Predicting the path of the ISS in the sky

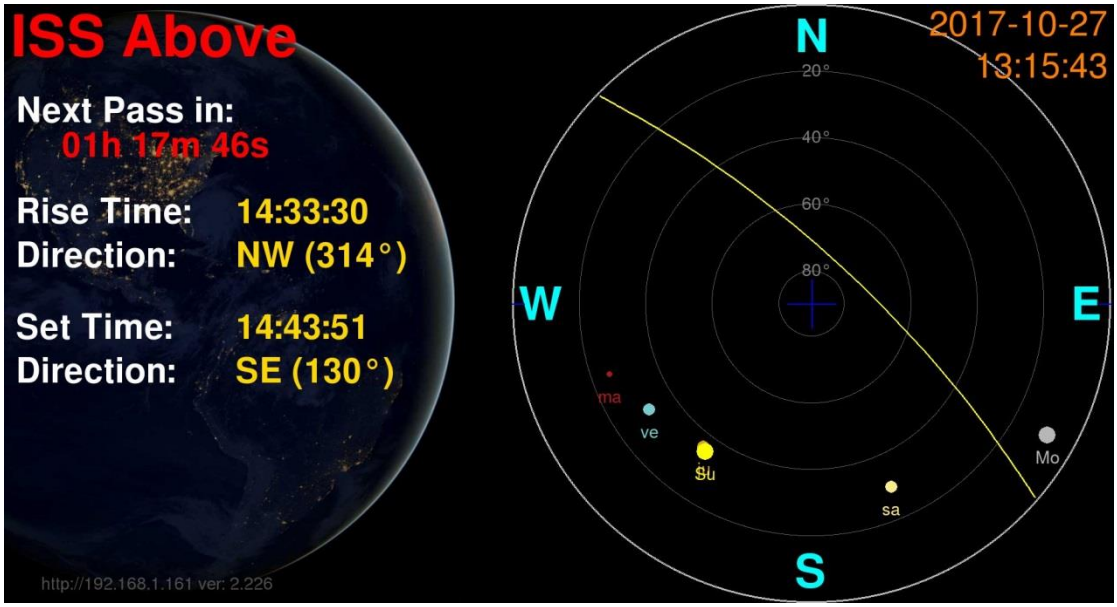
Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	To understand angles, degrees, and compass directions using ISS-ABOVE data. To understand the maximum altitude and directional data from the ISS Above.
Materials:	• ISS Above (set up and ready to go) • Classroom space for a 6'6" diameter circle • 8 strips of paper, 32" by 2", for number line / compass circle • 8 pieces of card 8.5" x 5.5" for the compass points • String approx. 10 feet in length • Rulers • Sticky tape • 1 Compass • 1 large protractor • Photo or drawing of the ISS that fits an 8.5"x11" paper or card
NGSS Essential Standards and Clarifying Objectives:	**NGSS Essential Standards and Clarifying Objectives:** *MS-ESS1-3:* Analyze and interpret data to determine scale properties of objects in the solar system. **Science and Engineering Practices:** • Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Develop and use a model to describe phenomena. **Disciplinary Core Ideas:** • *ESS1.A:* The Universe and Its Stars Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. • *ESS1.B:* Earth and the Solar System The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. **Crosscutting Concepts** • Systems and System Models ✓ Models can be used to represent systems and their interactions. • Connections to Nature of Science ✓ Scientific Knowledge Assumes an Order and Consistency in Natural Systems Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
Differentiation strategies to meet diverse learner needs:	• Think-pair-share, for students that learn best when engaging with classmates. • Multisensory learning, to accommodate students that are auditory learners and visual learners, as well as encourage students to engage their senses in the learning process. • Awareness of social and cultural backgrounds of students to reinforce the real-life application of what they are learning.
Student Worksheet	Worksheet indicating data to gather from the ISS-ABOVE plus instructions for the ISS pass (fly-over) illustration.
Skills Needed	Students need an understanding of degrees and compass points.

ENGAGEMENT

The Next Pass screen on ISS-ABOVE

Hand out the Student Worksheet. The students will fill in side 1 after the Questions.

Hold the ISS-ABOVE display at the **Next Pass** screen (press key '2' on remote):



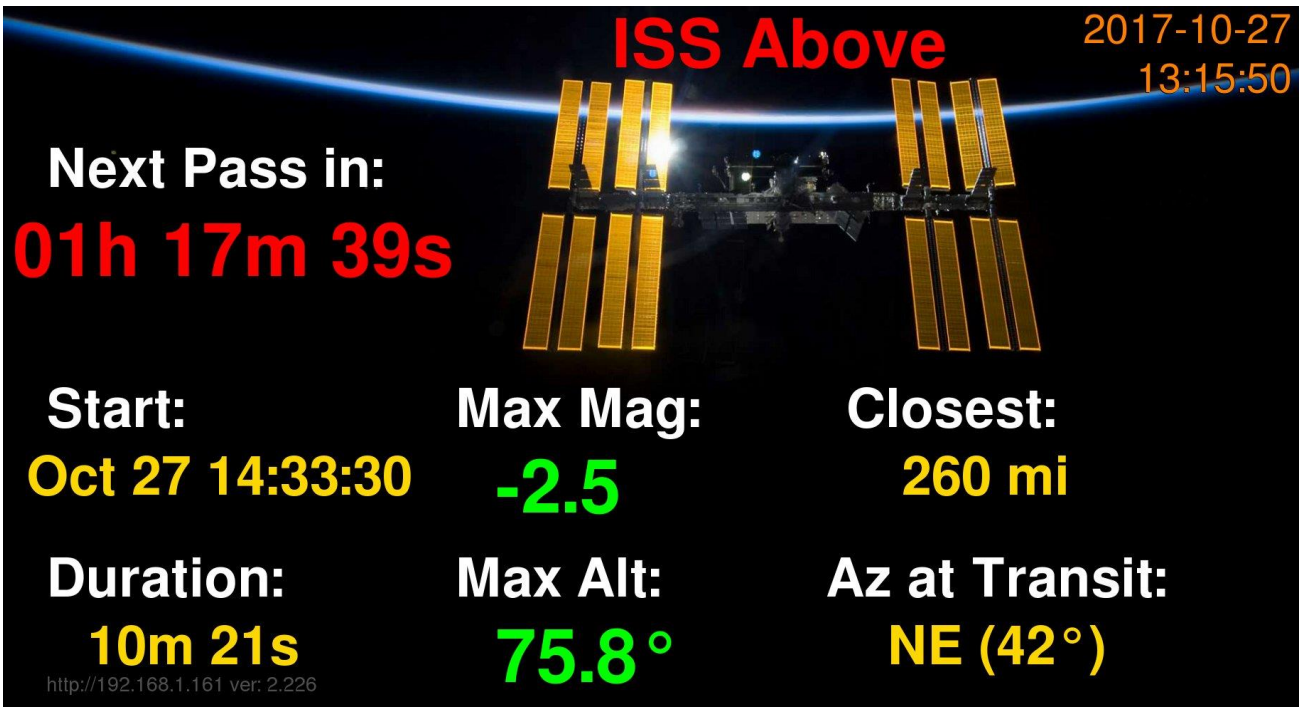
Have the students picture that they are standing at the center of the circle on the right. Answers to the questions below are in italics based on the screenshot above. The live screens displayed on your ISS-Above when you run this lesson will be different.

Questions

1. How long is it until the next pass? *1 h* 17*m 46s*
2. If straight in front of them is North:
   (a) Which way would they have to look to face the direction from which the ISS is rising above the horizon? *To the North West.*
   (b) Which way would they have to look to face the direction in which the ISS will set? *To the South East.*
3. What is the rise time of the ISS (expressed in the 12-hour clock)? *2:33pm*
4. What is the set time of the ISS (expressed in the 12-hour clock)? *2:43pm*
5. How would they work out how long the ISS will be in their sky? *Subtract the rise time from the set time.*
6. Will it be visible? *The ISS is only visible if it's in the sky around sunrise or sunset, It's not visible during the day or late at night. Its visibility depends on the reflection of the sun from the solar panels, so it cannot be seen if it is between Earth and the Sun (day) or behind the Earth from the Sun (night).*

From the other **Next Pass** screen, students should note on their Worksheet the **Direction** from which the ISS will **rise** and **set**. For example, from the screenshot above, rise and set would be NW 314° and SE 130°. Note that the ISS always rises on the left-hand half (W) of the circle and sets on the right-hand half (E).

Now move to the **Next Pass In** screen (press key "1" on the remote):



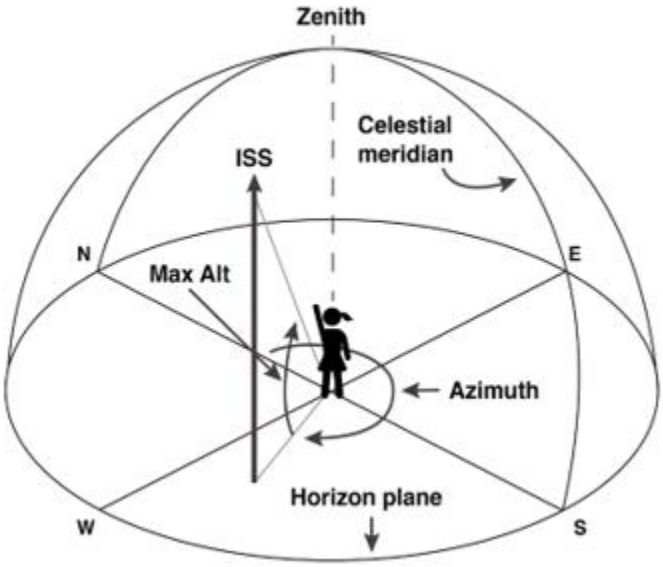
On this screen they can check if their calculation of how long the ISS will be above the horizon is correct (**Duration**).

1. How close will the ISS be when it's at its closest? *260 miles*
2. At what point in the fly by will it be at its closest? *Exactly half-way through the pass (fly over)*.
3. How high in the sky will it be? *At an Altitude of 75.8° (in the above case, almost overhead)*.
4. At what compass position will it be at its closest? At an Azimuth of 42°, roughly NE (but as it's REALLY high up in the sky at that point it will feel like you are pointing almost straight up anyway).

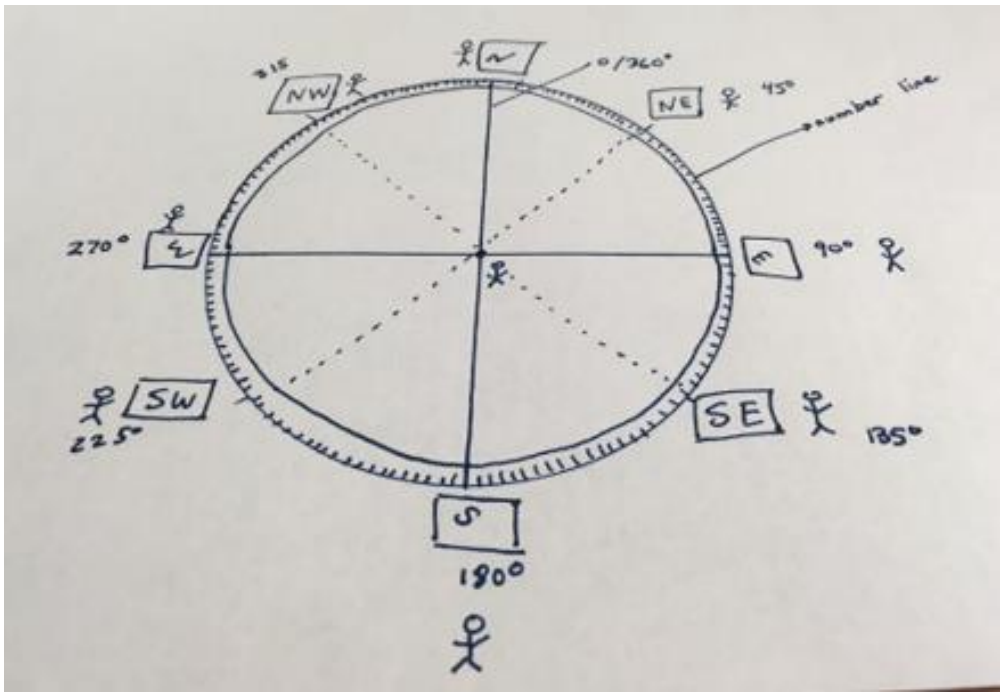
From the **Next Pass In** screen, students should note the **Duration**, **Az at Transit** and the **Max Alt** on their worksheet. The ISS-Above displays some pretty low passes of the ISS over your school… some where the ISS may only barely rise above your horizon. That is completely normal.

EXPLORATION

Students are going to create a model with themselves as the compass points on a circular 'horizon' and track a specific pass of the ISS.



Schematically, the setup is shown in the diagram below:



Eight students will act as the points of the compass and one will stand at the center. If there is enough room, two additional students can stand inside the circle.

PREPARING THE MATERIALS

This exploration assumes a circle of 6ft 6in in diameter, approximately 20ft in circumference.

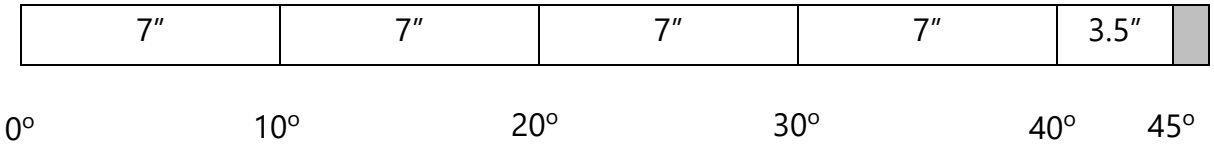
Preparing the number line

Have students (suggested teams of 3) create 8 number line segments of 32″ in length. Each segment spans from one main compass point to the next (e.g. N to NE, NE to E etc.).

Students mark the number line in 7″ divisions with the final division being 3.5″. The example below is for the N to NE, 0º to 45º segment of the circle. ½ inch is left at one end for overlap to the next segment:

Use the model below for the segments N to NE, E to SE, S to SW and W to NW

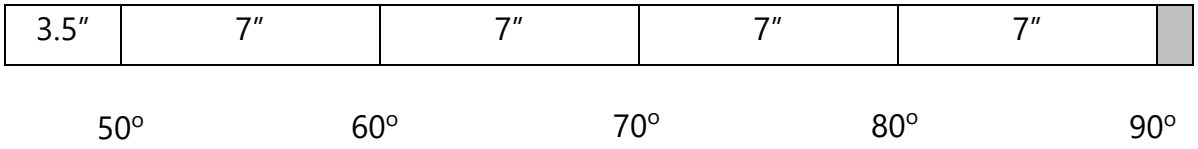
(the angles will need to be adjusted for each segment)



The segment for NE to E, 45º to 90º is a mirror image:

Use the model below for the segments NE to E, SE to S, SW to W, NW to N

(the angles will need to be adjusted for each segment)



Have students sketch their number line based on which segment they've been allocated. When all segments are completed, students will join the number line into a continuous circle.

Preparing the compass points.

Groups of 2-4 students can prepare the 8 compass points on 8 pieces of card or paper. Ask one student to Identify which direction is North (using the compass). Students need to know 'which way is North', so they can take up the right positions on the human compass (see next page).

Setting up the teams

Create 2-3 teams each with 9-11 students in each. Start with Team A.

1. 8 of the students arrange themselves at the compass points. The other 3 students stand in the center. Two hold the ends of the string and the third stand in the middle with the protractor and (optionally) the picture of the ISS.
2. Arrange the number line with 0° at North and then around the circle. The 8 students should be able to hold it as well as their compass direction sign.
3. The 2 students with the string go to the rise and set points as noted on their Worksheet and carefully wrap the end of the string around the correct point on the compass number line. They hand the approx. center of the string to the student in the center.
4. Using the Azimuth measurement from the Worksheet, the student in the center faces that point on the number line.
5. Using the Max Alt measurement from the Worksheet and the protractor, the student in the center holds the center of the string and points upwards in the direction of the highest position of the ISS
6. The other 2 students stand half way between and center and the rise and set points and raise the string with both hands spread apart to form an arc. This should be the path of the ISS as shown on the Next Pass screen but modelled in 3D.

Team B can now take their turn.

Use the table below (or use your ISS-ABOVE browser admin screen to show upcoming passes) to provide a different fly over, but this time based on numbers with no visuals. Students will need to interpret compass points that lie between the 8 major points:

Date	Brightness	Start		Highest point		End		Closest	Pass type
	[Mag]	Time	Az.	Time	Alt.	Time	Az.		
Oct 25	---	02:47:09 PM	NW	02:52:29 PM	31°	02:57:48 PM	ESE	452 mi	daylight
Oct 25	---	04:23:47 PM	WNW	04:28:46 PM	18°	04:33:45 PM	SSE	653 mi	daylight
Oct 26	1.2	05:50:07 AM	SSE	05:53:37 AM	5°	05:57:07 AM	E	1141 mi	night visible
Oct 26	---	07:24:03 AM	SW	07:29:30 AM	80°	07:34:58 AM	NE	254 mi	daylight
Oct 26	---	09:01:39 AM	W	09:06:19 AM	12°	09:11:01 AM	NNE	825 mi	daylight
Oct 26	---	10:41:04 AM	NW	10:44:09 AM	3°	10:47:14 AM	NNE	1247 mi	daylight
Oct 26	---	12:18:55 PM	NNW	12:22:21 PM	4°	12:25:47 PM	NE	1185 mi	daylight
Oct 26	---	01:54:56 PM	NW	01:59:58 PM	18°	02:04:59 PM	E	664 mi	daylight
Oct 26	---	03:31:10 PM	NW	03:36:32 PM	39°	03:41:54 PM	SSE	381 mi	daylight
Oct 26	---	05:10:46 PM	WSW	05:12:14 PM	1°	05:13:42 PM	SW	1421 mi	daylight

Three suggested examples are highlighted in gray. The teams can take turns.

EVALUATION

Students can be evaluated in the following ways:

1. Using the 8-person number circle, other students in turn stand in the center. Seated students in turn:
    (a) Give them an Az at Transit measurement between 0º and 360º - they should point to it and say which compass direction that's closest to.
    (b) Give them a Max Alt measurement between 0 º and 90 º - they should use the protractor to point in that direction to where the ISS would be at its highest.
2. Direct students to the Worksheet which shows the table from the previous page to test the following:
    (a) What things do you need to know to figure out the arc of an ISS fly over?
        - *The rise and set compass points*
        - *The angle (given by Max Alt)*
        - *The direction (given by Az)*
    (b) Create a circular diagram of the compass points and use it to plot one of the passes shown in the table. Note on your circle the Rise and Set points. Draw a line from the center to the edge of the circle to show your Az angle and on that line, note roughly where the ISS Max Alt would be.

Student Worksheet
– Tracking an ISS pass (fly over)

Space Station Orientation

On the table below, note the values using the ISS-ABOVE screens:

Rise Direction: _____ °

Set Direction: _____ °

Duration of pass: _____ min _____ sec

Max Alt: _____ °

Az at Transit: _____ °

You will need this data when you create your human compass.

More data

The table below provides some additional data for ISS-ABOVE passes. You can use this table for some extra examples of ISS passes that you can illustrate using your human compass. Your teacher will give you directions when you get to this part of the exercise.

Date	Brightness	Start		Highest point		End		Closest	Pass type
	[Mag]	Time	Az.	Time	Alt.	Time	Az.		
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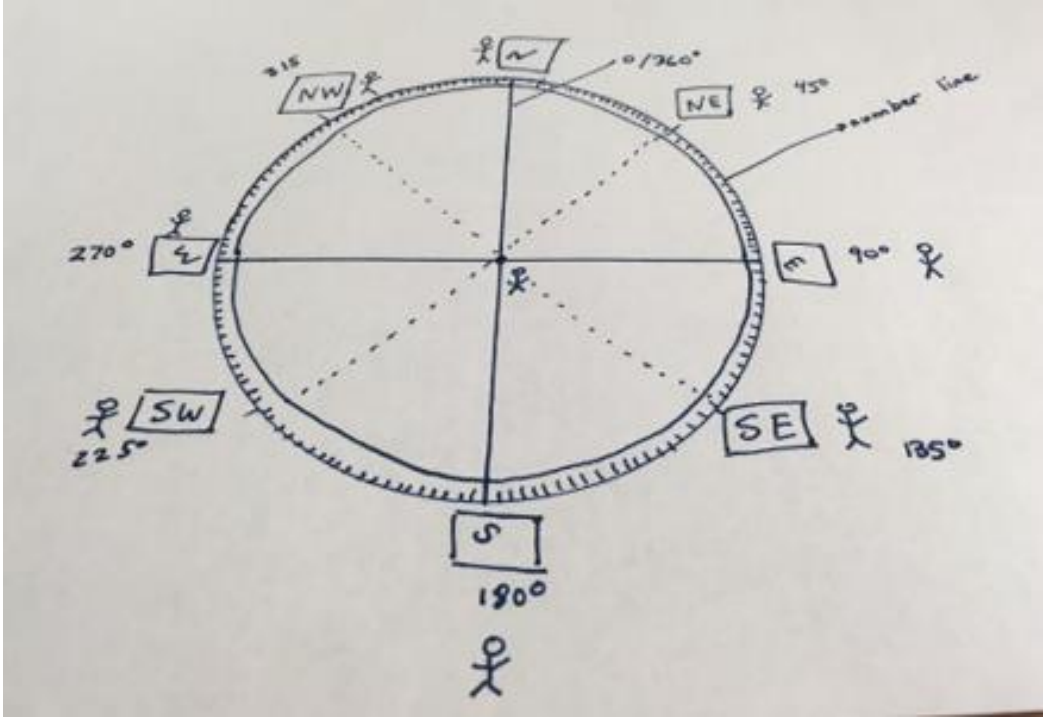
TURN OVER THE PAGE TO CREATE THE MATERIALS FOR YOUR HUMAN COMPASS

Creating the materials for your human compass

Your team of 3 is going to prepare a part of the compass number line. The diagram below shows you the whole compass circle.



The compass circle will be approximately 6ft 6in in diameter, approximately 20ft in circumference. Read the instructions through fully before you start on the tasks.

Preparing the number line

Your teacher will tell you which compass segment you need to create. Each segment is 1/8th of the circle. Each segment spans from one main compass point to the next (e.g. N to NE, NE to E etc.)

The paper for your segment should be 32″ in length.

With a ruler, mark the number line in 7″ divisions with the final division being 3.5″. The example below is for the N to NE, 0º to 45º segment of the circle. ½ inch is left at one end for overlap to the next segment:

Use the model below for the segments N to NE, E to SE, S to SW and W to NW

(you may need to adjust the angles for your segment)

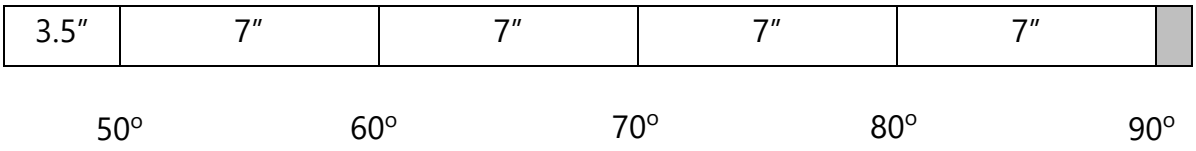
7″	7″	7″	7″	3.5″	

0º 10º 20º 30º 40º 45º

The segment for NE to E, 45° to 90° is a mirror image:

Use the model below for the segments NE to E, SE to S, SW to W, NW to N

(you may need to adjust the angles for your segment)



Sketch your number line based on which segment you've been allocated. When all segments are completed, you will join your number line to the others to form a continuous circle.

Preparing the compass points.

Using a piece of card, write the first compass direction on it. For example, if you were given the segment SE to S, write S on the card (nice and big).

Let your teacher know when you are done.