored when a material is stretched or twisted.

Context: Twisting the rubber band stores elastic potential energy that is released when the propeller spins.

Kinetic Energy

Definition: The energy of motion.

Context: When the rubber band is released, its stored elastic potential energy turns into kinetic energy, making the flying machine move.

Wing

Definition: The flat surface attached to the fuselage that helps the flying machine lift off the ground

Context: Learners can design and modify the wings to change how the machine flies.

Iteration

Definition: Repeating a process to improve a design or solution.

Context: Learners create multiple versions of their flying machine's wings, testing each one to see which design flies the best.

Aerodynamics

Definition: The study of how air moves around objects.

Context: The shape and size of the wings affect the aerodynamics of the flying machine, determining how well it flies.

Energy Transfer

Definition: The movement of energy from one object or system to another.

Context: Twisting the rubber band transfers energy to the flying machine, which is then used to make the propeller spin and the machine fly.

Balance

Definition: The even distribution of weight that allows the flying machine to fly smoothly.

Context: Adjusting the size and placement of the wings helps balance the flying machine.

Lift

Definition: The force that pushes the flying machine upward, opposing gravity.

Context: The wings of the flying machine generate lift as air moves over and under them.

Tick-Tock Technique (Only for this project!)

Definition: The method of releasing the propeller first (tick) before releasing the fuselage (tock) to ensure smooth flight.

Context: Learners use the tick-tock technique to let the propeller gain momentum before launching the flying machine.

Engineering Design Process

Definition: A series of steps that engineers follow to come up with a solution to a problem.

Context: Learners follow the engineering design process to build, test, and improve their flying machines.

Prototype

Definition: A first or early version of a project that can be improved upon.

Context: The initial flying machine built by learners is their prototype, which they can refine and improve through iteration.

Momentum

Definition: The strength or force that keeps something moving.

Context: The propeller needs momentum (a spinning motion) before the flying machine is released for flight.

Sample Lesson Plan – Flying Machines

Objective:

Build a flying machine to explore energy conversion, aerodynamic principles, and the iterative design process.

Time Required: 30 minutes without extension, up to one hour with extension.

Prep Required: Gather Sparks materials, access the [slide deck](#).

Materials:

Spark kit, extra cardstock, scissors, drawing materials, masking tape or painter's tape.

Activity Steps:

1. **Introduction:** Begin with a discussion on energy transfer, introducing key vocabulary (propeller, fuselage).
2. **Build:** Follow the step-by-step guide to construct the flying machine.
3. **Test Flight:** Have learners launch their flying machines using the “tick-tock” technique. Encourage them to observe and document the flight outcomes.
4. **Iterative Design Process:** Introduce the “Flying Machines Extension Doc” suggestions. Replace sticky foam with masking tape to allow for wing modifications. Use the wing evolution worksheet to guide learners through drawing new wing designs, testing, and documenting the results for up to four iterations.
5. **Post-Activity Discussion:** Facilitate a reflection session, asking learners how different wing shapes affected flight. Discuss energy conversion from elastic potential to kinetic energy.
6. **Competition:** If time allows, organize a friendly competition based on distance or target accuracy, as suggested in the “Flying Machines Extension Doc.”

Assessment:

- Use a learner self-assessment in a reflective writing prompt, using the reflection / exit questions:

"What's the difference between potential energy and kinetic energy? Give me examples."

"What challenges did you encounter, and how did you solve them?"

"What changes would you make if you could, and why?"

"What pro tips would you offer to other learners so they're successful?"

"How does this project connect to something you've experienced before?"

"Are there ways your flying machine could be modified to fly longer / farther / faster?"

Extensions:

For older students, explore more complex wing shapes and introduce additional constraints, such as weight limits. Use the iterative process outlined in the "[Flying Machines Extension Doc](#)" to deepen their engineering design experience. Use the [wing evolution worksheet](#) to evaluate students' understanding of the iterative design process and their ability to document observations and improvements.

Aligned Standards and Classroom Connections:

Next Generation Science Standards:

[PS3.B: Conservation of Energy and Energy Transfer](#) – Students explore how stored energy in a rubber band (elastic potential energy) converts into kinetic energy to propel their flying machine.

- Example: As students wind the rubber band and release the propeller, they witness the conversion of stored energy into motion, directly demonstrating how energy is conserved and transferred.

[ETS1.B: Developing Possible Solutions](#) – Students use iterative design by experimenting with various wing shapes and sizes, testing their flying machine's performance, and making adjustments to improve flight.

- Example: Utilizing the wing evolution worksheet, learners draw different wing designs, analyze their flight, and iterate on their designs to achieve better results.

CASEL SEL Competencies:

[Self-Awareness & Self-Management](#): Learners experiment with wing designs, acknowledging successes and areas for improvement. Self-management skills are honed as they persevere through the iterative design process, adjusting their strategies as needed.

[Social Awareness & Relationship Skills](#): This project encourages learners to collaborate, share ideas, and provide constructive feedback. Through this process, they learn to understand different perspectives and strengthen their relationship skills.

[Responsible Decision-Making](#): By evaluating their designs' performance, learners practice responsible decision-making, considering how changes in wing shape and size affect their flying machine's flight.

ELA Connections:

[Vocabulary Development](#): Introduce key terms like "propeller" and "fuselage," helping students expand their vocabulary in a hands-on context.

[Active Listening and Speaking](#): During group work, learners practice listening to peers' ideas, providing feedback, and articulating their design decisions.

[Reflective Writing](#): Encourage learners to document their observations, reflections, and improvements on the wing evolution worksheet, promoting critical thinking and communication skills.

Math Connections:

[Measurement and Data \(K.MD, 2.MD, 4.MD\)](#): Learners might measure wing dimensions and weight distribution, understanding how these factors impact flight performance. Example: Students use rulers to measure cardstock wings, adjusting their length and width to find the optimal balance for flight.

[Geometry \(3.G, 5.G\)](#): Through the exploration of wing shapes (triangles, rectangles, organic shapes), learners apply geometric principles to optimize aerodynamics.