THE GREAT AIR RACE!

BACKGROUND:

Any good pilot will agree that the key to safe and enjoyable flight is navigation. Few things are as disconcerting as being lost, especially when the fuel gauge indicates it's time to go home. In a cross-country air race, the pilots who navigate well usually find the finish line first. Careful flight planning can win races and lessens the chance of accidents.

OBJECTIVE/GOAL:

The Great Air Race! participants will use traditional navigation techniques to plan a cross-country air race. The flight planners will develop pilotage skills and gain an understanding of deduced reckoning using a chart, plotter, and aircraft specifications.

REQUIREMENTS:

Each *The Great Air Race!* participant will need a place to work. Set up tables or workbenches so that each person can hear and see as you lead the group through the flight-planning process.

TIME:

1 hour to 3 hours (instructor's discretion)

AGE:

13 years to 16 years

Each Participant Will Need:

- "Aeronautical Chart"
- "Aircraft Specifications"
- "Challenges"
- "Flight Plan Form"
- Plotter
- Pen/pencil
- Calculator (optional)

As a Leader You Will Need:

- Your own set of supplies. It is recommended that you work through a *The Great Air Race!* flight plan prior to leading this exercise.
- The instruction sheets are for you to read; you do not need to make copies for each person.

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DO THIS:	SAY THIS:
1. Stand in front of the group and speak in a relaxed, conversational tone . . . like you are telling a good story.	Congratulations! You have been selected to join *The Great Air Race!* *The Great Air Race!* is a rigorous cross-country competition, and we need the very best navigators to help the pilots find their way.
2. Wait for a show of hands. It's always interesting to see how many young people think of navigation as a mysterious, ancient ritual. Asking questions to guide someone toward understanding is an effective way to make a point. By asking the kids if they have walked to a store, you are personalizing their navigation experience and adding a lot of relevance to what you are saying.	How many of you have navigation experience? I'd bet that all of you have navigated a lot more than you think. Have any of you ever walked to the store? Did you know which direction to travel, or did you just hope to come across a store? Did you know how long the trip was going to take, or did you pack a lunch in case it took all day? You have all navigated! I'd consider you all qualified navigators!
3. The group will have all kinds of names for directions. Among those names should be the ones you are looking for: north, south, east, and west. Having the children point to the north will orient them and help make the concept of direction more concrete.	If you knew in which direction the store was, then you understand direction. What names do we give directions? Can any of you point to north? How about south? East? West? Do you want to learn a trick to remember the directions of the compass? Repeat after me . . . Never Eat Soggy Waffles! Never as in north. Eat as in east. Soggy as in south. And Waffles as in west.

DO THIS:

SAY THIS:

4. If you have a magnetic compass handy, hold it up or pass it around so that they can see it. You might be surprised to learn that many young people have never seen a compass, let alone used one!

These directions can be found on a compass.

The compass is a magnetic device that points to the North Pole. The Earth is surrounded by an invisible magnetic field, and the compass has a tiny magnet in it that wants to be with the big magnetic area up by the North Pole.

A long time ago people figured out how to use this strange magnetic phenomenon to find their way. Hundreds of years ago sailors made compasses to take with them as they explored the oceans. Right now there are sailors in submarines looking at compasses deep under water.

Pilots carry compasses on airplanes. Even with all of our fancy modern navigation equipment, the compass is still a very dependable tool.

5. You can pass out the charts at this time, or lay them on the workspace before you begin.

It's also a good idea at this point to have the children write their names on the charts.

Now, find your "*The Great Air Race!* Aeronautical Chart." Write your name on the the chart.

6. Be sure the children label the compass directions on their charts.

Again, let the group describe distance. This enables them to take part in the "conversation" you are having with them.

Which direction is north on the chart?

That's right, charts and maps almost always have north at the top.

Take your pencil and write "North" at the top of the chart.

Go ahead and label the other directions too. This will help you later.

Let's talk about the other aspects of navigation.

When you walked to the store, you knew how far away it was, didn't you?

How do we describe distance?

DO THIS:

SAY THIS:

On land in the United States, we use miles when we talk about distance. The miles we use actually have a first name, statute. Can any of you tell me another type of mile?

7. Wait for them to suggest other types of miles.

Nautical miles are a little different than statute miles. Think of nautical miles as the big brother of statute miles. Statute miles are not as long as nautical miles, so think of nautical as being a little taller than his little brother statute. It's not important right now just how much longer a nautical mile is, just as long as we remember that it's longer.

8. Point to the scale at the bottom of the chart. One of the young people may ask why pilots don't use statute miles. You will be talking about speed next, so you can mention that it has to do with the next thing you are going to talk about.

In airplanes, pilots often use nautical miles instead of statute miles to measure distance.

Look at your chart again. You'll find a distance scale at the bottom of the chart. It is in nautical miles. As we plan *The Great Air Race!* flights, we will use nautical miles.

OK, so we have talked about direction and distance. What else do we need to know to navigate properly?

Let me give you a hint. . . . If you don't pay attention to this in a car, the police will pull you over and remind you.

9. The concept of speed measurement is really fascinating, so you can spend some time brainstorming ideas. Some individuals may have amazing ideas about how to measure speed! Allowing them to discuss their ideas will enable you to evaluate their understanding of the subject.

Speed! We need to know about speed to navigate well. How do we measure speed in a car?

A speedometer! A car's speedometer works because it measures how fast the wheels of the car are spinning. How could we measure speed in an airplane?

DO THIS:

SAY THIS:

10.

Obviously, there are other factors at work in the airspeed indicator. In an attempt to simplify the explanation of how an airspeed indicator works, static air pressure and some of the other components have been left out. If you wish to explain the mechanics of instrumentation further, this is a great opportunity.

A great way to measure speed in an airplane is with a little tube called a pitot tube. This tube sticks out of the plane's wing or fuselage. As the airplane moves through the air, some of the air is forced into the tube. This air inflates a set of bellows and causes a system of gears to move. Those gears move a needle on an instrument. Anyone want to guess what that instrument is called?

That's right, the airspeed indicator! Pretty simple, isn't it? The airspeed indicator measures how much air is flowing around the aircraft, so the pilot has a pretty good idea how fast he or she is going.

11.

Let the participants guess the name for speed. They will probably guess miles per hour.

Children respond well to the concept of distance, so they will probably understand that knots are faster than miles per hour.

What's the name we use for speed in an airplane? In a car it's what the numbers on the speedometer represent – miles per hour.

The name for speed in an airplane is knots. Remember that a car is on the ground where we use statute miles. In an aircraft we use statute's older brother nautical. So, instead of saying "miles per hour," pilots say "knots." A knot is about 1.2 miles per hour.

12.

Explaining the background of a word helps to engage children. They like to know why and how things get their names.

Knots is a great name. It is not a misspelling of an abbreviation for nautical (nauts). The term *knots* comes from the days of sailing ships and the chip log. To measure speed, sailors used to toss a wooden chip over the back of the boat and allow it to trail off behind on a line. The long line would be wound around a spool called a log. Using some incredibly simple math, the sailors would count 28 seconds as the boat sailed away from the chip. Knots were tied every 48 feet on the line (or every eight fathoms). After counting 28 seconds, the sailors would haul in the chip and count the knots. The number of knots would be the number of nautical miles per hour. The chip log is surprisingly accurate and is the source of the name *knots*.

DO THIS:

SAY THIS:

13. Children can understand difficult concepts easier when relating something familiar, such as the speed of a car.

So, when you think about the speed of airplanes, think nautical miles per hour . . . or knots.

If we are in an airplane and the airspeed indicator needle is pointed at 100, we are going 100 nautical miles per hour, or 100 knots.

Let's put all of this navigational knowledge to work!

14. Distribute the "Challenges" sheet if you haven't already done so.

Locate your "Challenges" sheet and a pencil.

15. There are many ways to explain the degrees of a circle. If you have a favorite, feel free to use it. Any tricks you learned to help you understand headings may be helpful to the kids. Take your time and allow them to ask questions if they don't understand.

The circle you see is called a compass rose. While it doesn't look like a rose, it does represent the directions of the compass. You'll notice north is at the top with an N to help you remember. Above the N is a number. What number is it?

Navigators use degrees to indicate a precise direction. Saying, "I'm flying north-by-northwest" isn't good enough when you are talking with the air traffic control tower.

The circle is divided into 360 degrees. Think of them as very, very thin slices of pizza. The slice at the top is zero and as you count clockwise you count 90 slices of pizza to get to east. North is 0 degrees, east is 90 degrees, south is 180 degrees, and west is 270 degrees.

DO THIS:

SAY THIS:

16.

Encourage the group to give answers.

To figure out which heading the pilot must fly, let's convert a simple direction into degrees.

If we want the pilot to fly southeast, what heading should he or she fly?

Southeast is halfway between south and east, so add 45 degrees to 90 degrees (east) to determine the heading of 135 degrees.

How about northwest? What heading would that be?

If you add 45 degrees to 270 degrees, you end up with 315 degrees.

Now that we understand direction, let's move on!

17.

Talk the kids through the first challenge. Then, have them work the other two on their own. Allow time for the young people to work through the time-speed-distance challenges. If you have children that breeze through the challenges, you can suggest that they help the others.

Answers to the "Challenges" sheet are on page 13.

We are going to calculate distance. As a pilot, it is always good to know how far you have flown from the airport. While it's fun to look down and guess how far the plane has flown by using landmarks, the mathematical way is often more accurate. On cloudy days the mathematical way is a lot more accurate!

On the "Challenges" sheet are some distance challenges to tackle.

Let's try the first one together.

Imagine we are in a Boeing 777 airliner flying to Tokyo. The airspeed indicator in the cockpit indicates our speed is 600 knots. Our watches show that it is now 3 p.m. We left Los Angeles at 1 p.m. How far have we flown?

Start with the time. We have been in the air for two hours. Our average airspeed has been 600 knots, so we have traveled 600 nautical miles each hour. That means we have gone 1,200 nautical miles.

Easy? Try the other challenges on your own.

DO THIS:

SAY THIS:

You are really good at this! Let's combine direction with our speed and distance calculations to really make things fun!

I'm going to tell you a little about our flight, and I want you to calculate our imaginary aircraft's speed and heading. Ready?

We are 500 nautical miles from the airport we departed. We have been flying for two and one-half hours. Our direction of travel is southwest.

18. You may need to remind the group that heading is given in degrees, not simple directions such as north or south.

What is our heading?

The heading was easy wasn't it? Southwest is also known as 225 degrees.

What is our speed?

Speed is calculated by dividing the distance by the time. In this case you divide 500 by 2.5. The answer? 200 knots.

I have one more thing for you before we begin planning *The Great Air Race!* We need to talk about how much fuel an airplane uses.

19. Hand out the "Aircraft Specifications" sheets.

If you have an aircraft nearby, you can add it to the three listed on the specification sheet.

Here is the "Aircraft Specifications" sheet with information for three aircraft.

The first airplane is a Cessna 172 Skyhawk. The Skyhawk is one of the most common aircraft around. More Young Eagles fly in 172s than any other kind of airplane.

The second plane is the Piper Warrior III. The Piper is a low-wing plane, and it is also very common.

DO THIS:

SAY THIS:

The third plane is the Van's RV-6A. The EAA has two of these homebuilt airplanes as part of the Young Eagles program in Oshkosh, Wisconsin.

20. Continue referring to the "Aircraft Specifications" sheet.

These airplanes all have different engine sizes, so the amount of fuel the airplanes use varies. You'll find the fuel use for each airplane listed on the "Aircraft Specification" sheet.

You'll notice that airplane fuel use is measured by gallons per hour. In cars, fuel economy is measured in miles per gallon.

During *The Great Air Race!*, we are going to use average fuel use rates for the airplanes, just to keep thing simple. In a real airplane, the fuel use rate changes depending on several factors such as aircraft load, air temperature, and altitude.

It's very important to keep track of how much fuel you are using as you fly.

If you run out of gas in your car, you can always pull over and call for help. You can't do that in a plane, can you? Careful pilots are always checking their fuel level and calculating their range.

We have figured out fuel economy and basic navigation. Why don't we plan our flights for *The Great Air Race!*

DO THIS:

SAY THIS:

21. Each person should choose one aircraft to flight plan. If someone finishes quickly and wants to try another aircraft, that is fine.

Distribute the "Flight Plan Forms" and plotters if you haven't already done so.

First, choose an aircraft from your "Aircraft Specifications" sheet.

I'd like you to find the Sea Wind airport on the "Aeronautical Chart." Sea Wind is the home airport for *The Great Air Race!* pilots. All navigation must start at Sea Wind.

You'll notice that "Sea Wind" has been printed in the Departure Airport field on your Flight Plan.

Using the straight edge of the ploter, draw a line from Sea Wind to Oak Valley airport. This is called your true course line. The shortest distance between two points is a straight line, so our air race pilots will want to fly along this true course line from Sea Wind to Oak Valley.

Go ahead and enter the name of the destination airport, Oak Valley, on your "Flight Plan Form."

22. Determining heading may be a challenge for many kids. Be patient and help them understand the use of the plotter. If you would like, this is a good time to talk about the grid lines on the chart. The heading is due east or 90 degrees.

The course from Sea Wind to Oak Valley is straight East isn't it? That's a course of 90 degrees. That one was so easy, it's already printed on your "Flight Plan Form."

23. As the young people measure the distance of their flight, walk around and check their work. Be sure they use the proper scale. The distance should be about 33 nautical miles.

Next, measure the length of the true course line. This is the distance from Sea Wind to Oak Valley. Use the nautical miles scale on the bottom of the chart to calculate the proper distance. Double check your measurement with the scale on the bottom of the plotter. Enter this distance on the "Flight Plan Form."

You are doing great! According to the scale at the bottom of the chart, the distance between Sea Wind and Oak Valley is a nice, easy 33 nautical miles.

If you got it right, excellent! If not, go ahead and change it on your "Flight Plan Form."

DO THIS:

SAY THIS:

Ignore the fuel used box on the "Flight Plan Form" for now. We need to calculate the flight time before we can figure out how much fuel we've used.

On the "Aircraft Specification Sheet" you will find each airplane's cruising speed. You can pick any airplane that you want, but for this example, let's use the RV-6A. Enter the cruising speed for the RV-6A on the "Flight Plan Form."

24. Wait for the group to suggest a way to calculate the flight time.

If no one answers quickly, it's okay to give the answer or to give hints.

We know the distance to Oak Valley and the speed of the aircraft. How do we calculate the flight time?

That's right! Divide the distance by the speed and you will get the flight time. The time will probably be in decimal form.

After you have the decimal version of your flight time, multiply that number by 60. That will give you your time in minutes, with a decimal thrown in. Round the number up to the next whole number to make it easier.

Isn't this fun?

The flight times for each airplane have been printed in the first section of the "Flight Plan Form" so you can check your work.

DO THIS:

SAY THIS:

Now that we know how long the flight will take, we can calculate how much fuel we will use.

25. The Fuel Use rate for each airplane is on the Aircraft Specification Sheet. Make sure the group refers back to it.

Fuel use is in gallons per hour, so the calculation will be Flight Time x Fuel Use Rate = Fuel Used.

Find the fuel use rate for the RV-6A on the "Aircraft Specifications" sheet. Our flight time is less than an hour, so we will use less than the number of gallons listed. In this case, our flight was 11 minutes. That means we need to do some fancy math to figure this out!

Remember the decimal version of the flight time we came up with earlier? It was .18 for the RV-6A. Take that fraction of an hour and multiply it by the fuel use rate, or 14 gallons of fuel per hour.

The RV-6 would use 2.52 gallons of fuel for this flight. Enter the fuel you will use on the "Flight Plan Form."

We have one more thing to do.

Pilots like to have plenty of air between them and the ground, so we have to figure out how high they must fly to stay clear of obstacles such as mountains and radio towers.

26. Refer back to the "Aeronautical Chart." Point out the legend on the right.

Look at the "Aeronautical Chart." On the right side is a legend. This is the answer key for the chart. At the bottom you'll find the altitude legend. This chart is what is known as a topographic chart. That means that the land has been shaded to indicate its altitude. As you can see by the legend, white areas indicate land less than 500 feet high.

Oak Valley is in a white area, so it must be lower than 500 feet above sea level. In the information box next to the airport, you'll see a number. This number is the altitude of the airport above mean sea level or MSL. The runway at Oak Valley is 222 feet MSL.

DO THIS:

SAY THIS:

Are there any mountains or towers between Sea Wind and Oak Valley? If there are obstacles, you need to guide the pilot above them. Choose an altitude that is at least 1,000 feet above the ground and 500 feet above any aerial obstacles such as radio towers.

We can see from the chart that the ground is pretty flat between Sea Wind and Oak Valley. There aren't any big towers or mountains in the way, so we can fly 1,000 feet over the ground. Since Oak Valley is 222 feet above sea level, let's round up just to be extra safe and set our cruise altitude at 1,300 feet.

Go ahead and enter 1,300 feet on your "Flight Plan Form."

27. *The Great Air Race!* is designed to be flexible. The "Aeronautical Chart" is only the beginning. For a bigger challenge, use outdated sectional charts and create your very own air race!

Have fun!

Congratulations! You have just completed a flight plan! You calculated fuel use, flight time, altitude, distance, and heading!

Go ahead and plan flights for all of the legs of The Great Air Race.

Here are some race routes:

- Sea Wind to Oak Valley to Grandview
- Sea Wind to Big Bend to Oak Valley
- Sea Wind to Oak Valley to Big Bend to Sea Wind
- Sea Wind to Big Bend to Grandview to Oak Valley
- Sea Wind to Oak Valley to Grandview to Big Bend to Sea Wind

Be inventive! Try to plan the toughest race ever!

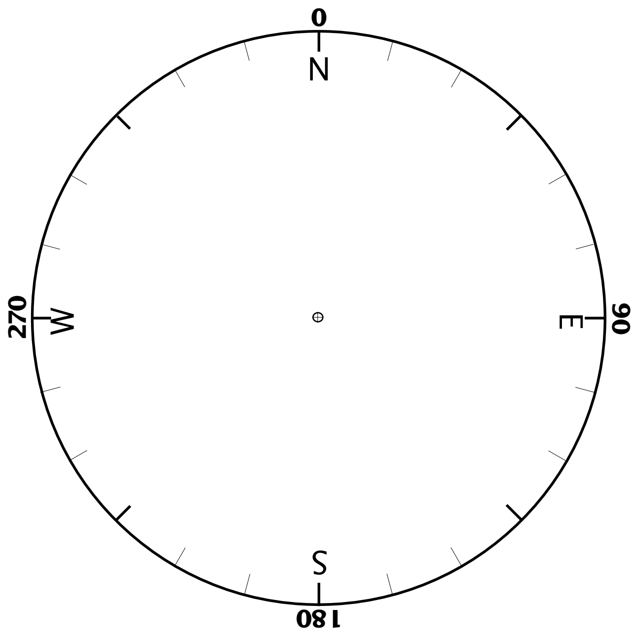
Be sure to avoid the military areas on the chart. Radio traffic indicates heavy military air traffic in the restricted area.

Happy planning!

"Challenge" Answers
1. 1,200 nautical miles 2. 1,925 nautical miles 3. 637.5 nautical miles

THE GREAT AIR RACE!

Challenges



Challenges

1

Flight path:	Los Angeles, USA to Tokyo, Japan
Airspeed:	600 knots
Departure time:	1 p.m.
Current time:	3 p.m.
Distance flown:	__________ nautical miles

2

Flight path:	New York, USA to London, UK
Airspeed:	550 knots
Departure time:	10 a.m.
Current time:	1:30 p.m.
Distance flown:	__________ nautical miles

3

Flight path:	Miami, USA to Seattle, USA
Airspeed:	425 knots
Departure time:	6:30 a.m.
Current time:	8 a.m.
Distance flown:	__________ nautical miles

THE GREAT AIR RACE!

Flight Plan Form

1.

DEPARTURE AIRPORT	DESTINATION AIRPORT
Sea Wind	

HEADING	DISTANCE	FUEL USED	CRUISING SPEED	FLIGHT TIME
90° due east		RV-6A 2.52 gallons		RV-6A 11 minutes

CRUISE ALTITUDE

2.

DEPARTURE AIRPORT	DESTINATION AIRPORT

HEADING	DISTANCE	FUEL USED	CRUISING SPEED	FLIGHT TIME

CRUISE ALTITUDE

3.

DEPARTURE AIRPORT	DESTINATION AIRPORT

HEADING	DISTANCE	FUEL USED	CRUISING SPEED	FLIGHT TIME

CRUISE ALTITUDE

4.

DEPARTURE AIRPORT	DESTINATION AIRPORT

HEADING	DISTANCE	FUEL USED	CRUISING SPEED	FLIGHT TIME

CRUISE ALTITUDE

THE GREAT AIR RACE!

Aircraft Specifications

Cessna 172 Skyhawk

Seats:	4
Cruising speed:	115 knots
Fuel capacity:	42 gallons
Fuel use rate:	14 gallons per hour

Piper Warrior III

Seats:	4
Cruising speed:	115 knots
Fuel capacity:	48 gallons
Fuel use rate:	14 gallons per hour

Van's RV-6A

Seats:	2
Cruising speed:	185 knots
Fuel capacity:	38 gallons
Fuel use rate:	14 gallons per hour