The Forces of Flight

| ACES Team | 1 Hour | Grade 7-8

SUPERNOVA
DALHOUSIE UNIVERSITY | HALIFAX, NOVA SCOTIA

OVERVIEW

Description
Participants will explore the four forces of aerodynamics through an interactive investigation on wing design.

Learning Outcomes
- Learn about the four forces of aerodynamics
- Apply knowledge gained of aerodynamics through plane wing design

Outline *(with time indications/estimations)*
1. The 4 forces of aerodynamics (15 mins)
    a. Lift, Drag, Thrust and Gravity
2. Paper Airplane Activity (30 mins)
    a. Testing different plane designs
        i. Participants will follow the procedure listed below to test 6 different plane wing designs.
        ii. The 6 different plane designs can be downloaded in the Materials and is also found in the Appendix.
3. Design Comparisons (15 mins)
    a. Compare the results obtained in the paper airplane activity.

Materials

Item (*be very descriptive*)	**Quantity Per Child** (*with units*)	**Quantity Per Camp** (*with units*)
Templates and Instructions	1	N/A
Notebook / Lined Paper	1	N/A
Pencil	1	N/A

SAFETY CONSIDERATIONS

- Precautions for Instructor and Participants.
- Please use caution, and explain each safety measure to the participants. Ensure any incidents are reported appropriately.
- Indicate with an ‘x’ next to the items that apply to this activity.

Material/Chemical Safety	
	SDS Required (*attach in write up)*
	Electrical Components
	Food &/or Potential Allergens
	Other:
Equipment Precautions	
	Sharp Objects: Scissors/ Staplers/ Scalpel
	Burn Risk: Glue Guns/ Hot Plate/ Flame
	Tools
	Other:

Digital Safety [ ] Yes [ ] No	
Special Clean-up Required? (indicate below)	
Safety Equipment or Protection	
	Goggles/ Gloves
	Lab Coat
	Fire Extinguisher
	Other:
Other Safety Precautions? (indicate below)	

KEY INFORMATION

Information on the activity topic(s) that is necessary for the Instructor to be familiar with. ***(Suggested 300 words)***

The four forces of aerodynamics: weight (gravity), lift, drag, and thrust, all work together to make things fly and move through the air.

Gravity (Weight): Let's start with gravity, which you might already know about. Gravity is what pulls everything down towards the ground. When we talk about gravity in aerodynamics, we call it weight. Everything that has mass, or stuff inside it, has weight because of gravity. For example, you have weight, your backpack has weight, and even the air has weight, although it's very light. When something is flying, gravity is always trying to pull it back down to the ground. That's why when you let go of a balloon, it falls to the ground.

Lift: Now, lift is the force that helps things fly. When you throw a paper airplane, or when a bird flaps its wings, lift is what keeps them up in the air. Lift is created when the air moves over and under the wings of the object. The shape of the wings and the way they're angled help to create lift. It's like a magical force that pushes things up into the sky, fighting against gravity.

Drag: Drag is like air resistance. When something is moving through the air, the air pushes against it, trying to slow it down. Drag is important because it affects how fast or slow things can move through the air. If there was no drag, everything would move super fast!

Thrust: Thrust is the force that moves something forward through the air. Think about when you blow up a balloon and then let it go. The air rushing out of the balloon pushes it forward. That's thrust! In an airplane, the engines provide the thrust that helps the plane move forward. Cars have engines too, and they provide the thrust that makes them move down the road.

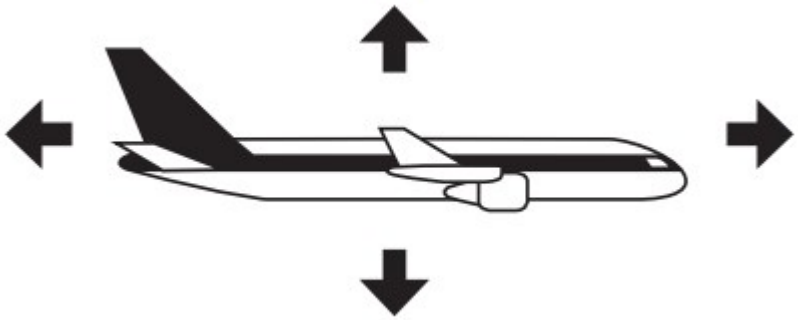
LESSON PLAN AND PROCEDURE

- *Should reflect Overview-Outline.*
- *Include any necessary inclusion and/or adaptation information.*
- *Refrain from including additional background information on the topic, instead refer back to the Key Information section, where necessary.*
- *Make note if anything needs to be prepared beforehand.*

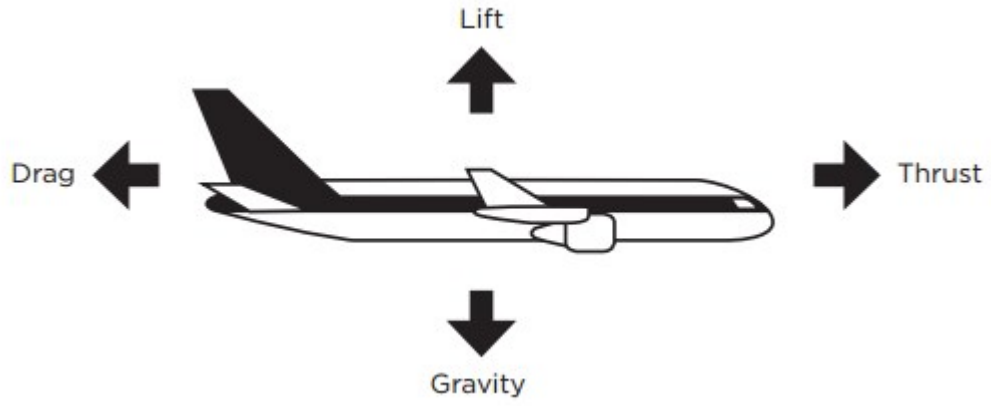
Title

1. Introduction - The four forces of aerodynamics
    a. Ask the class what they know about aerodynamics.
        i. Aerodynamics is the way objects move through air.
        ii. Airplanes fly using the rules of aerodynamics.

b. Tell the students there are four types of aerodynamics, also known as four forces of flights. These four forces lift, weight, thrust, and drag.
c. Demonstrate the forces of aerodynamics on the board. Draw an airplane (or box if easier) with arrows like the picture below.



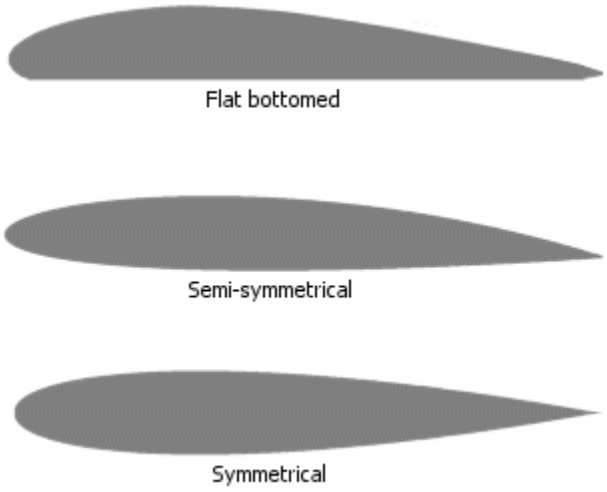
d.
e. Inform the participants that each arrow represents a force.
f. Add the names of the four forces to their respective arrows as shown below. Gravity is also referred to as weight.



g.
h. Begin discussing the four forces, starting with lift and move clockwise.
    i. Gravity: Concerning the forces of aerodynamics, gravity and weight may both be the term used. They represent the gravitational force exerted on an object, pulling it towards the center of the Earth.
        1. For instance, when you hold a book in your hand, you're feeling its weight due to Earth's gravity.
    ii. Lift: Lift is the upward force generated on an object moving through a fluid medium, such as air, perpendicular to the direction of motion.
        1. An example of lift is the force that enables an airplane to ascend into the sky, created by the shape of its wings and the difference in air pressure above and below them.
        2. Another example of lift can be found in the operation of a sailboat. When a sailboat is sailing against the wind, the sail is positioned at an angle to the wind direction. As the wind flows over the curved surface of the sail, it creates a pressure difference between the two sides of the sail. This pressure difference generates lift, pulling the sailboat forward across the water, even when sailing against the wind.

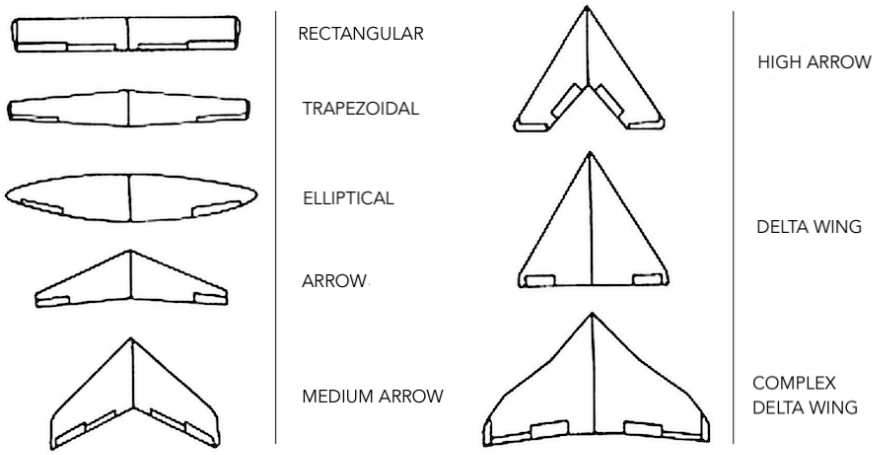
iii. Thrust: Thrust is the forward force produced by engines or propulsion systems, propelling a vehicle or object in the direction of its motion.
    1. A jet engine on an aircraft generates thrust, allowing the plane to move forward through the air.
iv. Drag: Drag is the resistance force that opposes an object's motion through a fluid medium, such as air or water, acting in the opposite direction to its velocity.
    1. An example of drag is the resistance a swimmer encounters while moving through water, caused by water molecules colliding with the swimmer's body and creating friction. Air molecules have this effect on planes.

2. Begin the airplane wing design activity by providing some background information. **Each participant requires a copy of the airplane templates and instructions which can be downloaded in the materials section and also accessible in the Appendix.**
    a. Participants now will look at making their own paper airplanes and testing them out to see the difference between each design. Each paper airplane has its pros and cons in terms of wing design. While sustainable aviation fuel is important to make the aviation industry more sustainable we also have to consider other aspects of flying. One of the most important pieces of a plane is the wings or aerofoils. The wings of the airplane is what gives it lift and the wings are also what allows the plane to continuously fly through the air.



    b. Different wings give different types advantages and disadvantages to planes and how they fly. Typically, a more narrow and more aggressive wing gives slightly less lift, however the plane is more maneuverable and can fly faster with a powerful engine. A fairly symmetrical wing will produce more lift at lower speeds, thus saving on fuel while going slower. With symmetrical wings it would be more sustainable because we are burning less fuel while going further due to the increased lift from the wing.

c. How the wings are mounted on a plane is also very important. Depending on how they sit on the plane it will make a significant difference on how the plane will fly through the air and how fast it will go.



d. Here we will test different types of plane wing designs. In the Appendix you will find six different types of plane wing designs. Each of the paper airplanes will have different advantages and disadvantages. The goal of this will be to build all of the paper airplanes. Once you have done that, test each one out and record the following information.
e. Tell participants to begin the activity. There are 6 plane designs, they may freely attempt them or the teacher may choose to collectively try each design as a class.
f. For each activity, participants should record their observations.
    i. How far did the paper airplane go?
    ii. How did it fly through the air?
    iii. Did it go up and down alot or did it have a stable flight path?
    iv. Was the paper airplane slow or fast through the air?
    v. Once that information is recorded ask yourself which one would be the most sustainable while also allowing us to get to our destination quickly.

3. Design Comparisons
    a. Ask the participants to determine what was their best airplane.
        i. Using the information on each airplane collected in the observation, determine the following:
            1. What plane had the greatest drag?
            2. What plane had the greatest lift?
            3. Overall most effective plane… What makes it the best?
            4. Overall less effective plane…. Why was it ineffective?
            5. Is there another plane design you could make that would be more effective than any others tested?

Debrief

- *What are the four forces of aerodynamics?*
- *How to apply knowledge of aerodynamics to design problems.*

SuperNOTE

Participants tested their knowledge of lift, thrust, gravity and drag through an airplane design challenge.

REFERENCES & RESOURCES

Topic A

-
- https://www.foldnfly.com/#/1-1-1-1-1-1-1-1-2

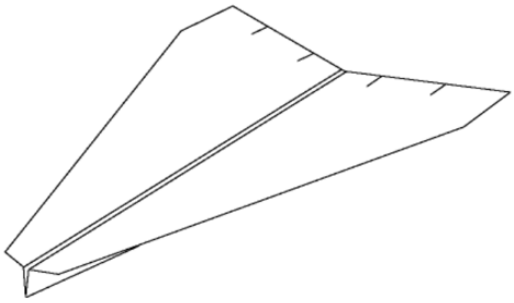
Topic B

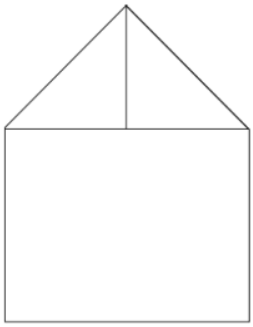
- Link a

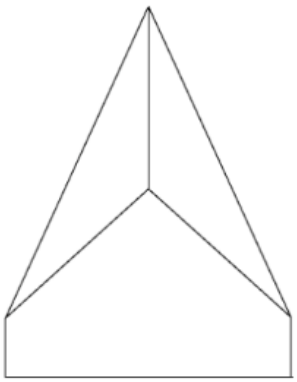
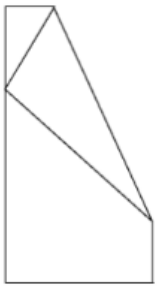
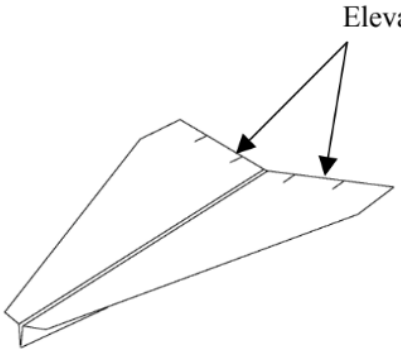
DOCUMENT TITLE NAMING CONVENTION

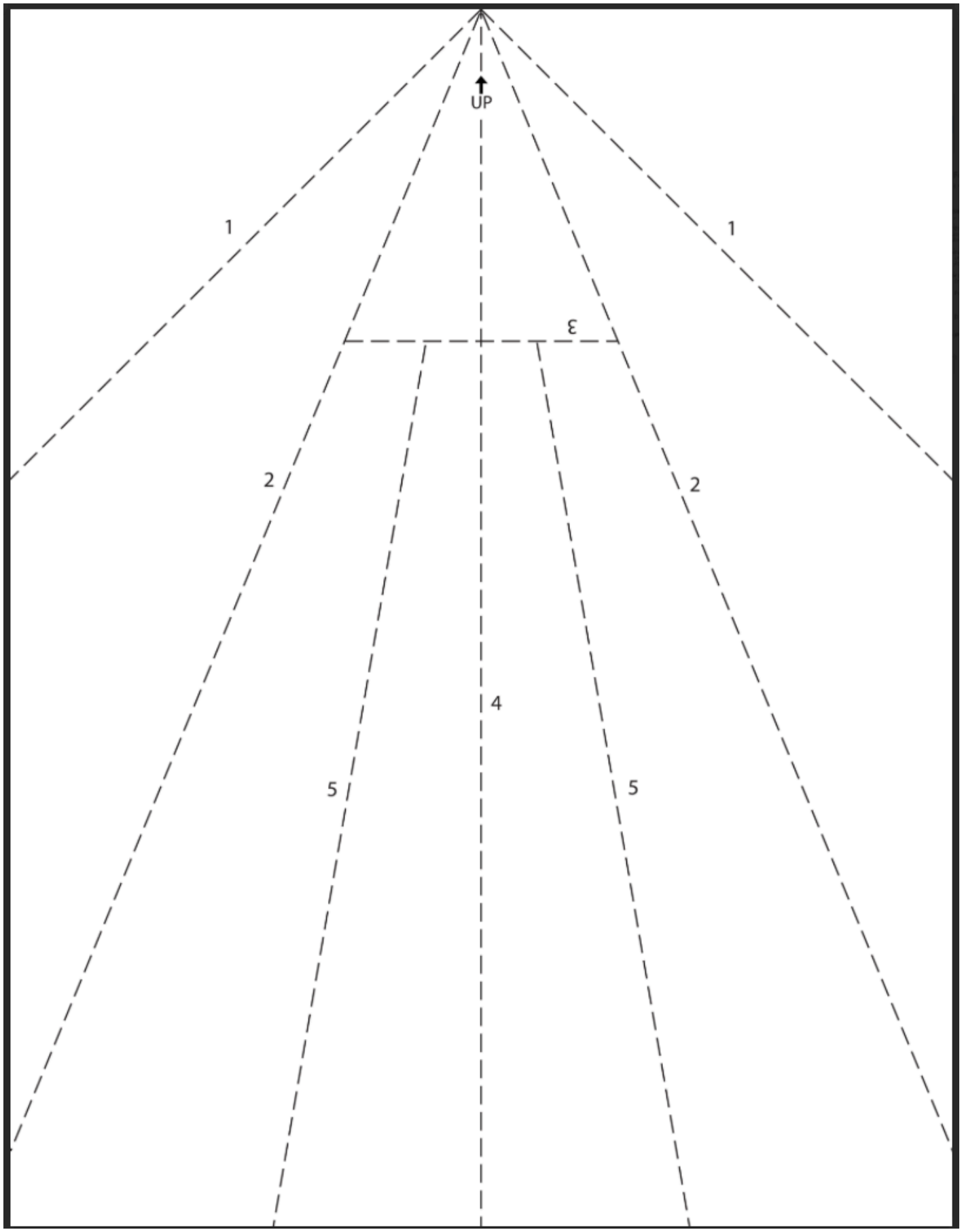
Appendix

Arrow



	● Orient the template with the “UP” arrow at the top of the page. ● Then, flip the paper over onto its backside, so that you cannot see any of the fold lines.
	● Pull the top right corner down toward you until fold line 1 is visible and crease along the dotted line. ● Repeat with the top left corner.

	● Fold the right side over again and crease along fold line 2. ● Repeat with the left side.
	● Fold the tip down toward you and crease along fold line 3.
	● Now, flip the paper over. ● Then, fold the left side over onto the right side and crease along fold line 4 so that the outside edges of the wings line up.
	● Fold the wings down along fold lines 5. Partially open the folds you just created so that the wings stick out straight. ● Cut two slits, one inch apart, along the back edge of each wing for elevator adjustments. ● Add wing dihedral by tilting the wings up slightly away from the fuselage. The wings will have a slight “V” shape when viewed from the front. ● Fly!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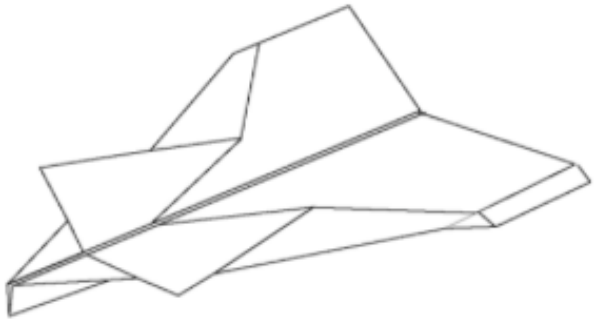
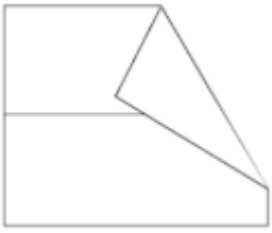
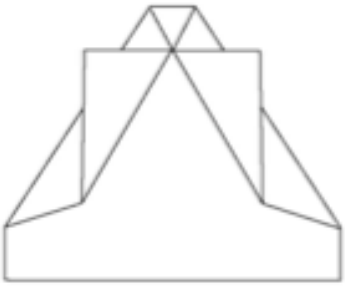
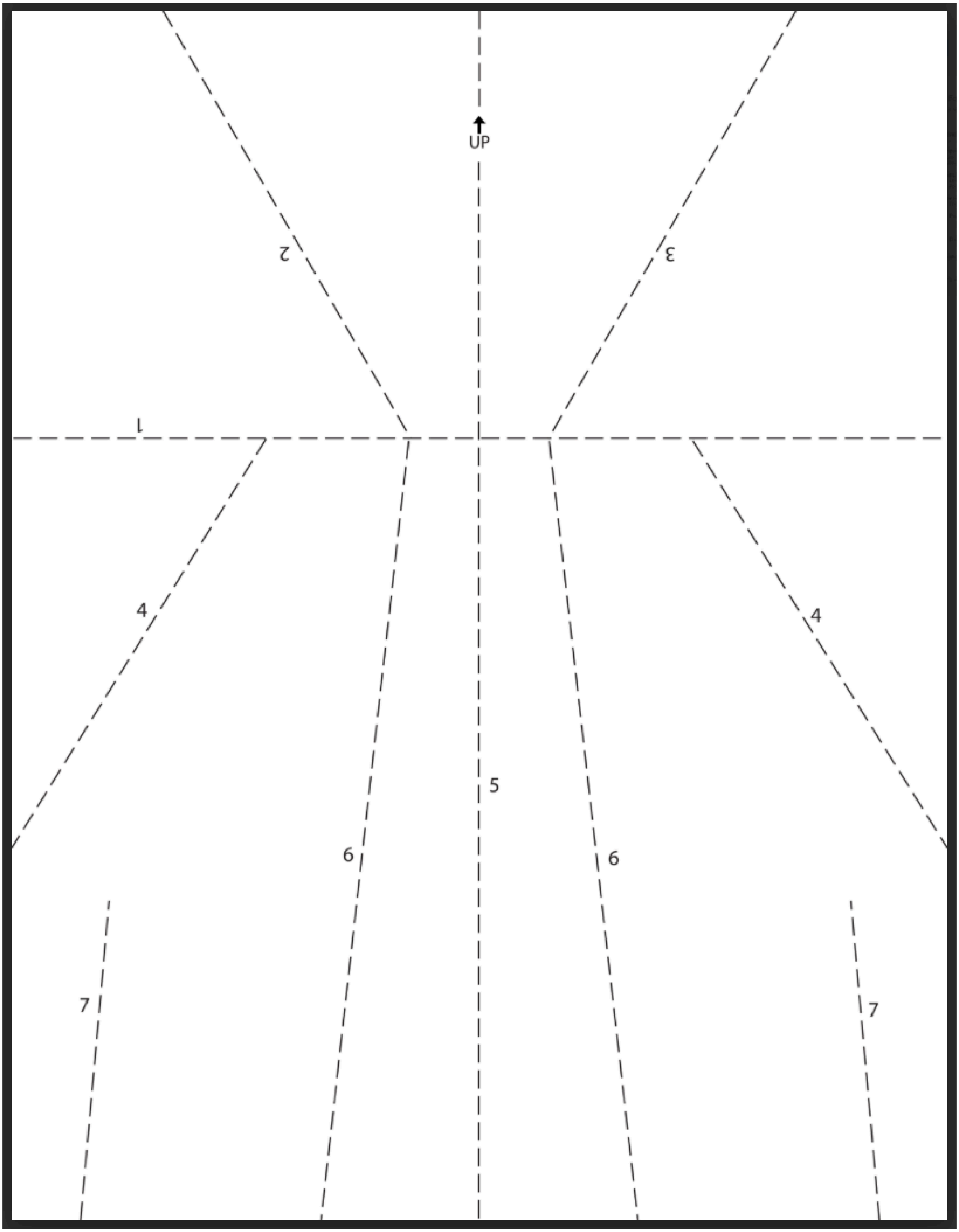


	● Orient the template so that the “UP” arrow is at the top of the page. ● Then flip the paper over so that none of the fold lines are showing.
	● Fold the top edge of the paper down toward you until fold line 1 becomes visible. ● Make a crease along the dotted line.
	● Fold the top right corner down and toward you and make a crease along fold line 2. ● Be aware that you will not be able to see the fold line after making this fold.

	● Fold the top left corner down and toward you and make a crease along fold line 3.
	● Fold the corners of the flaps you just folded up along fold lines 4.
	● Fold the left half of the plane over onto the right half along fold line 5 so that the outside edges of the wings line up.
	● Fold the wings down along fold lines 6 and winglets down along fold lines 7. ● Add wing dihedral by tilting the wings up slightly away from the fuselage. ● The wings will have a slight“V” shape when viewed from the front. ● Fly!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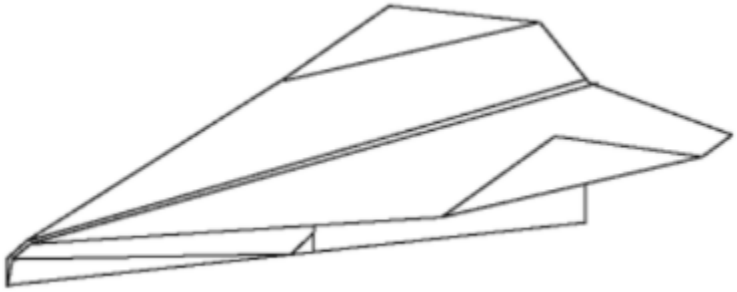
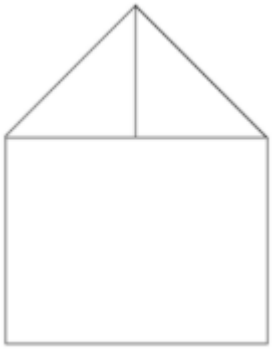
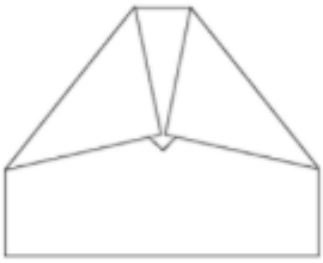
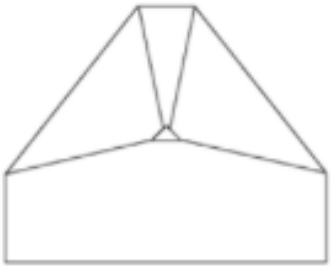
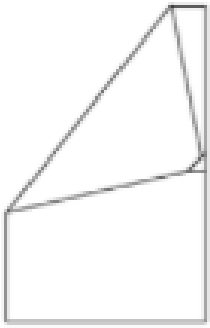
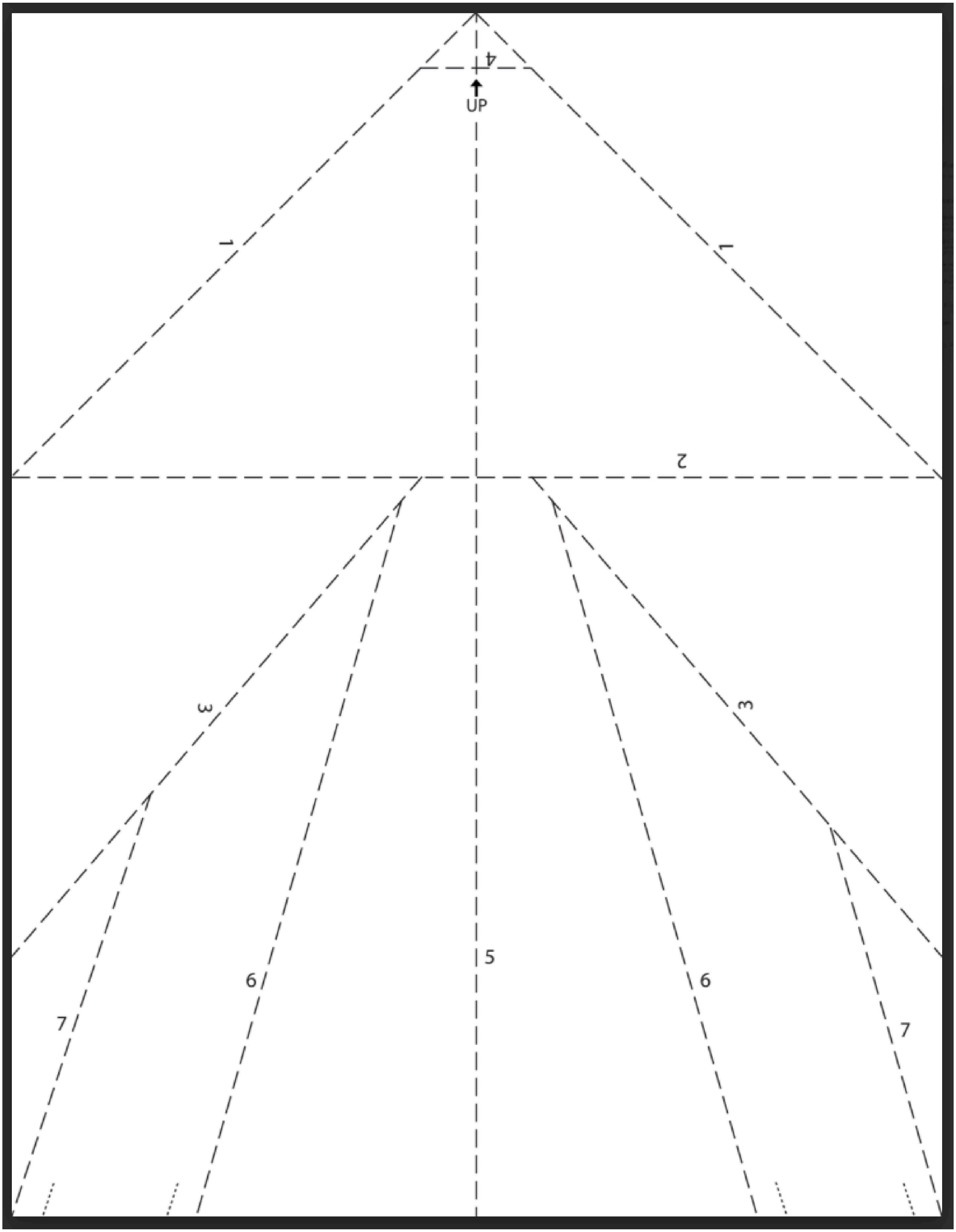
Classic Dart



	• Orient the template with the “UP” arrow at the top of the page. • Then, flip the paper over onto its backside, so that you cannot see any of the fold lines.
	• Pull the top right corner down toward you until fold line 1 is visible and crease along the dotted line. • Repeat with the top left corner.
	• Fold the top point down toward you until fold line 2 is visible and crease along the dotted line.

	● Fold the top left and top right corners down and toward you and crease along fold lines 3.
	● Fold the tip up and over the two diagonal folds along fold line 4 to secure them in place.
	● Flip the plane over and fold the right side over onto the left side as shown along fold line 5 so that the outside edges of the wings line up. ● Also make sure the diagonal folds do not become untucked from the tip you folded up in the previous step.
	● Fold the wings down along fold lines 6 and the winglets up along fold lines 7. ● Add wing dihedral by tilting the wings up slightly away from the fuselage. ● The wings will have a slight “V” shape when viewed from the front. ● Cut two slits, one inch apart, along the back edge of each wing to make elevator adjustments. ● Fly!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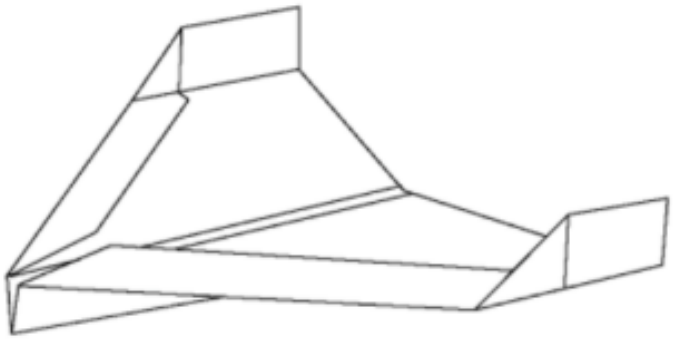
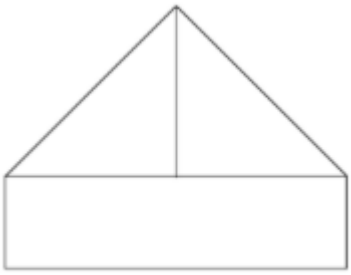
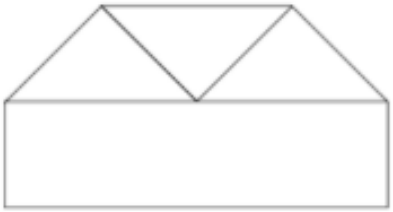
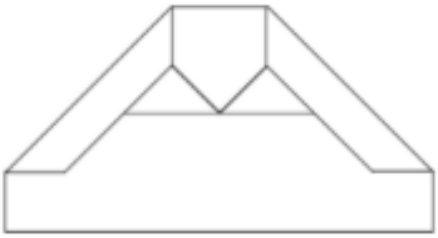
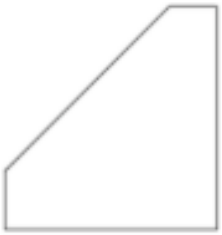
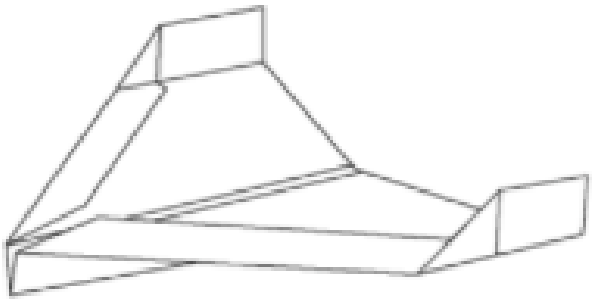
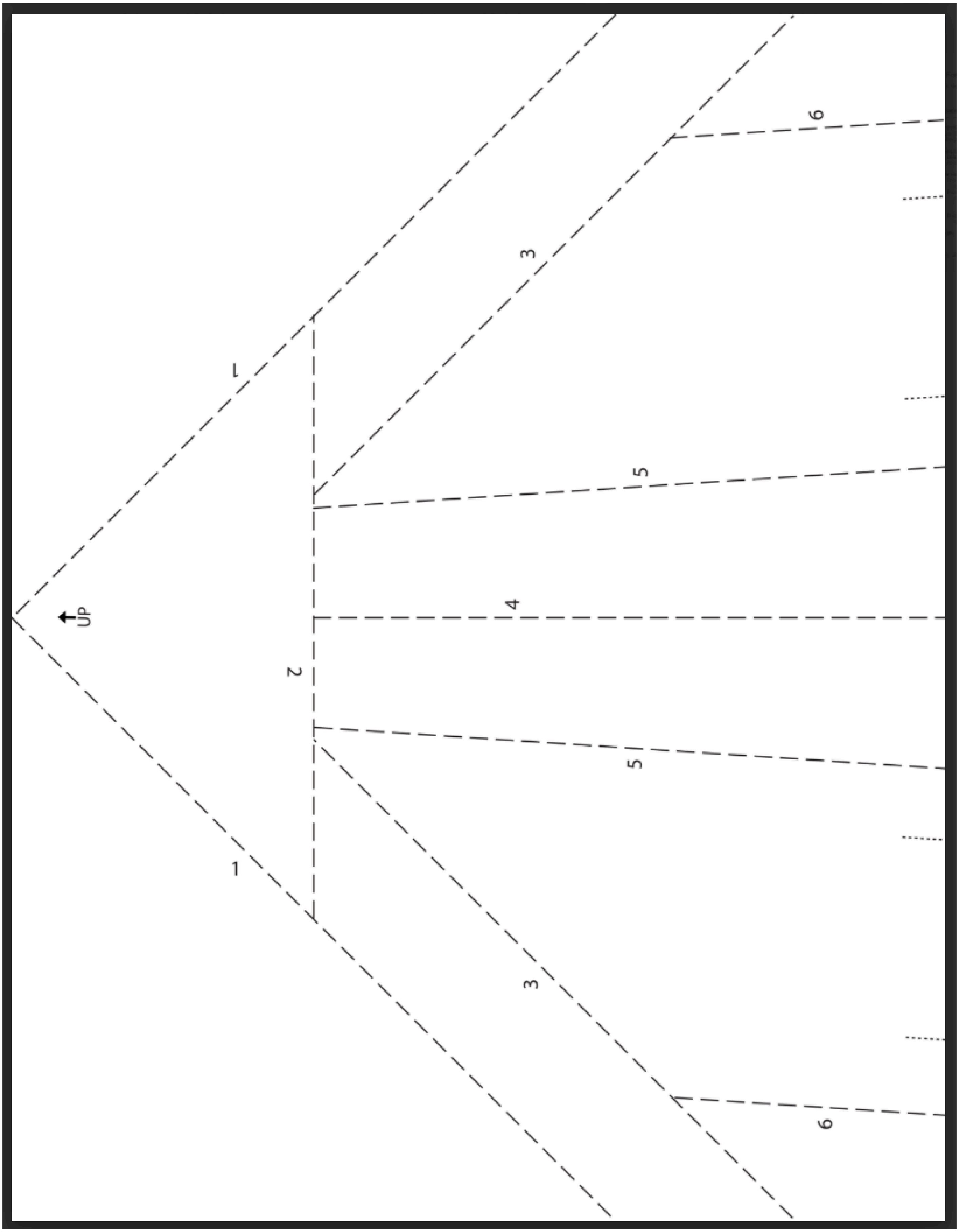


	● Orient the template so that the “UP” arrow is at the top of the page. ● Then flip the paper over so that none of the fold lines are showing.
	● Fold the top left corner down toward you until fold line 1 becomes visible. ● Crease along the dotted line and repeat with the top right corner.
	● Fold the nose down until fold line 2 becomes visible and crease along the dotted line.

	● Fold the outside wing edges in and crease along fold lines 3.
	● Fold the right half of the plane over the left half and crease song fold line 4 so that the outside edges of the wings line up.
	● Fold the wings down along fold lines 5 and the winglets up along fold lines 6. ● Add wing dihedral by tilting the wings up slightly away from the fuselage. ● The wings will have a slight “V” shape when viewed from the front. ● Add elevator slits along the back edge of the wings to adjust the flight if necessary. ● Fly!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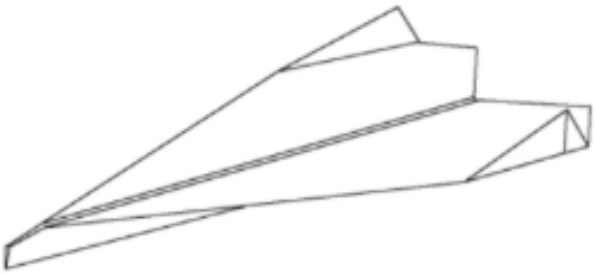
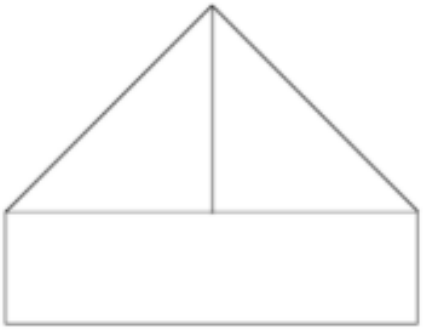
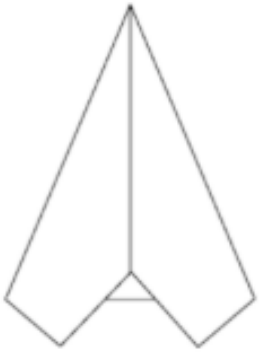
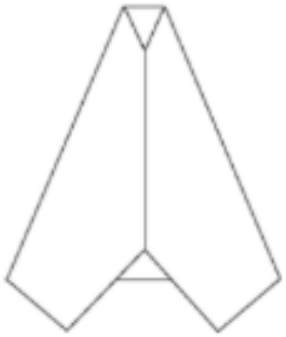
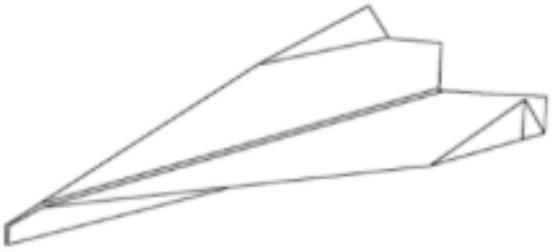
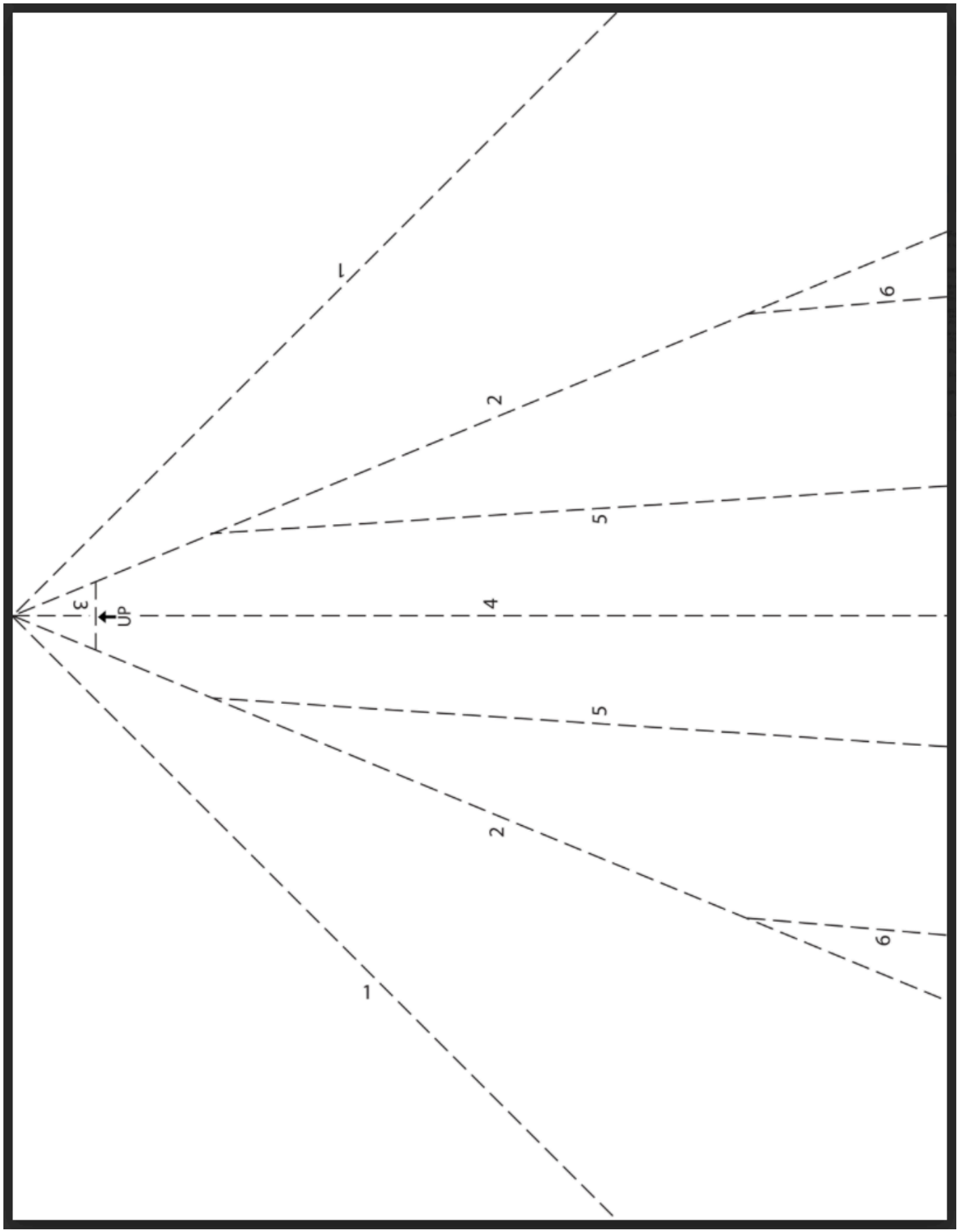


	● Orient the template so that the “UP” arrow is at the top of the page. Then flip the paper over so that none of the fold lines are showing.
	● Fold the top left corner down toward you until fold line 1 becomes visible. ● Crease along the dotted line and repeat with the top right corner.
	● Fold the left side over again and crease along fold line 2. ● Repeat with the right side.

	● Fold the nose down and toward you along fold line 3.
	● Fold the right half of the plane over the left half along fold line 4 so that the outside edges of the wings line up.
	● Fold the wings down along fold lines 5 and the winglets up along fold lines 6. ● Add wing dihedral by tilting the wings up slightly away from the fuselage. ● The wings will have a slight “V” shape when viewed from the front. ● Fly!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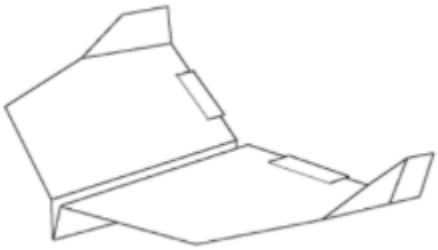
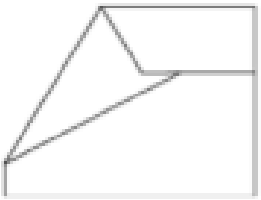
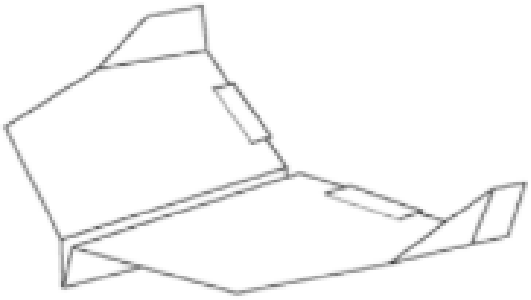
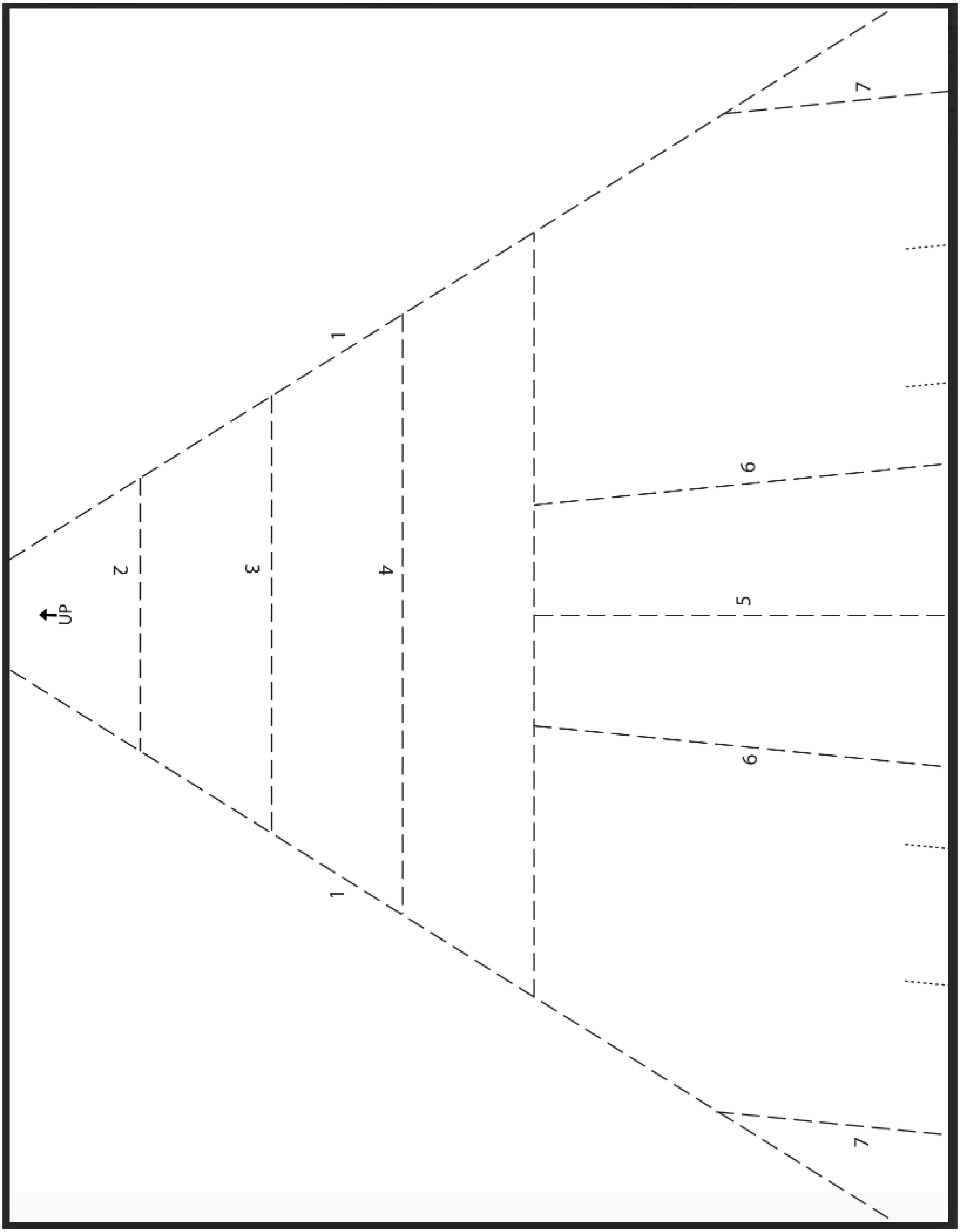


	• Orient the template so that the “UP” arrow is at the top of the page. • Then flip the paper over so that none of the fold lines are showing.
	• Fold the top right and top left corners in until fold lines 1 appear and crease along the dotted line.
	• Fold the nose down toward you and crease along fold line 2.

	● Fold the nose down toward you again and crease along fold line 3.
	● Fold the top edge down toward you again and crease along fold line 4.
	● Flip the plane over and fold the right half over the left half along fold line 5.
	● Flip the wings down along fold lines 6 and the winglets up along fold lines 7. ● Cut slits along the back wing edge for the elevator adjustment. ● Add wing dihedral by tilting the wings up slightly away from the fuselage. ● The wings will have a slight “V” shape when viewed from the front. ● Fly!


UP
1
2
3
4
5
6
7