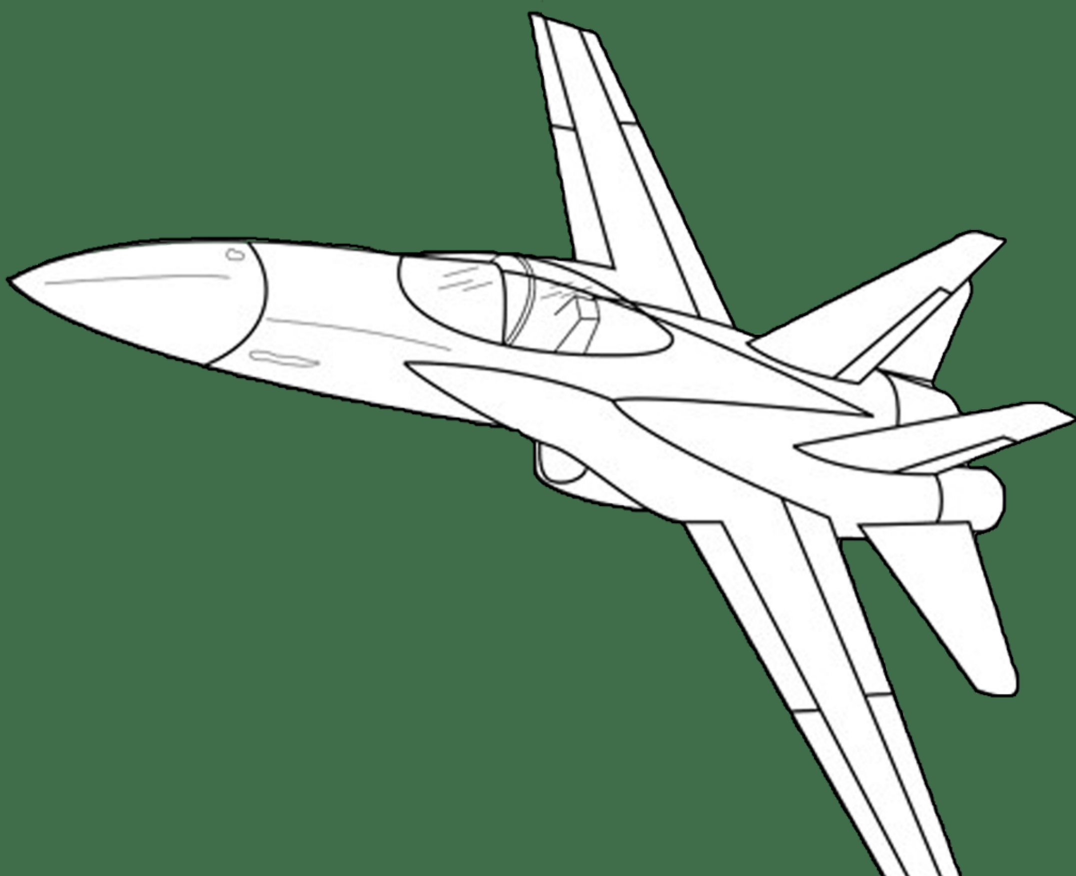
National Aeronautics and Space Administration

Angles Everywhere

A supplemental classroom lesson



Four to Soar Aerodynamics Unit

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Angles Everywhere

Students will learn what an angle is and how to measure angles.

Grades: **5–8**
Time: **1 hour**

Pictured left: *NASA X-43A Hypersonic Experimental Vehicle. This sleek black aircraft has many angles and is among the fastest aircraft in the world.*

Objectives

Students will:

- know the components of an angle.
- identify angles.
- measure angles with a protractor.

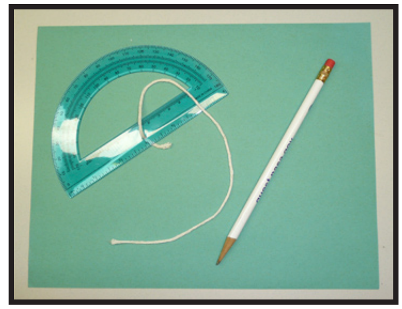
Main Concept

An angle is formed by two lines sharing a common endpoint (vertex). The opening between these two lines is measured in degrees using a protractor.

Education Standards

California Math Content Standards	*National Math Education Standards*
Grade 5 • Algebra and Functions: 1.1 • Measurement and Geometry: 2.1 Grade 6 • Measurement and Geometry: 2.1 Grade 7 • Measurement and Geometry: 3.1	Grades 6–8 Measurement, Content Standard C Geometry, Content Standard B

Materials List



Each team of 2 students will need:

- Protractor
- String
- Pencil for recording data
- ***Angle Diagram*** (p.7, as a worksheet or an overhead transparency)
- ***Sample Angles*** (pp.8–9)
- ***Angles Everywhere*** (p.10)
- ***Angle Challenge*** (pp.11–12)
- Blank paper

Background

An **angle** is a figure formed when two straight lines intersect. The point at which the two lines intersect is called a vertex. Angles are measured in degrees: the symbol for degrees is º and the symbol for angle is ∠. Angles are either named by the capital letter located at the vertex or by three capital letters representing the endpoints of the two lines forming the angle (particularly if there is more than one angle emanating from the same vertex). A lower case "m" is the symbol for "measurement of." Therefore,

$$m\ \angle A = 90^{\circ}$$

is read, "The measurement of angle A is 90 degrees."

Aircraft designs may have wings that are angled, or "swept", forward or backward. Swept wings help to reduce drag at high speeds. Severe wing sweep increases both takeoff and landing speed, and as a result it reduces flight safety during these periods. A few aircraft have been designed with wings able to sweep back and forth mechanically during flight. Such aircraft typically extend their wings fully outward for takeoff, landing, and other low-speed maneuvers, but sweep them back for high speed flight. Some aircraft designs include a small wing-like control surface called a canard, which is located ahead of the main wings and serves as a horizontal stabilizer.

Today NASA is testing aeroelastic technology. This technology allows wings to bend and stretch in flight and has been tested by NASA on a modified F-18 aircraft. If the techniques for controlling aircraft roll are successful, then engineers will be able to design thinner, more efficient wings for future high-performance aircraft. At the same time, these new wing designs can reduce the structural weight and increase the fuel efficiency and payload capability of the aircraft.

Engage

A **protractor** is a special tool scaled to measure the number of degrees in an angle. Using a protractor is important in developing the concepts of angle measure. Hands-on experience with a protractor helps students visualize geometric relationships and assists them in making realistic estimations as a means of problem solving. Students will need these skills for the Pre and Post Design Challenges (***Propeller Palooza*** and ***Flying Circus***) as well as for some of the museum experiments.

1. Have the students look at the ***Angle Diagram*** (p.7). You may either copy it to give to the class or display it on an overhead projector.

2. Divide the students into teams of two. Allow the teams five minutes to identify every angle they can find in the classroom.

3. Discuss the angles that students found in the classroom and how angles are used.

   - *Many of the angles you found were 90 degrees. Why do you think the 90-degree angle is so common?* (This is an easy angle to use, and it allows for shapes to fit easily together for packing, stacking, etc.)

   - *Think about tools and construction materials. How do they look and what kind of angles are there in the materials?*

   - *When might a person need to understand, use, or measure angles?* (Responses may include careers such as astronauts, pilots, architects, and engineers; however, encourage students to also describe uses that they and/or their parents may have. These personal uses could include home projects such as constructing a picture frame or a dog house, understanding angles for maximum success when flying a kite, or writing directions for describing turns in a scavenger hunt. Also, talk about different sports such as hockey or soccer where an angle could be created to show how a pass is made between players.)

4. Explain to the students that they will be measuring angles during their museum visit and that they need to become experts in measuring angles.

Explore

Students complete the following worksheet activities:

1. ***Sample Angles*** (pp.8–9)
2. ***Angles Everywhere*** (p.10)
3. ***Angle Challenge*** (pp.11–12)

Explain

1. Students share the angles that they found in the classroom. Encourage them to use the new vocabulary words of "intersection" and "vertex" when describing their angles. Discuss:
   - *What is the most common angle? Why is this so?*
2. Discuss the importance of angles in aircraft.
   - "*What angles did you notice on the aircraft you measured?"*
   - *"Why do you think these angles might be important to flight?"*

     The angles of wings are very important in determining how an aircraft flies. Students should notice that some aircraft designs have incorporated wings that are swept at an angle. Different wing angles work best at different airspeeds, with greatly swept wings performing best at high speed. Some designs use a small wing-like control surface called a canard (as seen in the first aircraft drawing), which is located ahead of the main wings. Canards act as horizontal stabilizers.
   - In preparation for the museum visit, inform students that, *"The angle that an airplane's wing makes with the oncoming air is called the "angle of attack" and is also very important in flight."*

3. Discuss new NASA aeronautics technology that would allow future aircraft to change their angles.

   - Since certain wing angles work best under different air speeds, NASA is trying to develop an airplane that, like a bird, can change its wing shape. NASA is testing aeroelastic technology that will allow wings to bend and stretch. If the techniques for controlling aircraft roll are successful, then engineers will be able to design thinner, more efficient wings for future aircraft. At the same time, these new wing designs will be lighter, more fuel efficient, and will be able to carry more cargo. It is important for all NASA design engineers and scientists to be able to measure angles accurately.

Extend & Evaluate

For an extension activity, have students work in pairs. Each member of the pair uses a pencil and ruler (or the straight edge of a protractor) to draw a series of angles on a sheet of construction paper. Students then exchange papers and use a protractor to measure the angles drawn by their partner.

Assess student learning via:

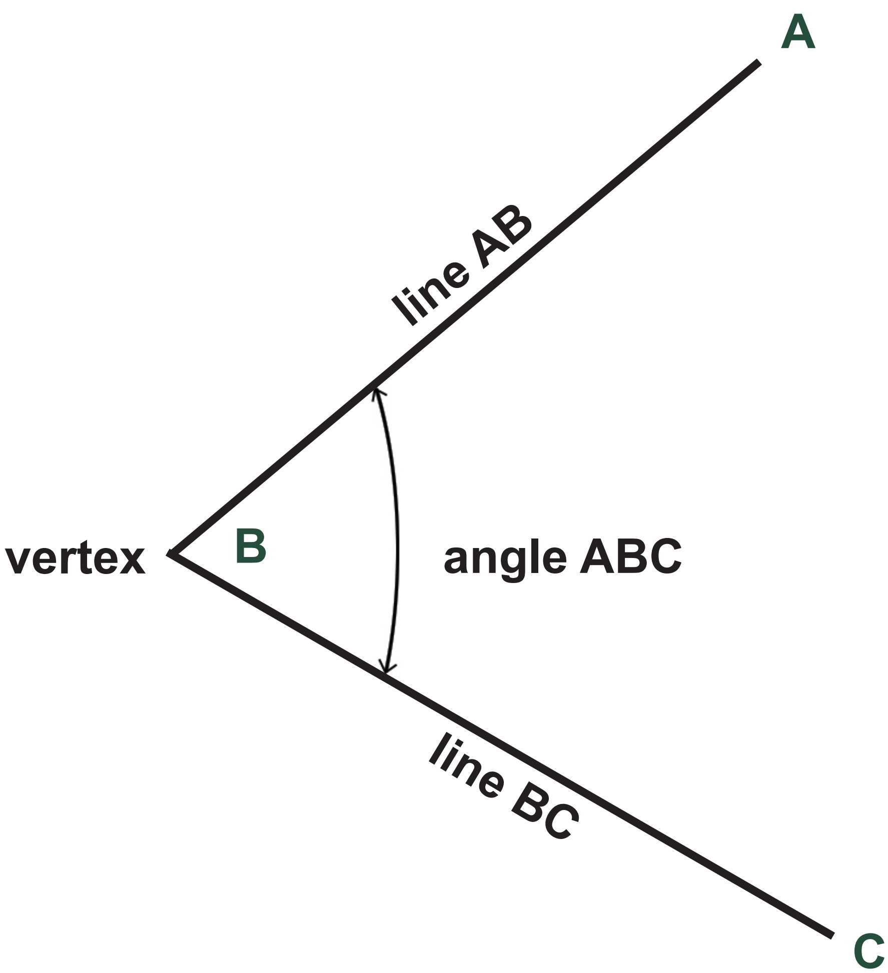
- Successful completion of the Angle worksheets.
- Correct use of a protractor.

Resources

- *What's Your Angle*, NASA Explores
  http://www.nasaexplores.com/show_58_teacher_st.php?id=021231112817

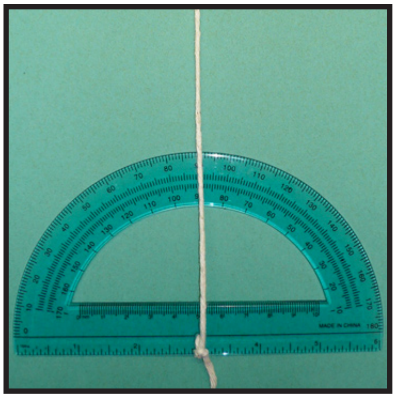
- NASA Dryden Gallery, Dryden Flight Research Center
  http://www.dfrc.nasa.gov/gallery/graphics/index.html

Angle ABC Diagram



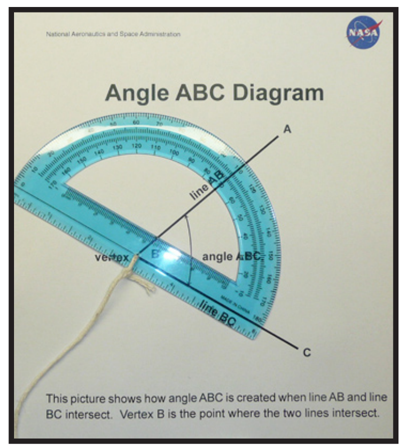
This picture shows how angle ABC is created when line AB and line BC intersect. Vertex B is the point where the two lines intersect.

Sample Angles



Getting started:

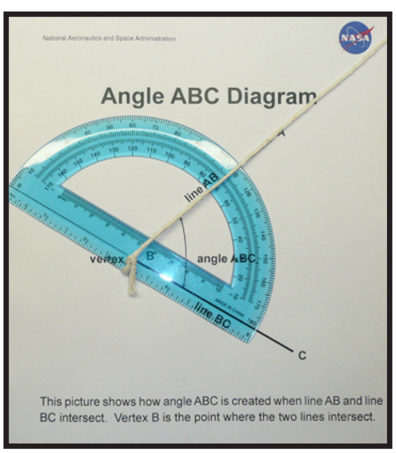
Your team has a protractor and a piece of string. Tie one end of the string through the hole located in the middle of the straight edge of the protractor as shown in the picture to the left.



Align the angle with the bottom of the angle scale, *not* the bottom of the protractor.

To measure an angle:

1. Find the center hole on the straight edge of the protractor. This is the hole where you tied the string.
2. Place the hole over the vertex, or point, of the angle you wish to measure.
3. Line up the bottom of the angle scale on the protractor with one of the sides of the angle.

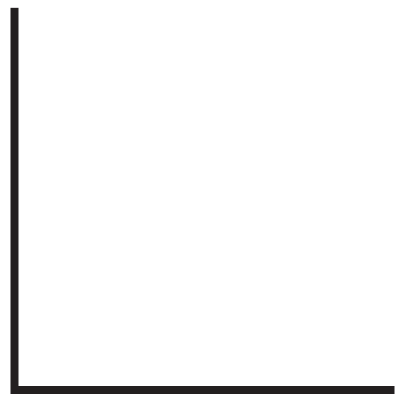


4. Find the point where the second side of the angle intersects the curved edge of the protractor (use your string to help do this).
5. Read the number that is written on the inner scale of the protractor at the point of intersection. This is the measure of the angle in degrees. Did you get 70º?

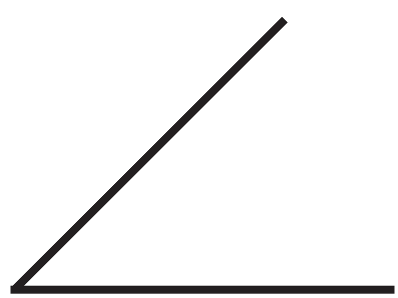
Note: In the example pictured above, the angle is measured using the *inner* scale of the protractor since the angle is oriented to the right. If the picture was reversed so that the angle was oriented to the left, then the angle would be measured using the *outer* scale of the protractor.

Practice makes perfect:

Practice measuring the two angles below using a protractor.



To measure this angle place the hole in the middle of the protractor's straight edge over the vertex of the angle. Align the bottom of the protractor's angle scale (*not* the bottom of the protractor) with one of the angle's sides. Use the string and guide it up the other side of the angle until the string intersects the numbers on your protractor. Since this angle is facing to the right, use the *inner* scale of numbers to make the reading. If your answer is 90º, then you are correct!



Let's try another. Did you get 45º? If so, then your team is ready for the ***Angles Everywhere*** worksheet.

Angles Everywhere

Team Name: ______________________________ Date: ________________

Team Members: ____

Your team must find 4 angles in the classroom of different sizes and record their measurements in the table below. When your team has completed this exercise, check in with your teacher and continue on to the ***Angle Challenge***.

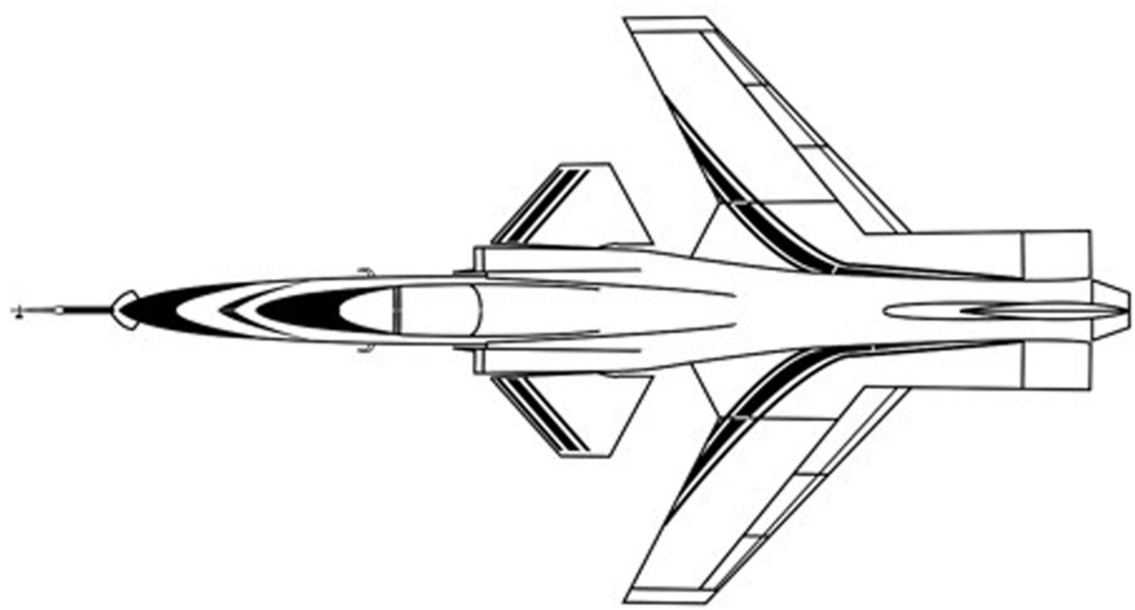
Description of Objects Forming the Angle	Angle Measure in Degrees

Angle Challenge

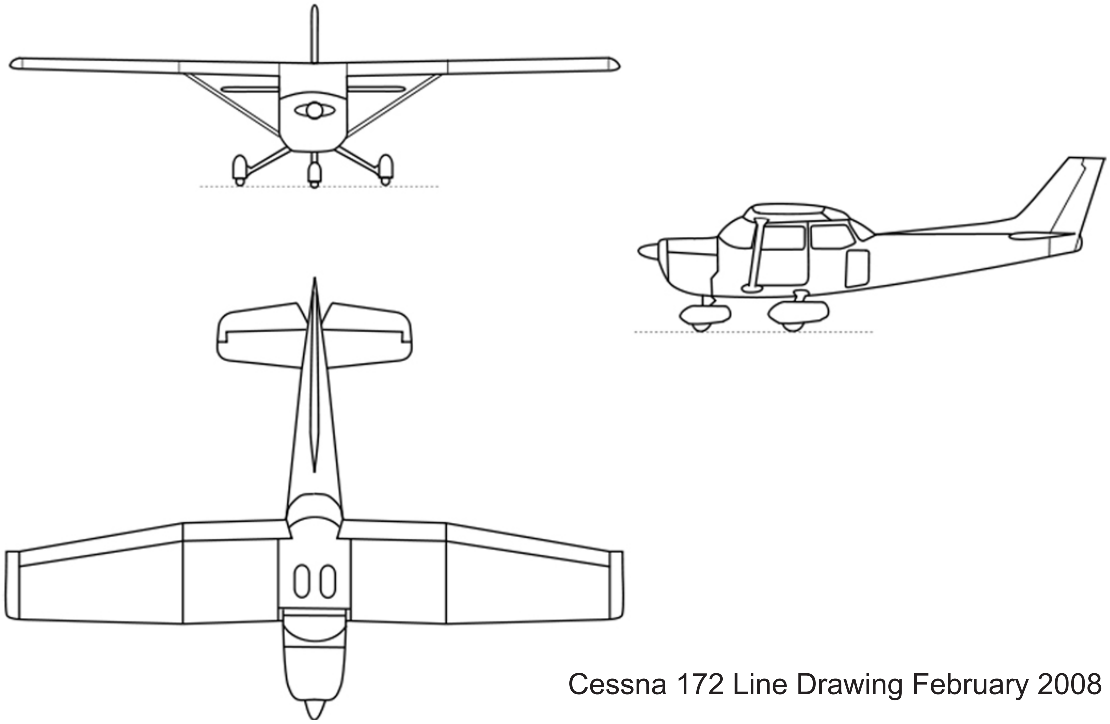
Team Name: ______________________________ Date: ________________

Team Members:____

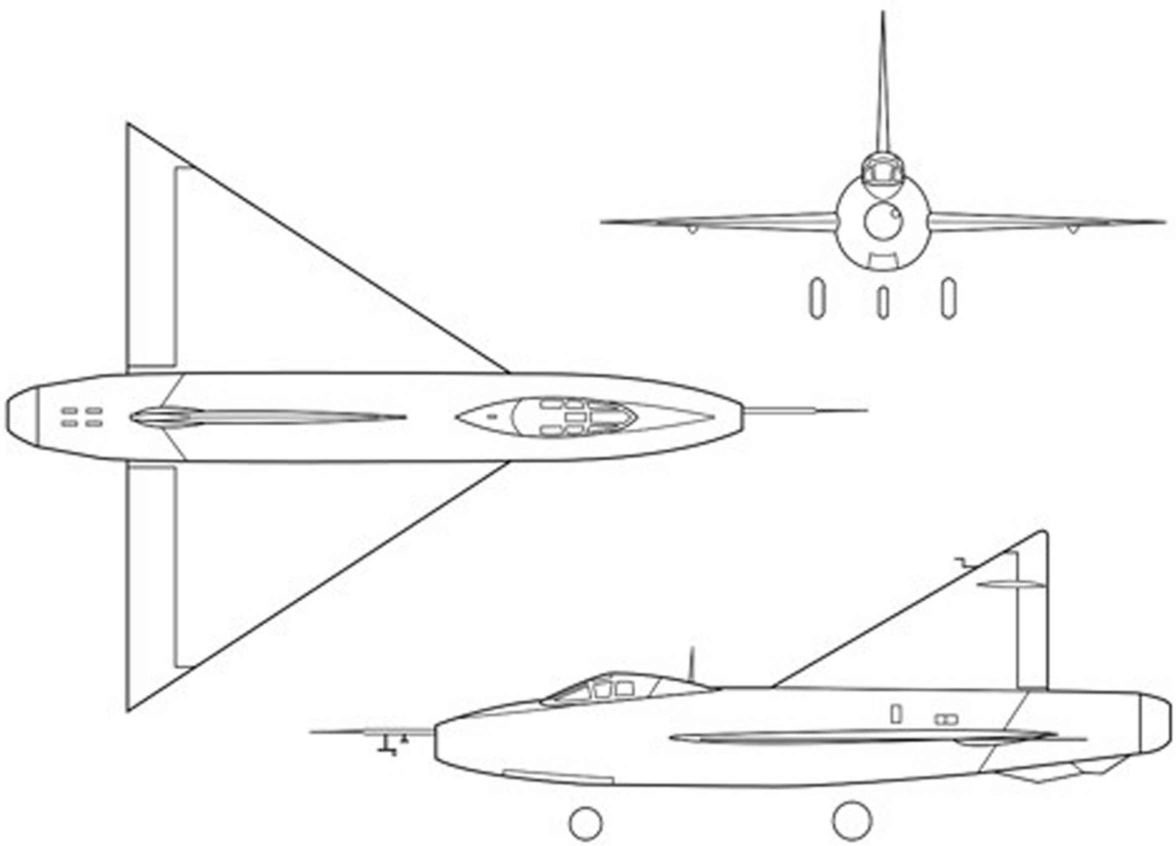
For each aircraft, measure the angle of the wings compared to the centerline of its fuselage.



Dryden Flight Research Center February 1998
X-29 top view



Cessna 172 Line Drawing February 2008



Dryden Flight Research Center February 1998
XF-92A 3-view