National Aeronautics and Space Administration

STEM ACTIVITY:
Design Your Own X-Plane

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DESIGN YOUR OWN X-PLANE

In this activity, learn what an X-plane is and how NASA uses X-planes for research. Then roll the dice to find out what features you will need to include on your own X-plane.

What is an X-Plane?

For more than 70 years, NASA has been designing and building experimental planes, better known as X-planes, to test cutting edge ideas in flight. These planes have helped test innovations that make aircraft fly faster, more efficiently, and safer.

When NASA develops an X-plane, it is flown by test pilots to collect data on the aircraft features being evaluated. Because many of the designs are very different from standard planes, flying them can be difficult. That is why specially trained pilots are the ones who fly them.

X-planes are not sold commercially, but the technologies developed are made available to aircraft manufacturers to improve their own aircraft. Many of the features seen on aircraft today were initially developed and tested on some of NASA's X-planes. Do you want to know more about X-planes? Take a look at our "History of X Planes" video.

Figure 1. Artist concept of the X-59 flying over land. Credit: NASA

Activity Directions

Now it is time for you to design your own X-plane! But just like NASA engineers, you will need directions on what the purpose of your plane is and how you should go about designing it. The features of your aircraft will be decided by rolling a six-sided die.

On pages 3-9, you will see the choices for each of the seven characteristics of your plane. For each feature, roll the die to see which option your X-plane will have. The choices listed also have brief descriptions. You can always research these choices more extensively on your own.

After you roll the die for a characteristic, circle the option you have chosen on the worksheet so that you have a record of what you will need to create. Once you have "chosen" all the characteristics, it is time to create a drawing of your X-plane. You can label parts of your drawing to explain what you have drawn or how it affects the aircraft.
After you complete the drawing, decorate your plane! Make it colorful or choose a color scheme that would help it achieve its purpose. For example, if you want to create an aircraft that is stealthy, you probably do not want a bright, colorful paint scheme!

Extension Ideas

- Label and describe each part of your aircraft
- Develop an ad or commercial for your aircraft. How is it useful? What parts of your aircraft make it unique? Why might someone want to purchase your aircraft?
- Draw what your X-plane looks like on the ground and what it looks like while flying in the air.
- Create a cross-sectional drawing of your X-plane. This involves creating three drawings of your plane. One shows a view of it from the side, one from the top, and one from the front. Take a look at the "NASA's BEST Engineering Drawing Tutorial" if you need help learning more about making a cross-sectional or engineering drawing: https://www.youtube.com/watch?app=desktop&v=41-Z06qQmTU.
- Using cardboard and other recyclable material, create a model of your X-plane.
- Create your aircraft on a CAD or computer-aided design tool. Perhaps you could 3D print your design!
- Create a poster highlighting your X-plane. It can show the plane and explain what it does. The purpose of the poster is to get people excited about the X-plane.

This activity was created in collaboration with Gus Posey and Valerie Blome of Wings Over the Rockies Air & Space Museum in Denver, CO.

PLANE'S PURPOSE

Every X-plane is built for a specific purpose. Roll the die to see your plane's main purpose.

1
HIGH SPEED

NASA's X-15 was the fastest piloted plane ever flown, traveling at Mach 6.7 (or 6.7 times as fast as sound).

2
FUEL EFFICIENT

The X-57 is designed to fly using only battery power, making it a very fuel-efficient plane.

3
QUIET

NASA designed the X-59 to fly faster than sound while being much quieter than previous supersonic aircraft.

4
TRAVELS LONG DISTANCES

NASA's Proteus aircraft is used for scientific data collection missions. It can fly for over 18 hours at a time.

5
FLIES AT HIGH ALTITUDES

NASA has used its WB-57 High Altitude Research Aircraft to fly missions at very high altitudes (well over 60,000 feet) to collect data about the atmosphere.

6
STEALTH

The US Air Force's F-117 uses a combination of color and design to make it very difficult to detect in the air.

Photo Credits: Photos 1-5 are from NASA. Photo 6 is from US Air Force.

NUMBER OF PASSENGERS

Roll the die to see how many people can be on your plane at one time.

1 or 2

0 people onboard (Uninhabited)

An uninhabited plane has no people onboard. It is either remotely flown or is autonomous, meaning that a computer is programmed to control all aspect of its flight.

3 or 4

1 person onboard (just the pilot)

Since X-planes are built to test concepts of flight, many of them only require a pilot onboard.

5 or 6

2 or more people onboard (the pilot and others)

Planes like the ones NASA uses for aerial data collection over Arctic regions require a pilot and crew to complete the mission.

Photo Credits: All Photos on this page are from NASA.

PROPULSION SYSTEM

Roll the die to see what type of propulsion system your plane will use.

1
PROPELLER ON THE NOSE

A propeller on the nose of the aircraft creates thrust that moves the plane forward. As it moves, air flows over the wing, creating lift.

2
WING MOUNTED PROPELLERS

Propellers mounted on the wings push air directly over the wing, producing lift for the plane.

3
REAR-MOUNTED PROPELLERS

When the propeller is mounted near the back of a plane, it is called a pusher configuration. This provides smoother airflow over the wings.

4
JETS MOUNTED ON THE FUSELAGE

Mounting jet engines on the fuselage allow the plane to fly very fast while also being maneuverable.

5
JETS MOUNTED ON THE WINGS

Jet engines mounted on the wings provide a plane with lots of speed but can make it less maneuverable than aircraft with other types of propulsion systems.

6
YOUR CHOICE!

You can use any of the propulsion system choices provided or come up with your own idea for a propulsion system. It could be something you have seen before or an original idea.

Photo Credits: Photos 1-4 are from NASA. Photo 5 is from US Air Force.

WING TYPE

Roll the die to see what type of wing your aircraft will have.

1
SWEPT BACK WINGS

Swept back wings increase the stability of the plane. They also reduce turbulence when flying at different speeds and can be made thin to reduce friction from air flow over the wings.

2
RECTANGULAR WINGS

Rectangular wings are relatively inexpensive to make and are easy to install. They help reduce stalling of the plane.

3
FORWARD SWEPT WINGS

Forward swept wings are quite efficient at low speeds. They also allow the plane to achieve high angles of attack, meaning they can climb quickly without stalling.

4
DELTA WINGS

Delta wings provide a large wing area which reduces the minimum speed of the plane while also making it stable at high speeds.

5
TRUSS BRACED WING

Adding trusses to the wings helps support the wings, allowing them to be longer than conventional wings. This helps reduce drag, meaning that the plane burns less fuel while flying.

6
NO WINGS

Having no wings can be achieved in different ways – you can use rotors like the picture above or you can shape the fuselage so it acts like one big wing, providing the aircraft with lift.

Photo Credits: All Photos on this page are from NASA.

EMPENNAGE (TAIL SECTION)

Roll the die to see what type of empennage your aircraft will have.

1
CONVENTIONAL (Low Horizontal Stabilizer)

The conventional tail is the easiest to design and provides good overall control of the plane.

2
T-TAIL (High Horizontal Stabilizer)

Having the vertical stabilizer high on the tail means it is not affected as much by the flow of air from the propulsion system.

3
TWIN TAIL

Planes with two separate tail sections can more effectively affect the flight of the aircraft than a single tail section.

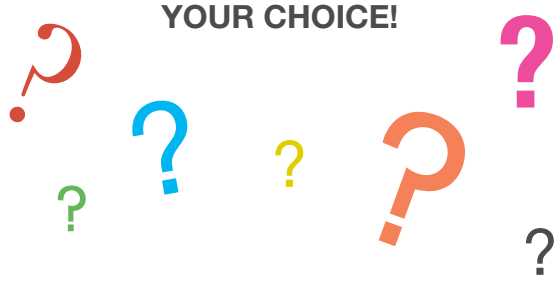
4
NO TAIL

A tailless aircraft has less drag than an aircraft with a tail. It can also be much harder to detect in flight (stealthy).

5
SINGLE VERTICAL TAIL (No Horizontal Stabilizer)

Having no vertical stabilizer reduces drag on the aircraft, but it provides less control during flight.

6
YOUR CHOICE!



What type of tail section would you design? Use a design you see already, or create a completely new idea for your tail section. Maybe look at birds or flying insects for inspiration.

Photo Credits: All Photos on this page are from NASA.

UNDERCARRIAGE (LANDING GEAR)

Roll the die to see what type of undercarriage your aircraft will have.

1
PONTOONS

Planes with pontoons can land on and take off from the water. There are often wheels attached to the pontoons so the plane can land on a regular land-based runway as well.

2
SKIS

When planes need to land on snow or ice, skis can be used as landing gear. As seen in the photo above, the skis often have wheels attached to them.

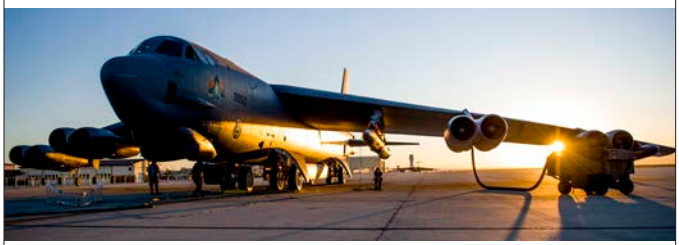
3
TRICYCLE

Wheels that form a triangle with one wheel in front and either one or two wheels on each side provide stability on the ground.

4
TAIL DRAGGER

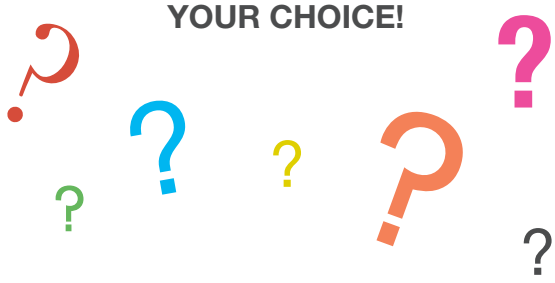
A tail dragger is an airplane that lands and taxis on a tail wheel or tail skid with its nose off the ground.

5
TANDEM



Also known as bicycle landing gear, this type of landing gear lines up main landing gear and tail gear along the airplane's axis, front to back. For a sail plane or some military aircraft, they allow a plane to produce less drag when the wheels are down, or deployed.

6
YOUR CHOICE!



You can use any of the undercarriage choices provided. Or you can come up with your own idea for an undercarriage. It could be something you have seen before or an original idea.

Photo Credits: Photo 1 is from Getty Images (by: wyldephyre). Photo 2 is from ARCUS. Photo 3 and 4 are from NASA, Photo 5 is from US Air Force.

IS THE UNDERCARRIAGE RETRACTABLE?

Roll the die to see what type of undercarriage your aircraft will have.

1, 2, or 3

No, the undercarriage is not retractable.

For some planes, like NASA's X-48, the landing gear does not retract. Instead, in remains in place for the duration the flight.

4, 5 or 6

Yes, the undercarriage is retractable.

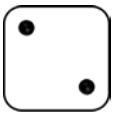
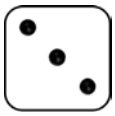
For many planes, the landing gear retracts into the fuselage and/or wings of the aircraft while in flight. This reduces the drag of the aircraft because air can flow more smoothly across the surface if the plane.

Photo Credits: All Photos on this page are from NASA.

Name: _____ Date: _____ Period/Section: _____

MAKE YOUR OWN X-PLANE

You will be rolling a six-sided die to determine each of the factors for your plane. For each line in the table below, roll the die and circle the description under that number.

						
Plane's Purpose	High Speed	Fuel Efficient	Quiet	Travels Long Distances	Flies at High Altitudes	Stealth
Number of Passengers	0 (Uninhabited)		1 (Just the Pilot)		Multiple (Pilot plus passengers)	
Propulsion System	Propeller on the Nose	Wing Mounted Propellers	Rear-mounted Propellers	Jets on the Fuselage	Wing Mounted Jets	Your Choice
Wing Type	Swept Back Wings	Rectangular Wings	Forward Swept Wings	Delta Wings	Truss Braced Wings	No Wings
Empennage (Tail Section)	Conventional (Low Horizontal Stabilizer)	T-tail (High Horizontal Stabilizer)	Twin Tail	Tailless	Single Vertical Tail (No Horizontal Stabilizer)	Your Choice
Undercarriage (Landing Gear)	Pontoons	Skis	Tricycle	Tail Dragger	Tandem	Your Choice
Is the undercarriage retractable?	Yes			No		

Now it is time to design your plane. Your plane must show each of the features you circled in the table above. Your drawing should be on the back of this paper or on a separate piece of paper. Once you have drawn your new X-plane, add some color to it!

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Headquarters
300 E Street SW
Washington, DC 20546

www.nasa.gov

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