A TEACHER'S HANDBOOK

FOR THE

ISS-ABOVE

INCLUDING

LESSON PLANS AND ACTIVITIES

GRADES 6 – 8

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Genesis and Acknowledgements

When I picked up a Raspberry Pi in November 2013 and pondered what I might create with it, little did I know that the ISS-ABOVE as it is today would have over 2,000 individuals, companies and schools around the world.

In April 2014, an experiment with four Earth-facing video cameras on the outside of the ISS went live (called HDEV or High-Definition Earth Viewing) and the video stream became available to people everywhere. It was a huge opportunity for ISS-ABOVE. I added the capability to attach the ISS-ABOVE to a TV screen, see the video stream (available when the ISS is in sunlight) and intersperse the stream with informational screens which were based on the ones at ISS Mission Control in NASA Johnson Space Center.

Many enhancements have been made since then, but most significantly, the ***ISS-ABOVE in 100 Schools*** version has specific features for education and teachers, including information screens in Spanish, a remote for teacher control of the screens, some connection cables and a 3D printed TV bracket to attach your ISS-ABOVE. Basically, all you need to provide is a TV and an internet connection (wired or wireless). In addition, we added Lessons and Activities that engage students with the ISS through the ISS-ABOVE device.

My thanks…

To a whole host or organizations and people who made the ***ISS-ABOVE in 100 Hundred Schools*** project possible:

- CASIS (Center for the Advancement of Science in Space) funding has been the reason this project has happened. Thank you for seeing the potential of the ISS-ABOVE to inspire young people with an interest in the International Space Station, to discover that there have been humans onboard since Nov 2nd, 2000, to appreciate that the ISS has been an outpost of scientific and engineering achievement for all those years and, since the implementation of HDEV, to see the glory of our Earth in real time, from the viewpoint of the astronauts, scientists and teachers on the ISS.
- To CASIS Space Station Ambassadors for bringing together a whole host of committed science teachers from across the US who want to use the ISS as a source of engagement in STEM subjects and careers.
- To CASIS Space Station Explorers, a group of passionate organizations who have programs and products related to the ISS. I am proud to be part of that group supporting education in all things ISS and how to engage with the ISS.
- To the HDEV team at Johnson Space Center in Houston who built such a remarkable capability to capture and live stream video from the ISS.

- To the amazing group of educators, teachers and evaluators listed on the front cover, for working with me on the project and who have contributed so much, including ideas for ISS-ABOVE enhancements and for our curriculum as well as testing lessons for us. Special mentions to Dieuwertje Kast for pulling together our curriculum design and lesson, and to her assistants in that endeavor, Rita Barakat, Program Assistant, USC Young Scientists Program and Alyssa Matlosz for graphics for Unit 2, Lesson 1.
- To Fred Sayers, retired actor and cartoonist who created cartoons for the ISS Astronauts' Handbook duplicated herein by his kind permission.
- Finally, to my wife, Anna, who has believed in me and supported me throughout this exciting journey.

History…

In November 2013, I started creating the ISS-ABOVE to inspire my grandchildren to take an interest in space. That very first unit with flashing LED lights made its way to England and onto my grandchildren's Christmas tree.

Little did I know that my vision for that first device would translate to a mission to have young people believe that they are so much greater than they think they are, that's there's no limit to their opportunities if they'll just reach out and grab them. It's teachers who make that happen and I want to thank you all for the work you do to expand your students' horizons.

To all those future adults working in STEM careers, I can't wait to see who you'll become.

Liam Kennedy
Inventor
ISS-ABOVE

Note: The ISS-Above has a Space Act Agreement with NASA's Johnson Space Center (SAA-OA-22225) although this does not imply any endorsement of the ISS-Above by NASA. We acknowledge the use of NASA images / photos and video assets throughout the ISS-Above system – including this teacher handbook.

Preface

Who is this handbook for?

The primary audience for this handbook is Grade 6-8 teachers in schools and educators in after-school programs, summer programs and science centers delivering, either intentionally or by just following the lessons and activities, on selective NGSS and related standards for those grades.

Having said that, the primary purpose of the ISS-ABOVE and its associated curriculum is to inspire curiosity, develop skills and promote learning in scientific, mathematical, life science and earth science spheres through engaging interactions with the ISS-ABOVE and the questions it raises in students' minds.

For teacher guidance, the specific NGSS standards addressed by each lesson are noted in the lesson plans. As much as possible, the lesson plans include practical activities for students, so that they learn through discovery and hands-on experience.

Safety precautions

The ISS-ABOVE is based on the single board computer, the Raspberry Pi. There are more than 14 million Raspberry PIs in use, many of them in schools. After installation of your ISS-ABOVE, there are power and HDMI (and possibly Ethernet) cables attached to the device. We recommend attaching the ISS-ABOVE to your TV with the mounting bracket provided and securing loose cables behind your TV.

Some lessons call for the use of ordinary classroom equipment and resources, such as scissors. Unit 1, Lesson 1, uses oranges to represent the Earth and the ISS orbit. These oranges are then cut into quarters. Teachers will use their discretion in how to manage this activity.

Online Version

The complete Teacher Handbook is available as a pdf online at
www.issabove.com/schools/curriculum
You will also find the individual lesson plans and activities available as pdfs and as Word documents. We are also providing Spanish translation of Student Worksheets and Activities.

The ISS-ABOVE device

Installation

You have your package. Inside, you'll find the ISS-ABOVE unit packed in a plastic 'clam-shell' box which is not sealed. When you open the box, the instructions for installation (ISS-ABOVE QUICKSTART GUIDE) can be found in-between the sheets at the back of the clamshell package. You'll also find a paper slip with details about the ISS-ABOVE bracket and remote. The install instructions are easy to follow, although teachers sometimes need to ask IT for help, especially since the device needs internet access to steam video from the ISS. If you hit problems, email us at support@issabove.com. We typically respond same day.

The reverse side of the QUICKSTART GUIDE is a small poster, "Using Your ISS-ABOVE" which explains some of the basics of what you will see on the TV when the ISS-ABOVE is installed and how the PiGlow (flashing LED lights) provides information about how long it is until the ISS will be in your skies. If you pin this up near the ISS-ABOVE, it will answer a lot of student questions.

NOTE: The Raspberry Pi in the ISS-ABOVE is a small but mighty computer in its own right. You do not connect it to a desktop, laptop or tablet.

Special Additions for the Teacher Package
Your teacher package has shipped with some items that don't normally come with in ISS-ABOVE. These include this Handbook, plus a remote control and an HDMI to VGA converter for attaching your ISS-ABOVE to a monitor or projector that does not have an HDMI input. See the Teacher Guide for more information.

About Teacher Guide to the ISS-ABOVE

Once you have your ISS-ABOVE going, you'll see there is a wealth of technical information on the screens. The Teacher Guide below tells you what all those numbers mean (just in case you're not an astronomy geek). Where we reference the screens on our lesson plans, we try to make sure that students will fully understand the concepts, numbers and units. The guide also includes information about your remote. You'll find the guide on the next page.

Help and Support

On our website, you'll find a Get Help page (http://www.issabove.com/support/). There's a video on the initial setup using an Ethernet connection.

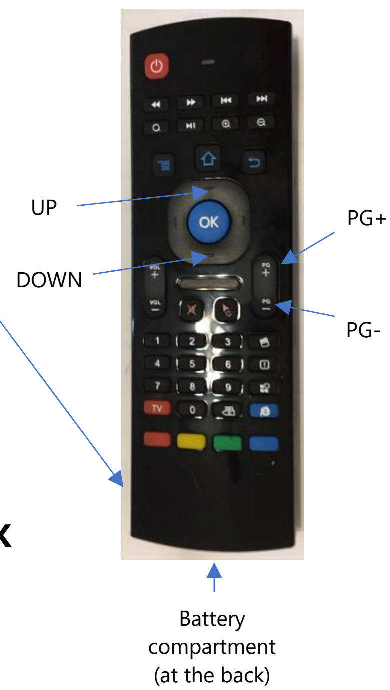
We've set up an ISS-ABOVE online community forum to help us collect feedback and ideas from the teacher community to make improvements to ISS-ABOVE and the lessons/ activities we've provided. It will also be a place where you can communicate with your peers in the teaching community about your experiences and share best practice ideas.

That forum is here-> http://help.issabove.info

You can also email us your questions at support@issabove.com. We'll get right back to you.

Teacher Guide to the ISS-ABOVE

Your remote



With your ISS-ABOVE, we shipped a remote. We did not supply batteries, so you'll need 2 x AAAs. The battery door is very tight. Prize it off at the (lower left or right) side with a small flat-head screwdriver.

A word of warning: Many of the buttons DO NOTHING. We've really just repurposed a multi-media remote to do some very helpful things with your ISS-ABOVE

On the 'remote' side of the Remote:
Use the up and down buttons on the control surrounding the **OK** button to switch to next screen or the previous screen.
You can also use the number keys 1-6 to reach specific screens.

PG- will stop the HDEV video and return to info screens (see below).
PG+ will start the HDEV video (if the ISS is in darkness the TV will display a completely black screen)

On the other side of the remote:
OOO (press letter O three times) – switches off the ISS-ABOVE
To restart the ISS-ABOVE pull the power cord and reinsert it.
RRR (pressing R three times) – reboots the ISS-ABOVE (when it is running), very rarely needed – but if you notice something weird – rebooting can sometimes help.

NOTE: During a live pass over your location (which last 5-9 minutes) only the Video on/off (PG+ / PG-) works.

If you're having problems with your ISS-ABOVE, we may ask you to press 00 (zero twice) for a diagnostics screen which might be helpful to you, your IT or to us. This screen stays on for a few seconds and then reverts to the regular info screens.

What information does the ISS-ABOVE display?

The ISS-ABOVE offers display information to appeal to different levels of technical understanding/age groups. There are three displays types: (1) LED flashing lights, (2) Information screens about the ISS and where it is (3) Live video from the external cameras on the ISS:

(1) LED flashing lights.

The PiGlow starts flashing to notify you when the ISS is approaching your skies. Count the colored flashes to tell you how long it is until the ISS passes overhead.

The number of flashes tells you:

If it's flashing ***RED:***

the # of **hours** to go

If it's flashing ***GREEN***:

the # of **10 minute** intervals to go

If it's flashing ***BLUE***:

the number of **minutes** to go

If it's flashing **all different colors** that means the ISS is ABOVE you RIGHT NOW!!

(2) Information displays:

There are a number of displays and more are added from time to time:

NEXT PASS SUMMARY: This screen tells you when the ISS will next be above your horizon. It doesn't mean it will be visible. See NEXT VISIBLE PASS screen for information on when you can next SEE the ISS.

Next Pass In: How long until the start of the next flyby in hours, minutes and seconds.

Start: The day, hour, minutes and seconds when the flyby will begin.

Duration: How long the ISS will be above the horizon in minutes and seconds

Max Mag: A scale that indicates the brightness of an astronomical object (including man-made ones!) Oddly, higher numbers are dimmer to the eye (you usually cannot see below +5). Negative number measures are bright and fairly obvious objects if you know where to look. These numbers below can vary (for example, the planets vary in brightness dependent where they are in their orbits compared to the Earth).

SUN: -26

FULL MOON: -13

VENUS: -4 at brightest

ISS: Varies from -3.5 to +0.6 (so can be brighter than Venus).

JUPITER: -2

SIRIUS (brightest northern hemisphere star): -1
SATURN: +1
BIG DIPPER (PLOUGH) STARS: +2
JUPITER'S MOONS: +5 (you can see the largest ones through binoculars or a small telescope)

You can see why humans have always been fascinated by planets (firstly, they move against the background of stars over a period of days/months – and they're bright. So is the ISS. If you've never seen it, plan to get out there! ISS-ABOVE will tell you when and where to look. Both Venus and the ISS are only visible around dawn or dusk, so the brightness comparison can be helpful.

Max Alt: If 0^{o} is the horizon and 90^{o} is straight up, then this is the angle between the horizon and the ISS at its highest (on any given pass). During a visible pass of the ISS Any Max Alt below 20^{o} can be hard to see (allowing for trees, buildings and hills).

Closest: In miles (or km) at Max Alt (in other words, when it's at its highest above you on any given pass, this will be how far away it will be). The ISS orbits around 250+ miles above the Earth, so anything close to that means it will be high up in the sky.

Az at transit: "Azimuth". The angle between North and the highest point of the flyby (you have to imagine drawing a line from the ISS to the nearest point on the horizon below it). The display also shows a compass bearing. Astronomers use Alt and Az to describe where an object is in the sky.

NEXT PASS SKY MAP: If the ISS is not in your skies, the next pass screen shows you when it will be coming by and the path it will take across your skies (above the school). If the next pass is during the school day – there is a good chance you and your students will see live video of YOU as the ISS passes over the school.

Next pass in: How long until the ISS will rise above the horizon, in hours, minutes and seconds.

Rise time and Direction: Which direction the ISS will rise from and what time.

Set time and Direction: Which direction the ISS will set and what time.

ACTIVE PASS SKY MAP: If the ISS is in your skies, you will see the active pass screen. This screen shows the important information for tracking a pass. The numbers on this screen change quickly as the ISS passes across your sky.

- Your location is the center of the circle (where the blue cross is).
- The green dot on the orbit path is the ISS.

- The altitude measures are shown relative to the horizon (horizon is 0^o, directly above you is 90^o).
- You may see dots for the Sun (Su). Moon (Mo), Venus(ve), Mars (ma), Jupiter (ju), Saturn (sa).

Sets:	How long until the ISS will set (finish its pass and go below the horizon)
Range:	The distance between you and the ISS at that moment.
Mag:	The brightness (see information from the NEXT PASS screen).
Altitude:	The current height of the ISS above the horizon.
Direction:	The current direction of the ISS from you.

ORBIT (WORLD MAP): This screen shown a map of the Earth with the path of the ISS. Your location (where the ISS-ABOVE thinks it's located) is a red dot. The curvy line shows one and a half orbits. Find the little image of the ISS – that's where it is right now. You will see it move slightly on the orbit (we're talking 4.8 miles/second or 17,500 miles per hour). Parts of the orbit are yellow (the ISS is in daylight) and parts are blue (the ISS is in darkness). There's a short grey part of the curve between yellow and blue – this is dawn/dusk, when you are most likely to see ISS. The ISS orbits from West to East.

At the top of the screen, you will see the following:

Next pass	El	Vel	Sunset/ Sunrise	ISS Time	Beta ◢
When the ISS will next be above you	Elevation in miles (or km)	Velocity in miles (or km)/hour	Time to next sunset or sunrise (for the ISS)	Astronauts set their clocks to UTC time (GMT) – as if they were living in the UK	The angle between the orbital plane and a line drawn from the Sun to the Earth.*

*The Beta angle, when large, indicates that the ISS is spending a lot of time in sunlight (when it's above 71 degrees the ISS may not see a sunset for another 3-5 days). During this time Mission Control has to monitor very closely the thermal environment on the ISS and during "High Beta" they will occasionally change the orientation of the ISS to help keep critical components cool and to improve the energy capture of the solar panels. This change in orientation affects the views from the cameras, so some of your students may spot it and ask what's happening.

NEXT VISIBLE PASS SUMMARY: This screen has exactly the same information as the NEXT PASS SUMMARY screen except that it's giving you the data for the next opportunity to run outside and see the ISS. It has the date and time and where the ISS appears and sets, plus green bars to show you how bright it will be.

EXPEDITION CREW: All permanent ISS crews are named "Expedition n", where n is sequentially increased with each expedition. A tour of duty on the ISS is usually 6 months, and most astronauts are part of 2 Expeditions. The ISS typically houses 6 people (2-3 US, 2-3 Russian and 1-2 from other countries in Europe, Canada and Japan who support the ISS). In 2015 longer stays on the ISS (Scott Kelly and Mikael Kornienko going for 1 year – "the 1-year mission") are starting to assess how well humans will manage long-term space travel – like to Mars!

(3) LIVE HD Video:

The live stream of video is coming from 4 cameras in a housing attached to the underneath of the ISS (the side facing the Earth). The camera system is an experiment called HDEV (High Definition Earth Viewing) and was launched to the ISS in April 2014. The cameras are enclosed in a temperature controlled housing and are exposed to the harsh radiation of space. Analysis of the effect of space on the video quality, over the time HDEV is operational, may help engineers decide which cameras are best to use on future missions. Through the High Schools United with NASA to Create Hardware (HUNCH) program High school students helped design some of the cameras' components. Student teams operate the experiment.

The live video only shows when the ISS is in sunlight (i.e. usually half of every 92-minute orbit). During those 46 minutes, the HDEV cycles through the 4 cameras showing forward facing, downward facing and (2) rear facing views. ISS-ABOVE adds a geographic location letting you know where in the world the ISS-ABOVE is. Sometimes the automated sequence is postponed for hours or days at a time and the view will be fixed on one camera,

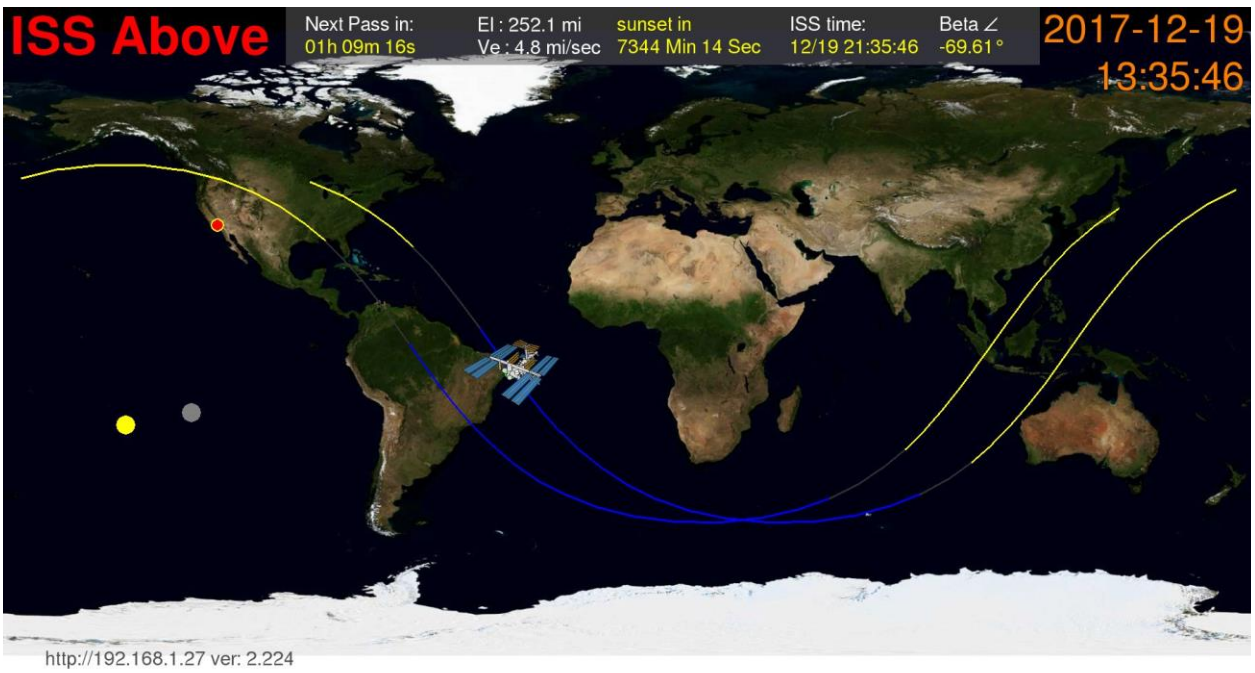
The rear facing camera shows part of the ISS – the two docking stations for the Russian Soyuz and Progress resupply spacecraft. You can sometimes see the spacecraft arriving, docking and leaving – it's very exciting. When the SpaceX Dragon resupply vehicle arrives that can usually be seen in the down-facing camera and while docked you will see part of its solar panels in the down camera. Very occasionally you may also see the Canadarm2 moving – it's the device (along with Dextre) that moves large sections of hardware and places them where needed – it was used to help in the installation of the HDEV experiment. Whenever the SpaceX Dragon is docked this will be used to remove experiments and payload from the Dragon's unpressurized trunk to other parts of the space station.

Configuring your ISS-ABOVE

There are a lot of settings YOU can control on how your ISS-Above works. This is done via the Web Admin system. You can access the admin website for your ISS-ABOVE from any browser, as long as it is on the same network as your ISS-ABOVE.

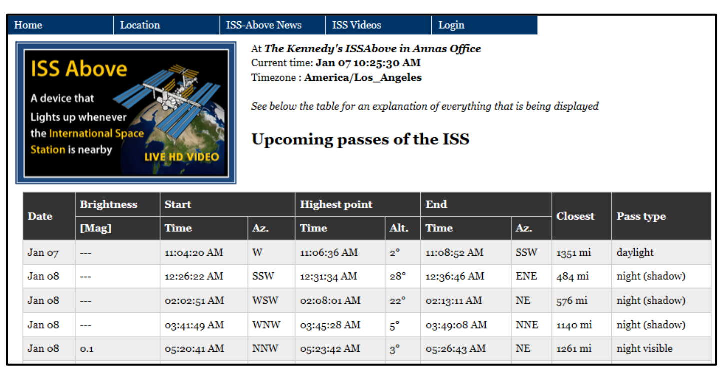
To access the web admin you will type in http://(your ISS-ABOVE's IP address)

You'll find the IP address displayed in the lower left of the information screens displayed on the TV. Below you can see the Orbit display and if you look to the lower left you'll see the IP address (http://192.168.1.27). Note: YOUR IP ADDRESS WILL BE DIFFERENT.



This is your own ISS-ABOVE's website home page prior to login.

You can see a full list of upcoming passes of the ISS over your school.



Home | Location | ISS-Above News | ISS Videos | Login

ISS Above
A device that Lights up whenever the International Space Station is nearby
LIVE HD VIDEO

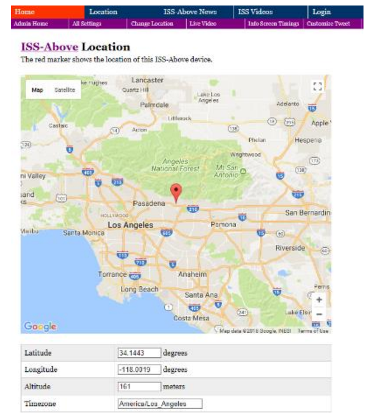
At *The Kennedy's ISSAbove in Annas Office*
Current time: **Jan 07 10:25:30 AM**
Timezone : **America/Los_Angeles**

See below the table for an explanation of everything that is being displayed

Upcoming passes of the ISS

Date	Brightness	Start		Highest point		End		Closest	Pass type
	[Mag]	Time	Az.	Time	Alt.	Time	Az.		
Jan 07	---	11:04:20 AM	W	11:06:36 AM	2°	11:08:52 AM	SSW	1351 mi	daylight
Jan 08	---	12:26:22 AM	SSW	12:31:34 AM	28°	12:36:46 AM	ENE	484 mi	night (shadow)
Jan 08	---	02:02:51 AM	WSW	02:08:01 AM	22°	02:13:11 AM	NE	576 mi	night (shadow)
Jan 08	---	03:41:49 AM	WNW	03:45:28 AM	5°	03:49:08 AM	NNE	1140 mi	night (shadow)
Jan 08	0.1	05:20:41 AM	NNW	05:23:42 AM	3°	05:26:43 AM	NE	1261 mi	night visible

THE BLUE MENU



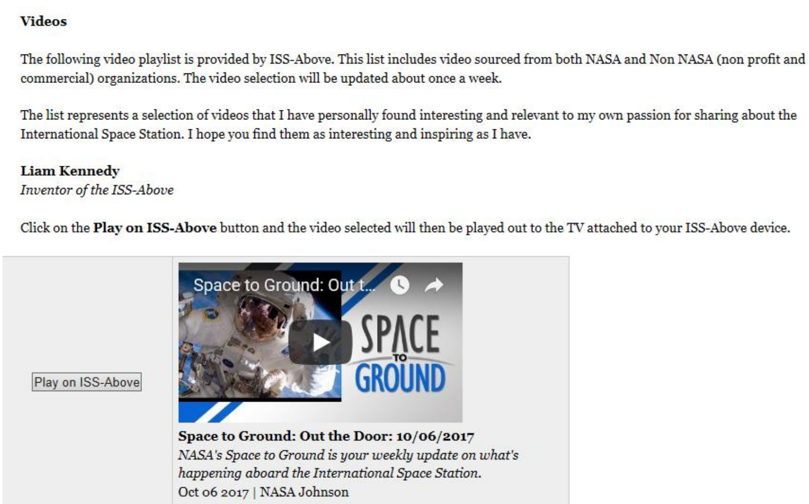
From the blue menu: Location

Shows your current location (where you set the ISS-ABOVE for).

You will also see the purple menu which allows you to configure the ISS-ABOVE. If you are not logged in, you can login from the blue menu with Username: admin, Password: nasa (we recommend you don't change these – we cannot recover user created passwords)

From the blue menu: ISS-ABOVE News

Goes to our blog.



From the blue menu: ISS Videos

This is a video on demand screen.

Clicking **Play on ISS-ABOVE** will play those videos on to the TV attached to your ISS-Above.

If you click the Play icon (over the video) it will only play that in your browser.

These videos get updated automatically when we update the list – usually every few weeks.

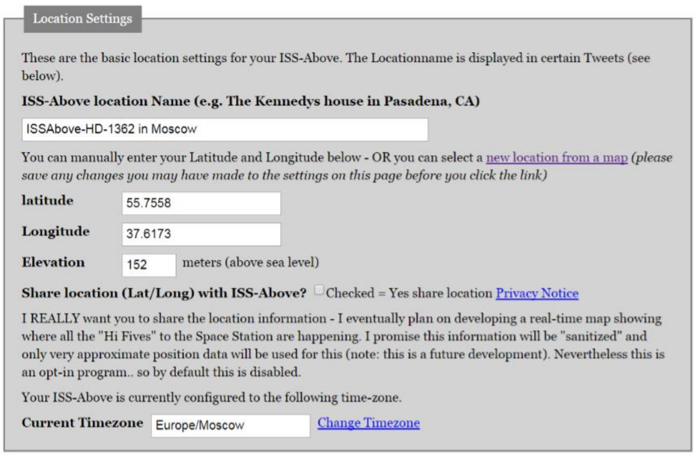
THE PURPLE MENU (ADMIN/SETTINGS)

From the purple menu: Admin Home

The Admin Home page is a series of quick links for basic settings (probably all you'll ever need) and more advanced settings (for non-standard configuration or troubleshooting).

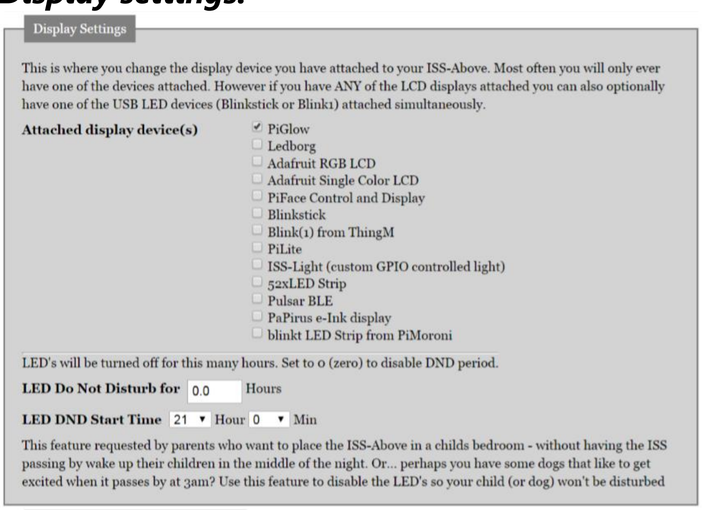
From the purple menu: All Settings

Your location:



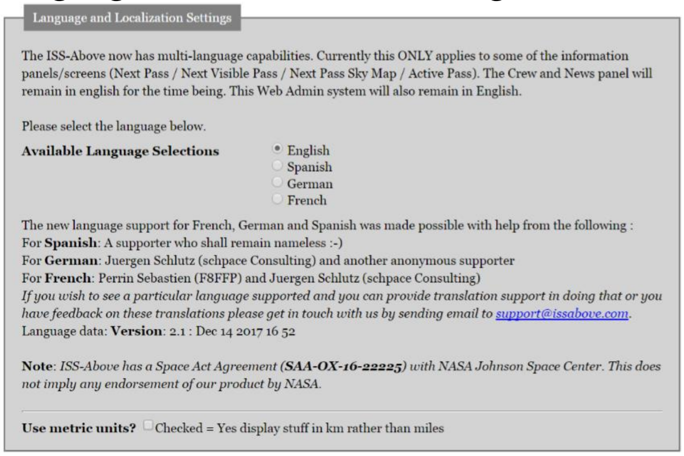
This panel shows you your location (where the ISS-ABOVE thinks it is.
The location Name is used when your ISS-ABOVE tweets to the Space Station.
The panel also shows Lat/Long, Elevation and Time zone. In general, we don't recommend you change the Lat/Long details here – but rather use the **Change Location** feature (see below)

Display settings:



The ISS-ABOVE comes with a PiGlow LED. If you have other display devices compatible with the Raspberry Pi (or you have a spare Raspberry Pi and buy an SD card with the ISS-ABOVE software), you can change out the PiGlow for an alternate display type. You can also set a Do Not Disturb time if you don't want the PiGlow flashing at specific times.

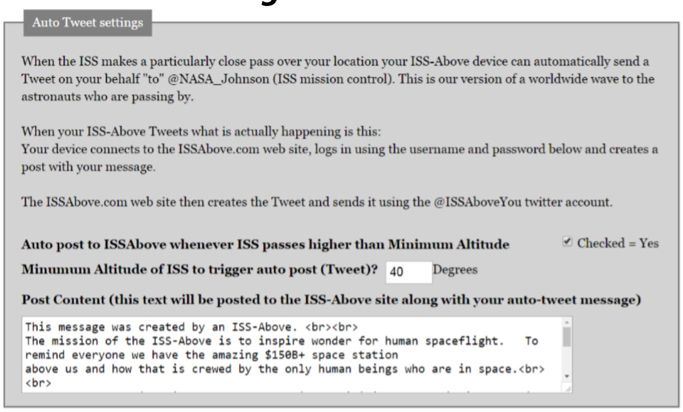
Language and localization settings:



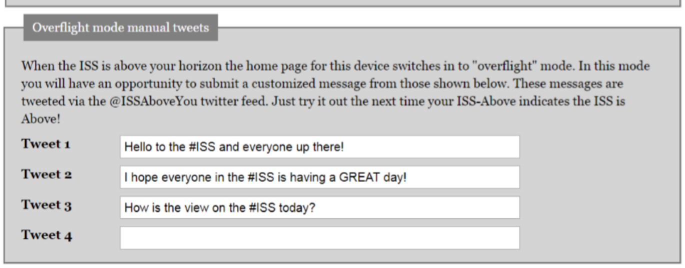
Text on the ISS-ABOVE screens is available in difference languages. It defaults to English. You can change it here. (Pressing "L" on the remote will switch between all the available languages)

The ISS-ABOVE also defaults to distances measured in miles. You can change to metric units at the bottom of this panel.

Auto Tweet settings

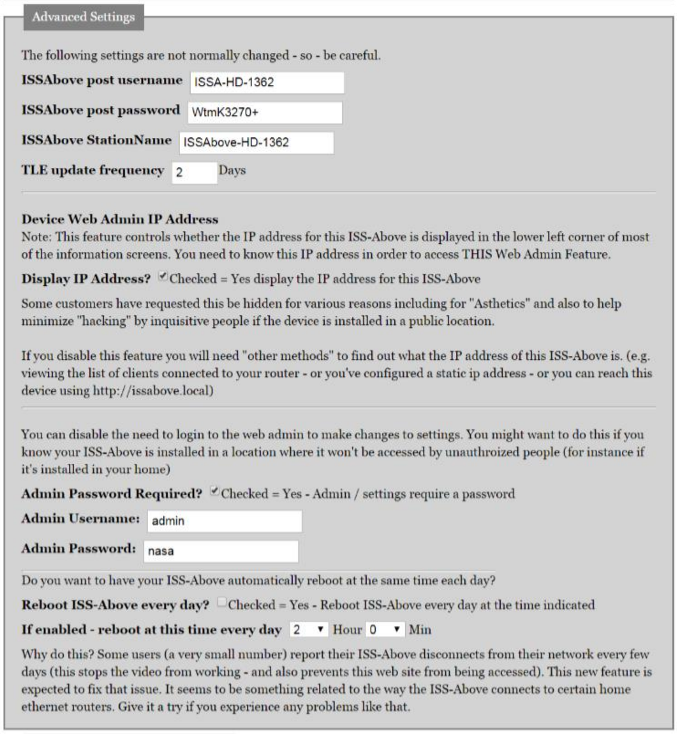


Your ISS-ABOVE automatically Tweets the Space Station and posts to ISSAbove whenever the ISS is above a certain altitude in your skies.
You can switch off auto-tweeting, or modify the message.



These messages are only used during a live pass of the ISS. If you bring up the home page for the web admin you can select one of these messages to Tweet to the @Space_Station

Advanced Settings


Advanced Settings

The following settings are not normally changed - so - be careful.

ISSAbove post username ISSA-HD-1362

ISSAbove post password WtmK3270+

ISSAbove StationName ISSAbove-HD-1362

TLE update frequency 2 Days

Device Web Admin IP Address
Note: This feature controls whether the IP address for this ISS-Above is displayed in the lower left corner of most of the information screens. You need to know this IP address in order to access THIS Web Admin Feature.

Display IP Address? Checked = Yes display the IP address for this ISS-Above

Some customers have requested this be hidden for various reasons including for "Asthetics" and also to help minimize "hacking" by inquisitive people if the device is installed in a public location.

If you disable this feature you will need "other methods" to find out what the IP address of this ISS-Above is. (e.g. viewing the list of clients connected to your router - or you've configured a static ip address - or you can reach this device using http://issabove.local)

You can disable the need to login to the web admin to make changes to settings. You might want to do this if you know your ISS-Above is installed in a location where it won't be accessed by unauthroized people (for instance if it's installed in your home)

Admin Password Required? Checked = Yes - Admin / settings require a password

Admin Username: admin

Admin Password: nasa

Do you want to have your ISS-Above automatically reboot at the same time each day?

Reboot ISS-Above every day? Checked = Yes - Reboot ISS-Above every day at the time indicated

If enabled - reboot at this time every day 2 Hour 0 Min

Why do this? Some users (a very small number) report their ISS-Above disconnects from their network every few days (this stops the video from working - and also prevents this web site from being accessed). This new feature is expected to fix that issue. It seems to be something related to the way the ISS-Above connects to certain home ethernet routers. Give it a try if you experience any problems like that.

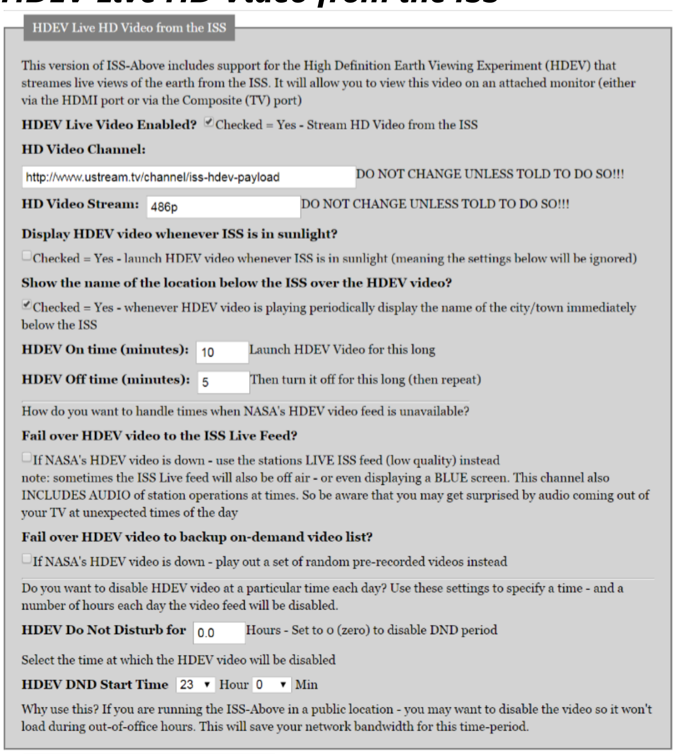
Our advice is, leave well alone.

Be aware that if you change the admin password we cannot recover them for you.

We don't need to tell you to be careful about student use of the admin panels. You're the experts when it comes to handling curiosity or 'let's mess it up'.

It can be messed up and of course, we're here to help if that happens.

HDEV Live HD Video from the ISS


HDEV Live HD Video from the ISS

This version of ISS-Above includes support for the High Definition Earth Viewing Experiment (HDEV) that streames live views of the earth from the ISS. It will allow you to view this video on an attached monitor (either via the HDMI port or via the Composite (TV) port)

HDEV Live Video Enabled? Checked = Yes - Stream HD Video from the ISS

HD Video Channel:

http://www.ustream.tv/channel/iss-hdev-payload DO NOT CHANGE UNLESS TOLD TO DO SO!!!

HD Video Stream: 486p DO NOT CHANGE UNLESS TOLD TO DO SO!!!

Display HDEV video whenever ISS is in sunlight?

Checked = Yes - launch HDEV video whenever ISS is in sunlight (meaning the settings below will be ignored)

Show the name of the location below the ISS over the HDEV video?

Checked = Yes - whenever HDEV video is playing periodically display the name of the city/town immediately below the ISS

HDEV On time (minutes): 10 Launch HDEV Video for this long

HDEV Off time (minutes): 5 Then turn it off for this long (then repeat)

How do you want to handle times when NASA's HDEV video feed is unavailable?

Fail over HDEV video to the ISS Live Feed?

If NASA's HDEV video is down - use the stations LIVE ISS feed (low quality) instead
note: sometimes the ISS Live feed will also be off air - or even displaying a BLUE screen. This channel also INCLUDES AUDIO of station operations at times. So be aware that you may get surprised by audio coming out of your TV at unexpected times of the day

Fail over HDEV video to backup on-demand video list?

If NASA's HDEV video is down - play out a set of random pre-recorded videos instead

Do you want to disable HDEV video at a particular time each day? Use these settings to specify a time - and a number of hours each day the video feed will be disabled.

HDEV Do Not Disturb for 0.0 Hours - Set to o (zero) to disable DND period

Select the time at which the HDEV video will be disabled

HDEV DND Start Time 23 Hour 0 Min

Why use this? If you are running the ISS-Above in a public location - you may want to disable the video so it won't load during out-of-office hours. This will save your network bandwidth for this time-period.

This panel allows you to control when live video from the Earth facing cameras displays. By default, the live stream shows for 10 minutes and then goes back to the information screens for 5 minutes.

Occasionally, the feed from the Space Station isn't working, so you can fail over to other video from the ISS or to some informational videos about the ISS.

You can also set Do Not Disturb for certain times of the day. You may want to configure the DND times so the video is not playing when the school is closed.

ISS-ABOVE version / update management

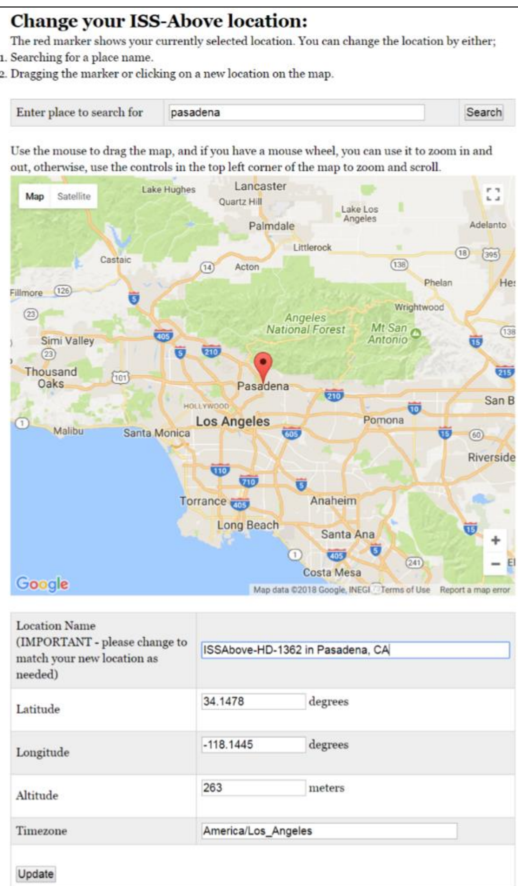
The ISS-ABOVE auto-updates when we create a new version. If you register your ISS-ABOVE with us (part of your install instructions), you will get email notifications of the updates.

If you change any settings in the above panels, don't forget to click **Save Settings** at the bottom of the page.

Some of the panels on this above screen (and some additional ones) are accessible from other tabs. See the tabs on the purple menu and also below.

From the purple menu: Change Location

Once your location is set (during install), you don't normally want to change. However, one the lessons uses the change location screen to see the ISS-ABOVE reset and display location data on the info screens for that location.



In the **Enter place to search for**, type the City you want to relocate to, then click **Search**.

The map should show the new location.

Below the map, you can change the location name.
The Lat/Long, Altitude and Time zone will reset.

Click Update at the bottom of the screen.

Your ISS-ABOVE will now restart (takes about 2 minutes).

The info screens show data for the new location.

From the purple menu: Live Video

HD Live Video Experiment

The live video stream will automatically start whenever the ISS is in sunlight. It will run for 10 minutes then switch back to regular information display for a further 5 minutes, then back to video again for 10 minutes. The video mode will end when the ISS moves over a location where the sun has set for more than 30 minutes.

You can use the buttons below to further control the video if you wish. This will override the automatic video mode for one orbit only (approx 92 minutes)

Start HD Live Video Stream

Click the button below to startup video. The video will remain on until you click the OFF button.

stream on

Note: it may take 1-2 minutes before the video starts up.

Stop HD Live Video Stream

Click the button below to stop the video

stream off

If you quickly want to disable or enable the HD Live Video, you can do that here.

Switching the video off is an override for one orbit only.

You can also do this from your remote with PG+ or PG-.

From the purple menu: Info screen timings

Info Panel Timings

Here you can adjust the timings for all the info panels the ISS-Above cycles through. If you want to disable a particular info panel just enter a 0 (zero) for the value.

Next Pass	15	seconds
Next Pass Sky Map	15	seconds
Orbit Track	30	seconds
Next Visible Pass	20	seconds
Crew Information	15	seconds
ISS-Above News	15	seconds
Custom Panel	0	seconds

Save Settings

Here you can choose how long each info screen displays. Note that you can also skip to specific screens using your remote control.

From the purple menu: Customize tweet

Auto Tweet Message Customization

Your ISS-Above (if configured) will automatically send your own custom message "to" the International Space Station every time the ISS gets "nearby" (determined by the "Tweet Altitude" on the /settings2 page.

This settings page allows you to change the message to suit your particular needs. If you wish to use a different language other than the default of English you may substitue your own words as appropriate.

This is what a sample tweet meesage will look like.
Hello .@Space_Station **from** The Kennedy's ISSAbove in Annas Office 260mi **away** @NASA_Johnson #issabove

Substitute your own word for "Hello" Hello

Substitute your own word for "from" from

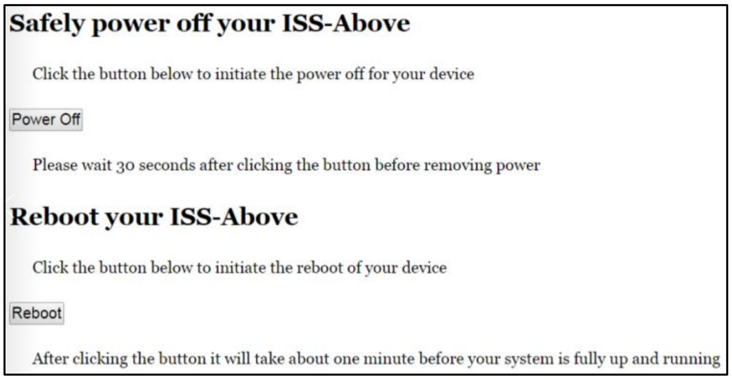
Substitute your own word for "away" away

Check out actual tweets from other devices here-> http://twitter.com/ISSAboveYou

Save Tweet Customizations

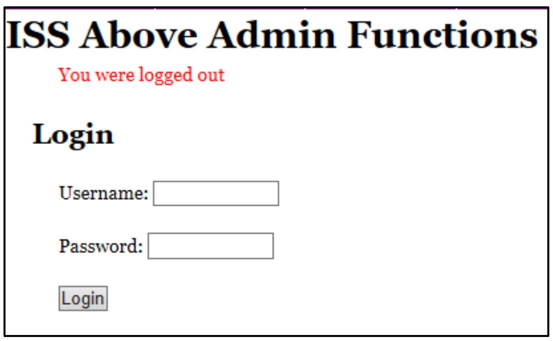
Your Tweet message has a certain format and you can change some of the words in the Tweet on the screen.

From the purple menu: Power off/reboot



Don’t pull the power on your ISS-ABOVE – you might corrupt the SD card.
Use the Power Off function, or Reboot your ISS-ABOVE from this screen.

From the purple menu: Logout



If you click on the purple menu **Logout** you will logout. Login again on this screen.

Evaluation Overview

The ISS-ABOVE in 100 Schools is a pilot project funded by CASIS for the addition of extra functions to the ISS-ABOVE and Curriculum.

The evaluation of the project will include surveys for teachers and students who participate in the project under the CASIS funding (namely those schools who received an ISS-ABOVE package free of charge). You should anticipate:

1. Pre- and post-surveys for teachers using the curriculum and for students who come into contact with the ISS-ABOVE whether or not they engage in specific lessons.
2. We expect pre-surveys to be conducted in February and post-surveys in May/June.

We hope to use the results from the survey to evaluate the impact of the ISS and above project, and to use feedback gained to improve the project in the future.

We are aware that you need Parent Consent for student surveys, so we will be working with your School District if a Digital Protection Agreement is in place and with your school if parent consent forms are needed.

Lesson Plans and Student Worksheets

The lesson plans are designed for Grades 6-8 and include using the ISS-ABOVE device and the information it conveys to extend students' understanding of the ISS, orbiting bodies, space flight and human existence in space. The lessons are grouped into Units covering related topics.

It may be appropriate for lessons to be conducted by a group of teachers, so please share this manual.
NOTE: You can download the manual as a pdf and lessons as pdfs or Word document at www.issabove.com/schools/curriculum

To support the evaluation of the project, we ask that you or your colleagues use a minimum of two to four lesson with your students. Thank you!

The lessons are structured as follows:

Unit 1 - Orbits
- Lesson 1: Orbit Tracks
- Lesson 2: Orbit Calculations

Unit 2 – ISS Passes
- Lesson 1: Active Passes of the ISS

Unit 3: - Scale of the Universe
- Lesson 1: Scale of the Earth, Moon and the ISS Orbit – Modelling
- Lesson 2: The Scale of the Solar System

Unit 4: - Changing Locations
- Lesson 1: Changing Location of Your ISS-ABOVE

Unit 5: - Scratch Coding
- Lesson 1: Scratch Coding to Calculate the Distance of the ISS from You

Unit 6: - Surviving in Space
- Lesson 1: Set a Table for the ISS Crew
- Lesson 2: Food, Exercise and Sleep on the ISS
- Lesson 3: Who's Onboard – ISS Astronauts, Current and Past

NOTE: In the Additional Resources section is a Space Lotería/Bingo game designed by NASA HDEV team for this age group. It can be downloaded and requires color printing.

ISS orbit projected onto a map

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	To understand orbital motions of satellites using the International Space Station.
Materials:	• ISS Above (set-up and ready to go) • Sharpies, black and red • Sticky tape • Scissors • 10 oranges, elastic bands, knife and kitchen roll/hand wipes (messy)! OR • Aluminum soft drink cans with scaled world map printout OR • World map (provided for printing out)
NGSS Essential Standards and Clarifying Objectives:	**NGSS Essential Standards and Clarifying Objectives:** *MS-ESS1-2:* Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. **Science and Engineering Practices:** • Developing and Using Models Modeling in G6–8 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	Worksheets for Option A and Options C. Option B available online.

ENGAGEMENT

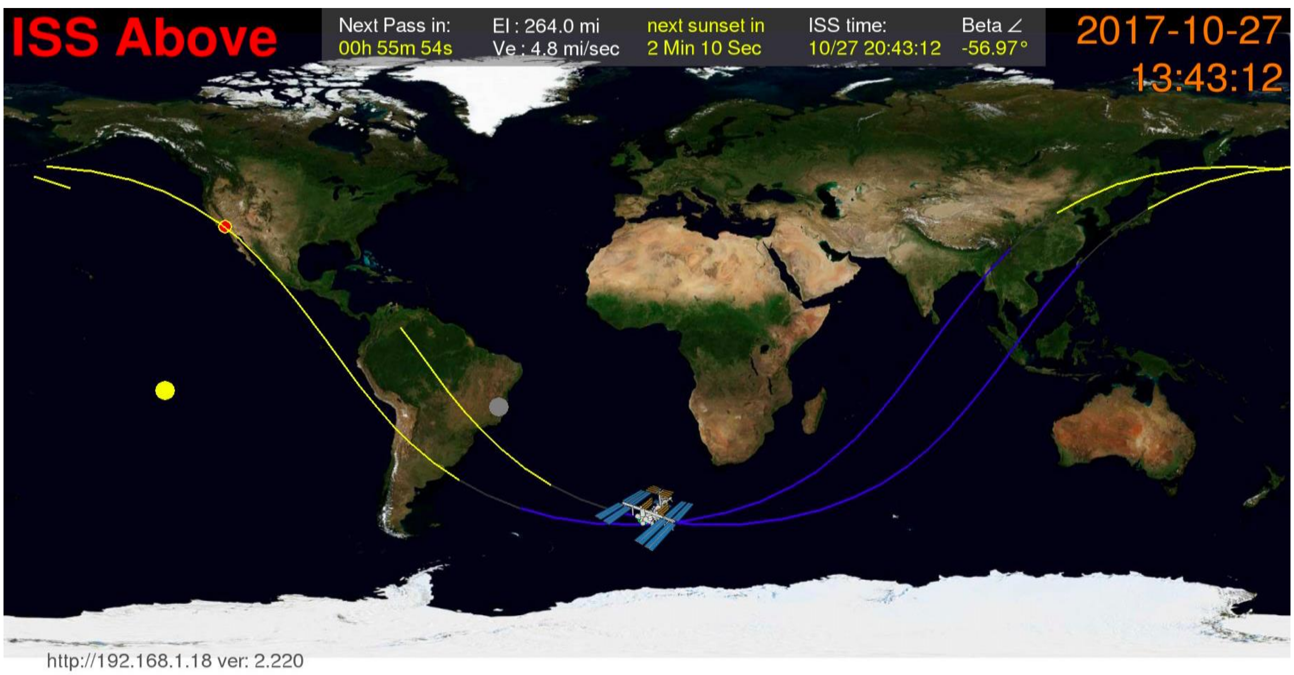
To engage students in this lesson, first make sure that the ISS Above is properly installed and ready-to-go in the classroom.

Have students look at the world map/orbital screen from the ISS Above (see screenshot below). Note: pressing "3" on your remote will set the screen to display this.

Questions

1. What do students notice?
2. What patterns do students observe in the movement of the ISS around the planet Earth?
3. Do they notice the ISS icon moving?
4. How would students describe the shape of the orbit path taken by the ISS? Is this how the ISS moves around the Earth?

ISS-ABOVE orbit on a Mercator Map



EXPLORATION

The ISS Orbit on a Mercator Map

Have students do one of the following exercises (see Student Worksheet) to get acquainted with the orbital path the ISS follows around Earth and how it is illustrated on a Mercator map. Students will draw a circle around a spherical object (e.g. an orange) or a cylindrical map (such as a map wrapped round a can) or plot the ISS wave track as shown on the ISS-ABOVE.

1. Option A: Use an orange to draw a circular orbit, then peel the fruit to create a Mercator Map (see example below). Team of 3-4 recommended. They can each eat part of the orange.

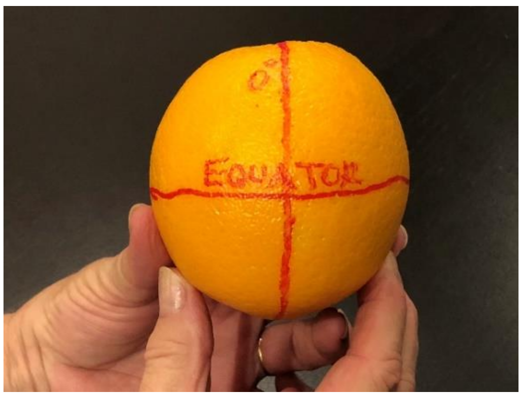


Fig 1 – Orange with Equator and GMT / 180° circle

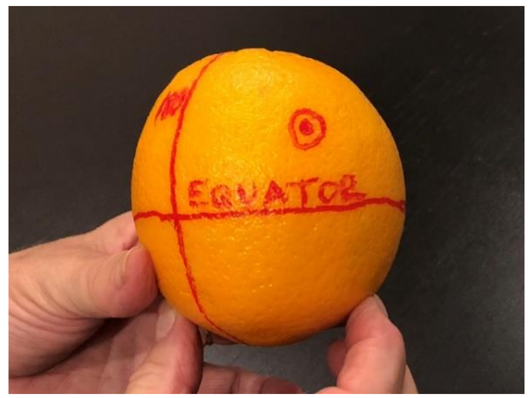


Fig 2 – Orange with Equator and my location dot

Fig 3 – Orange with black circle (ISS orbit)

Fig 4 – Orange Mercator map showing wave orbit

2. Option B: Take a Mercator Map (basically a flattened map) of the Earth and create a print-out of it to wrap around a can (see links provided courtesy of Sally Ride EarthKAM).

3. Option C: Use the full-page printout of the world map to draw the orbit as shown on the ISS-ABOVE world map/orbit screen, then rolled into a cylinder (see Supporting Materials for the map).

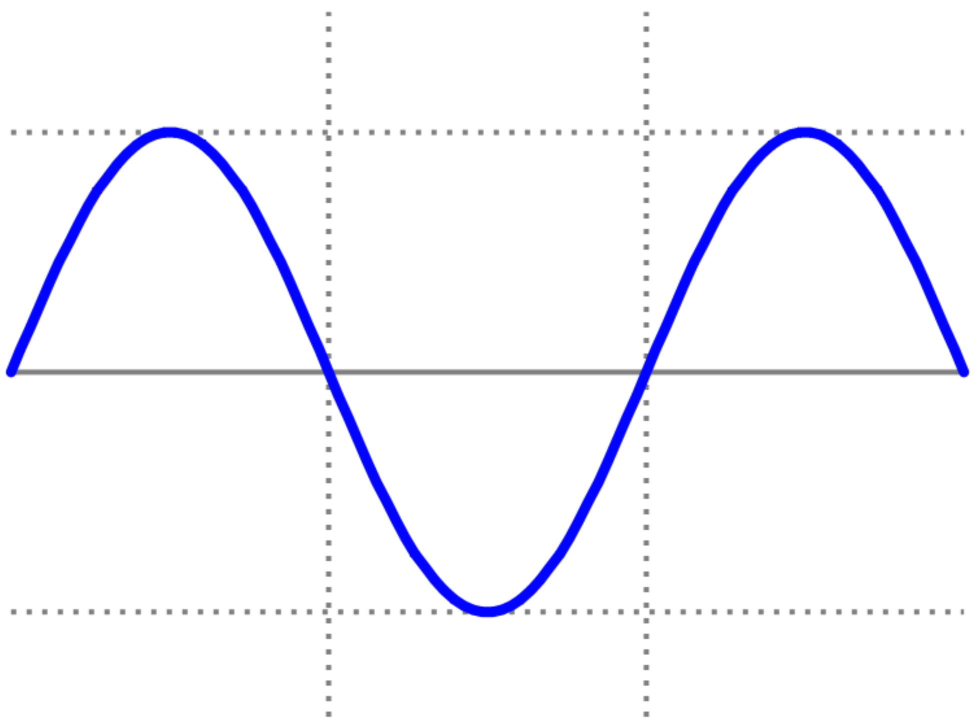
EXPLANATION

Explain to students that the reason why the ISS orbit looks like a *wave* is because an orbit is three-dimensional and moves around the Earth or any spherical object in a **circular** orbit, but when it's projected onto a two-dimensional (Mercator) map of the world, it flattens and looks like a sinusoidal wave.

OPTIONAL: Use the video https://www.youtube.com/watch?v=8-mKLs2b3MM to show that the ISS orbit really is a circle. Note: each orbit takes around 92 minutes, approx. 16 orbits per 24 hours.

OPTIONAL: Show this very short 8 second (blink and you'll miss it) video which animates a circular orbit into a Mercator map. https://www.youtube.com/watch?v=lTlLmcrrU0A

The ISS orbit projected onto a Mercator map can be predicted in mathematics using a *sinusoidal* wave described by the function sin(x). A sinusoidal wave looks like this:



What other situations show up as a sine wave or an approximation to one? (Ripples on a pond, tuning forks, AC electricity.)

EVALUATION

Choose from 2 videos:

1. A full explanation of how the 3D Earth and ISS orbit maps to a 2D Mercator map. Potential use for students who need additional support in understanding the 3D to 2D problem or as a wrap up. NOTE: The green circle around the ISS is the area of the Earth that the astronauts can see from ~250 miles up.

   https://www.youtube.com/watch?v=JyfEffMrglI Video 5:30min

OR

2. Astronaut Don Pettit from Expedition 30 describes the orbital trajectory around Earth and how that projects onto a map. Play time 6 minutes.

   https://www.youtube.com/watch?v=hO9-WqSK5HM Video 6 min

Questions

1. Why does the ISS-ABOVE screen show a sine-wave orbit even though the real orbit is circular?
2. How would you demonstrate that the orbit is circular using a 2D map of the world?

Student Worksheets

OPTION A: Oranges worksheet – see attached

OPTION B: Aluminum can map/exercise

Use the Teacher document below (courtesy of Sally Ride EarthKAM for a printout of a map that fits a soft drink can.

https://www.earthkam.org/dls/8_EarthKAM%20activities/EK_GroundTracks_**Teacher**.pdf

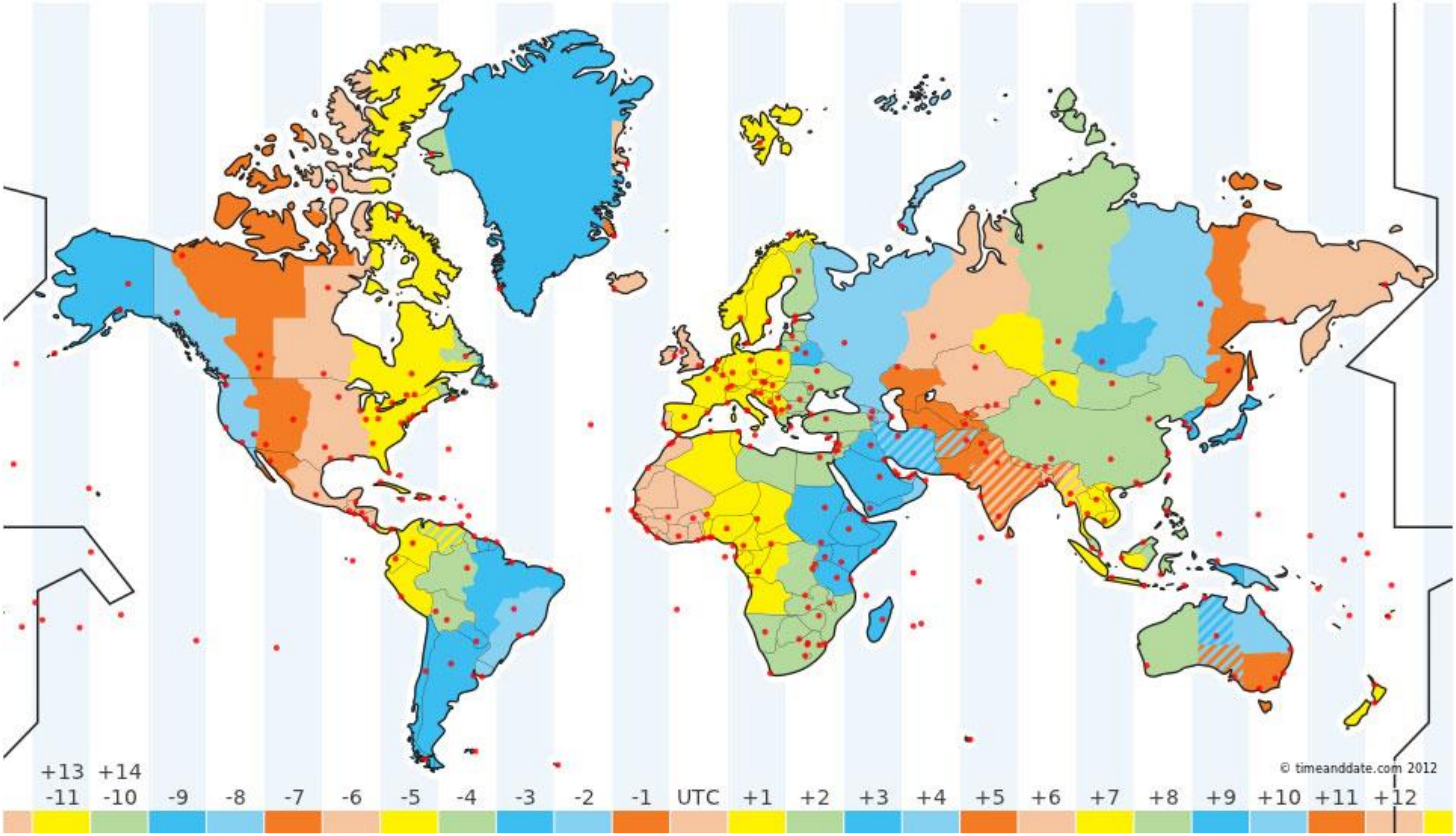
Student work sheet is below:

https://www.earthkam.org/dls/8_EarthKAM%20activities/EK_GroundTracks_**Student.**pdf

OPTION C: World map for 8.5"x11" paper (see next page)

The world map (courtesy of timeanddate.com) prints well in grayscale using black ink only. FYI, the dots are major cities and the colors indicate that the time zones are distorted for practical purposes. Unit 4 does more work on time zones.

Additional materials: A sheet on latitude/longitude is provided in the Additional Resources section.



By kind permission of timeanddate.com

Student Worksheet – OPTION A: The Orange Mercator Map

This experiment allows your team of 3-4 to convert a spherical orange with a circular orbit into a Mercator map with a sine-wave orbit. Each team member does one step.

STEP 1: Take an elastic band and put it around the 'waist' of your orange. Using a red Sharpie, draw an equator around your orange using the elastic band as a guide. Now move the elastic band and put it around the 'poles' of your orange. Draw a circle at 90^{o} to your equator. This is your GMT line (0^{o} longitude on one side and 180^{o} longitude on the other side). See Figure 1 below.

STEP 2: Using a red Sharpie again, mark the position of your school relative to the equator and the GMT circle. See Figure 2 - the example is Los Angeles, CA.

STEP 3: Take your elastic band and place it around the orange to represent the orbit of the ISS (you can use the ISS-ABOVE world map/orbit screen to see where the current orbit is). Using a black Sharpie, draw a circle to show the position of the orbit. See Figure 3.

STEP 4: Ask your teacher to cut your orange into four (from the north pole to the south, then each half from the pole to pole again. You will have four quarters as in Figure 4. Without touching the lines you've drawn, each student eats away the orange flesh, leaving the skin intact. Lay the four pieces together and you should see the sine-wave shape of the orbit on your orange Mercator map!

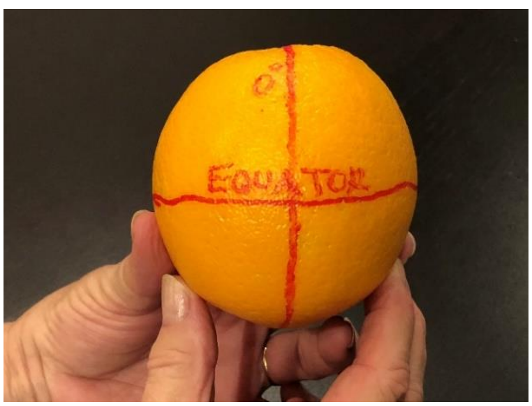


Fig 1 – Orange with Equator and GMT / 180º circle

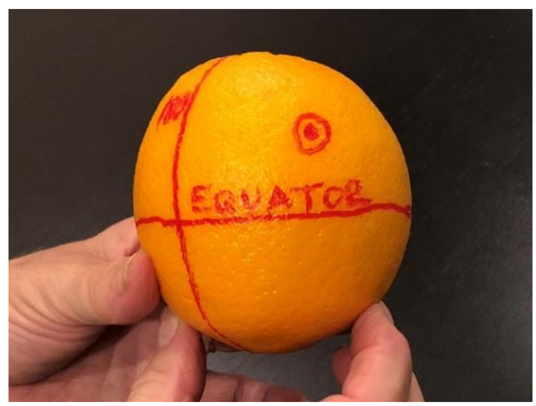


Fig 2 – Orange with Equator and my location dot

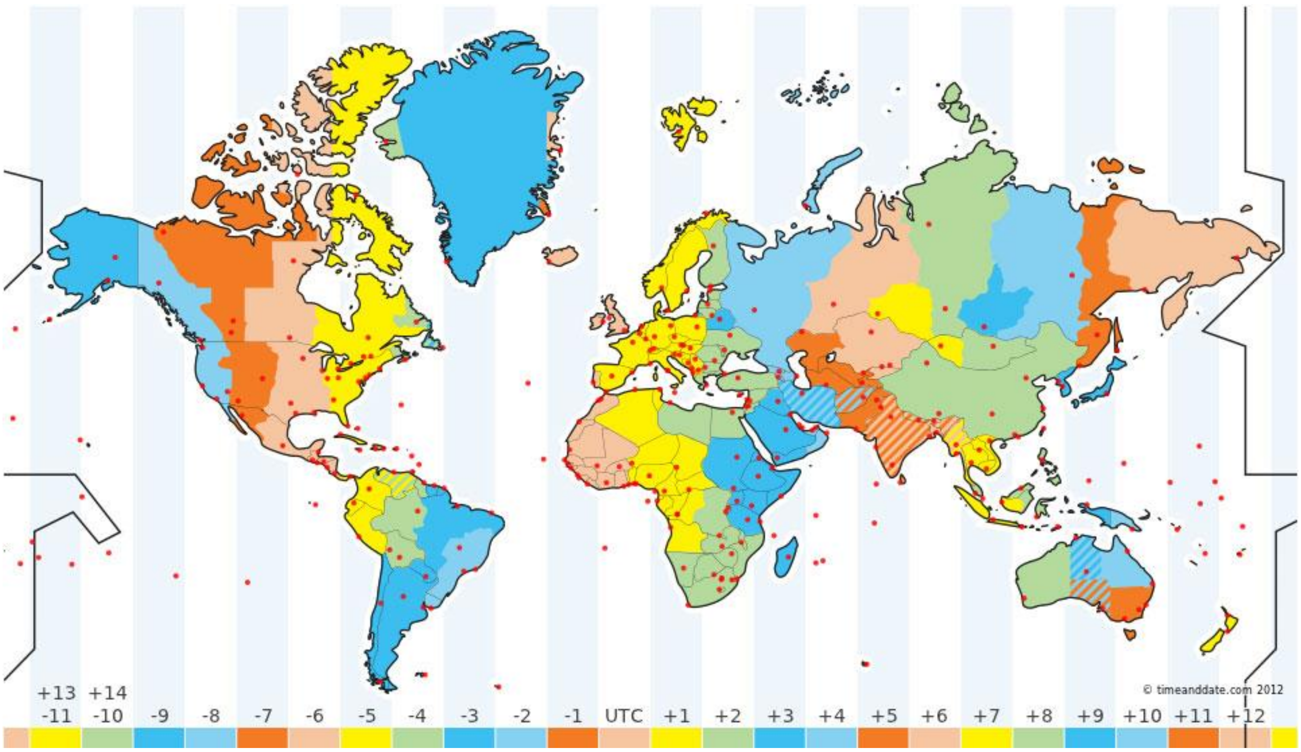
Fig 3 – Orange with black circle (ISS orbit)

Fig 4 – Orange Mercator map showing wave orbit

Student Worksheet – OPTION C: The World Map Orbit

This experiment allows your team of 3-4 to plot the ISS orbital path shown on the world map/orbit screen of the ISS-ABOVE onto a world map and then roll the map up to show that the orbit is a circle.

Your teacher will give you a copy of a map that looks like the one below:



Students do one step each:

STEP 1: Mark the position of your school on the map with a red Sharpie.

STEP 2: Copy the orbit path from the ISS-ABOVE screen onto your world map using a black Sharpie.

STEP 3: Cut along the black line on the right-hand side of your map.

STEP 4: Roll your map into a cylinder shape and match the shaped right-hand edge to fit the black lines on the left-hand side.

Look at the shape of the orbital path on the rolled-up map. It should be a circle.

The speed and orbit time of a satellite, ISS style!

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	To understand orbital motions of satellites using the International Space Station.
Materials:	• Scientific calculator
NGSS Essential Standards and Clarifying Objectives:	**NGSS Essential Standards and Clarifying Objectives:** *MS-ESS1-2:* Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. **Science and Engineering Practices:** ● Developing and Using Models Modeling in G6–8 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 for the speed of a satellite. Advanced exercise for the period of the ISS.
Skills Needed	Students need to be able to use a Scientific Calculator using exponential values, Pi and square root functions.

ENGAGEMENT:

What affects the speed of a satellite?

NOTE: While the equation below has to do with the *velocity* of an object in orbit (like the ISS), velocity has to do with both the *speed* and the *direction* of an object (making it a *vector quantity,* namely one that has quantity AND direction). For the purposes of these calculations, we will only focus on one of these, the **speed** of the satellite.

The equation shows the speed (V) of a satellite, based on 3 numbers:

The Gravitational Constant

The Mass of the Earth

$$V_{orbit} = \sqrt{\frac{GM}{R}}$$

The distance of the satellite above the center of the Earth

Questions

1. What factor determines the speed of a satellite like the ISS?

   The ISS orbit speed is dependent on how far the ISS is from the Earth. The Gravitational Constant and the Mass of the Earth are both constants, so only R, the distance of the satellite above the center of the Earth, affects the speed of a satellite.

2. If the ISS was further away from the Earth, would its velocity be higher or lower?
   It would be lower. If R increases, V decreases.

EXPLORATION

Hand out the Worksheet exercise for the speed of a satellite.

How fast is the ISS travelling? The equation for the speed of a satellite.

1. To calculate the speed (velocity) of the ISS orbiting around the Earth, we need to treat it like a satellite.
2. The formula is:

   Square root of ((Gravitational constant x Mass of Earth) ÷ Radius of the ISS from the center of the Earth).
   Units must be in metric, specifically in meter, kilogram, second.

$$V_{orbit} = \sqrt{\frac{GM}{R}}$$

V = Velocity (Speed) of the ISS in meters per second
G = Gravitational Constant: 6.67×10^{-11} m^3 kg^{-1} s^{-2}
M = Mass of the Earth (M): 5.97×10^{24} kg

R = Radius of the Earth in meters + Orbit Height of the satellite in meters.
Radius of the Earth is 6.37×10^6 m. The Orbit Height of the ISS is 254 miles.

The results from the calculations will vary slightly, dependent on how numbers are rounded.

Task 1: Convert to metric units

(a) Convert the ISS Orbit Height of 254 miles into meters. (Multiply miles by 1609).

(b) How should you express the Orbit Height to match the units for the radius of the Earth? (Hint: how would you show the Orbit Height as a decimal which when multiplied by 10^6 equals the number you got for the Orbit Height in part (a).
Ans: 408686 meters or 0.409×10^6

Task 2: Calculate the velocity of the ISS

(a) Add the Orbit Height to the Radius of the Earth.
Ans: 6,779,000 or 6.78×10^6 meters

(b) Calculate the speed/velocity of the ISS using a scientific calculator.
Ans: 7,663 m/s

(c) What is the speed of the ISS in miles per second? In miles per hour?
Ans: 4.76 miles per second. Approx. 17,145 miles per hour.

EXPLANATION

- Orbits:
  - ✓ Circular vs. Elliptical orbits: The ISS moves in an approximately circular orbital path (relative to other satellites/ planets), whereas the planets (including Earth) move in elliptical orbits around the sun.
  - ✓ Note that the mass of the ISS does not matter in these calculations.
- Satellite orbits can degrade. The ISS is at an altitude where there are some air molecules which 'drag' the ISS closer to the Earth. To solve this, the ISS Above has rockets which give it a little "kick" and serve to boost it back up to the correct distance from the Earth.

EVALUATION

Students can calculate the speed of a satellite at various heights from the Earth's surface. Have students check each other's work to make sure they all understand how they can calculate the speed of an object in orbit.

Calculate orbital speed of satellites at different heights above the Earth

Have students copy the table below:

Height	Height in meters (calculate this)	Speed in meters/second (calculate this)	Speed in miles/second (calculate this)
254 miles (ISS)	Already calculated	Already calculated	Already calculated
50 miles*			
20000 miles**			

*The speed should be faster than the ISS

**The speed should be slower than the ISS. This is the approximate height of geostationary satellites (such as communications and sat-nav satellites).

EXTENSION MATERIAL for Mathematically Adept Students

Have students calculate the orbit time of a satellite (see Student Worksheet for Lesson 2).

How long does it take for the ISS to complete an orbit of the Earth?

The Equation for orbit time of a satellite is significantly more complex to calculate.

The formula is:
Square root of ((4 x π^2) X (Radius of the ISS orbit)^3) ÷ (Gravitational Constant x Mass of the Earth)).
Units must be metric, specifically in meter, kilogram, second.

$$T = \sqrt{\frac{4\pi^2 R^3}{GM}}$$

Task 1: Calculate the orbit time for the ISS

From the prior exercise, students can use the values they already have to calculate the period of the orbit. Note that this is approximate as the orbit is not completely circular, but slightly elliptical.

In what units is the answer? It's in seconds.

Ans: Approx. 5,558 seconds

Task 2: What is the orbit time in minutes

Divide the orbit time in seconds by 60.

Ans: Approx. 92 minutes.

CONCLUSION: The ISS travels at 5 miles per second and orbits the Earth in 92 minutes.

Student Worksheet 1 – The speed of the ISS

Space Station Speed

How fast is the ISS travelling? The equation for the speed of an orbiting body.

The ISS is just a very large satellite and satellites behave like any other orbiting body (for example, the Earth around the Sun).

The formula is:

Velocity (speed) = Square root of ((Gravitational constant x Mass of Earth) ÷ Radius of the ISS from the center of the Earth).
Units must be in metric, specifically in meter, kilogram, second.

$$V_{orbit} = \sqrt{\frac{GM}{R}}$$

V = Velocity (Speed) of the ISS

G = Gravitational Constant: 6.67×10^{-11} m^3 kg^{-1} s^{-2}

M = Mass of the Earth (M): 5.97×10^{24} kg

R = Radius of the Earth in meters + Orbit Height of the ISS in meters.
Radius of the Earth is 6.37×10^6 m. The Orbit Height of the ISS is 254 miles.

Task 1: Convert to metric units

(a) Convert the ISS Orbit Height of 254 miles into meters. (Multiply miles by 1609.)

(b) Use the answer from (a) above and express it in the form of 0.nnn x 10^6. You are doing this to make is easier to add the Orbital Height of the ISS to the Radius of the Earth to get the value for R that you need for the equation.

Task 2: Calculate the velocity of the ISS

(d) Add the Orbit Height to the Radius of the Earth.

(e) Calculate the speed/velocity of the ISS using a scientific calculator. What units is this result in?

(f) What is the speed of the ISS in miles per second? In miles per hour?

Check your answers with your teacher.

Student Worksheet 2 – The orbit period of the ISS

How long does it take for the ISS to complete an orbit of the Earth?

The Equation for orbit time of a satellite is significantly more complex to calculate.

The formula is:

T (the orbit period) = Square root of ((4 x π^2) X (Radius of the ISS)^3) ÷ (Gravitational Constant x Mass of the Earth)).

Units must be metric, specifically in meter, kilogram, second.

$$T = \sqrt{\frac{4\pi^2 R^3}{GM}}$$

Task 1: Calculate the orbit time for the ISS

From the prior exercise, use the values you already have (R, G and M) to calculate the period of the orbit. Note that this is approximate as the orbit is not completely circular, but slightly elliptical.

What is the orbit time of the ISS?

In what units is the answer?

Task 2: What is the orbit time in minutes

Divide your answer to part (a) by 60.

Check your answers with your teacher.

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:**
	<u>*MS-ESS1-3:*</u> 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:
	• <u>*ESS1.A:*</u> 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.
	• <u>*ESS1.B:*</u> 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.

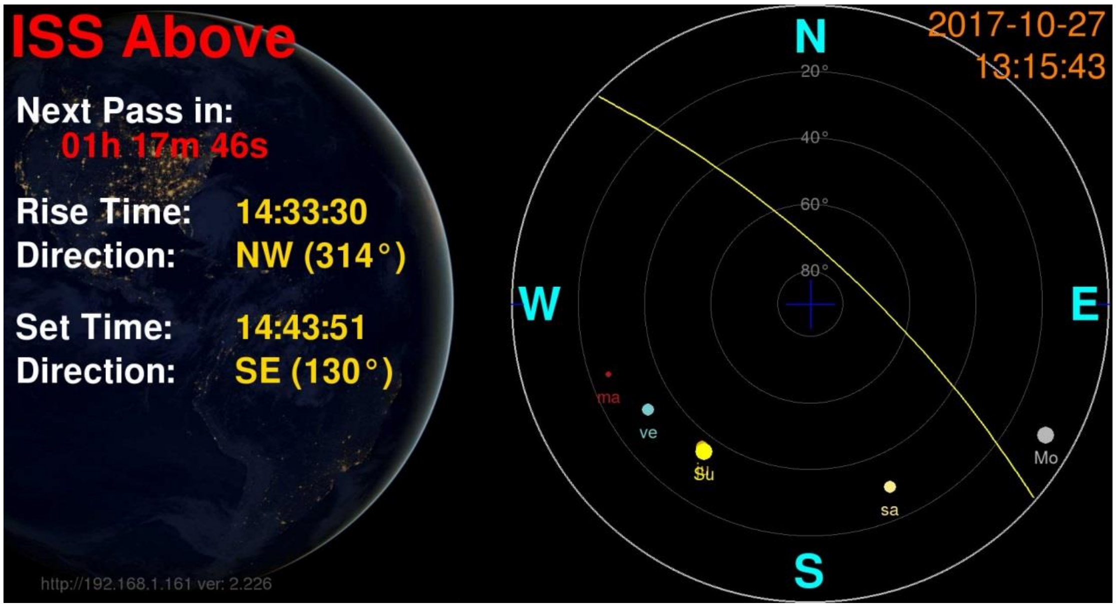
Differentiation strategies to meet diverse learner needs:	• <u>Think-pair-share</u>, for students that learn best when engaging with classmates. • <u>Multisensory learning</u>, to accommodate students that are auditory learners and visual learners, as well as encourage students to engage their senses in the learning process. • <u>Awareness of social and cultural backgrounds</u> 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):



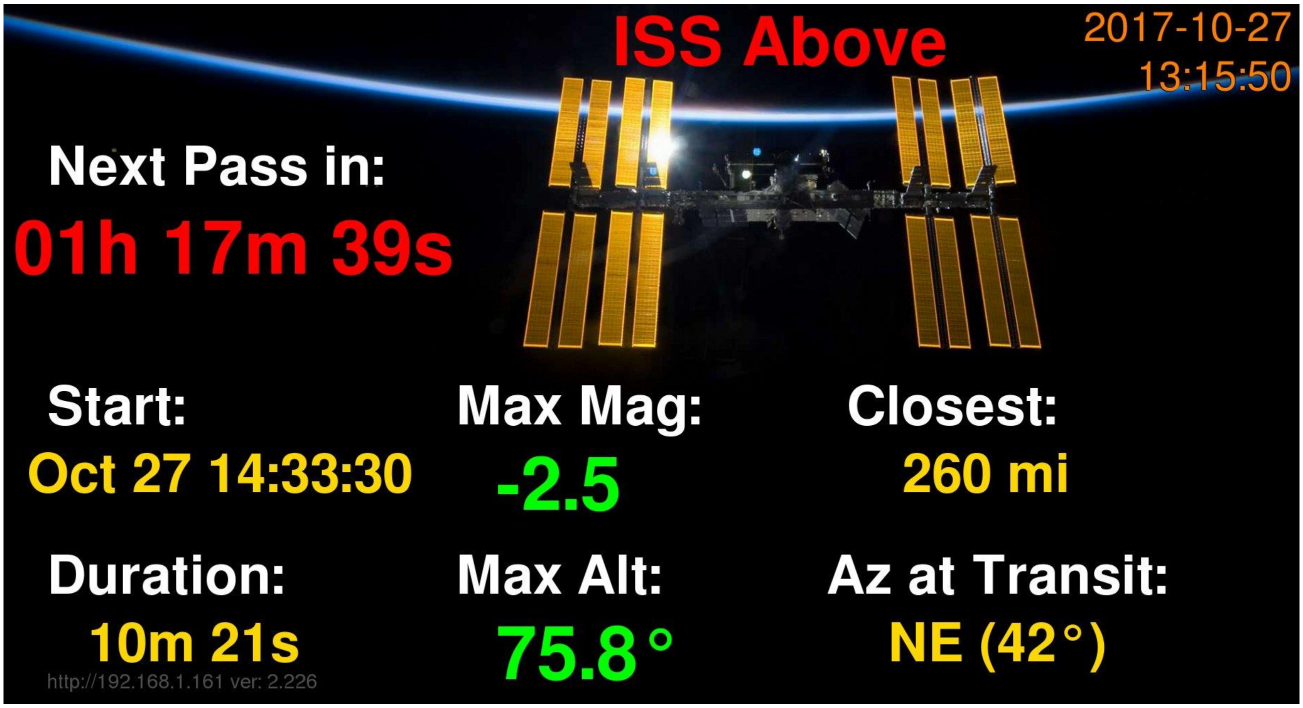
Have the students picture that they are standing at the center of the circle on the right. Answers to the questions below are in italics based on the screenshot above. The live screens displayed on your ISS-Above when you run this lesson will be different.

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 314º and SE 130º. 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):



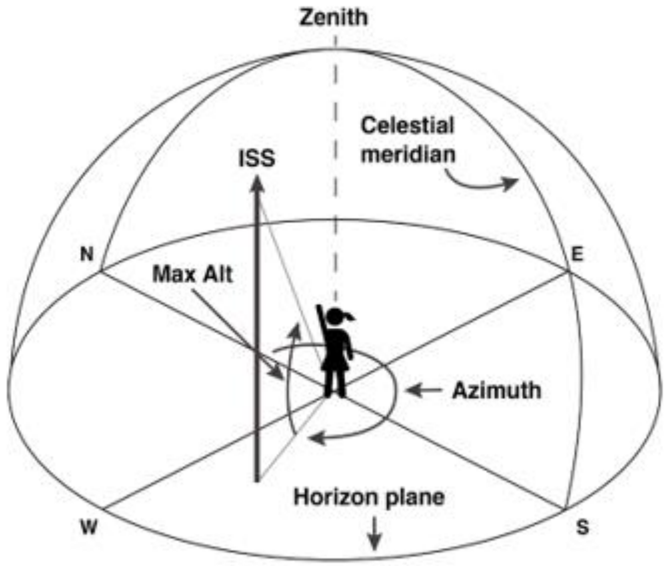
On this screen they can check if their calculation of how long the ISS will be above the horizon is correct (**Duration**).

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 75.8º (in the above case, almost overhead).*
4. At what compass position will it be at its closest? At an Azimuth of 42º, 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).

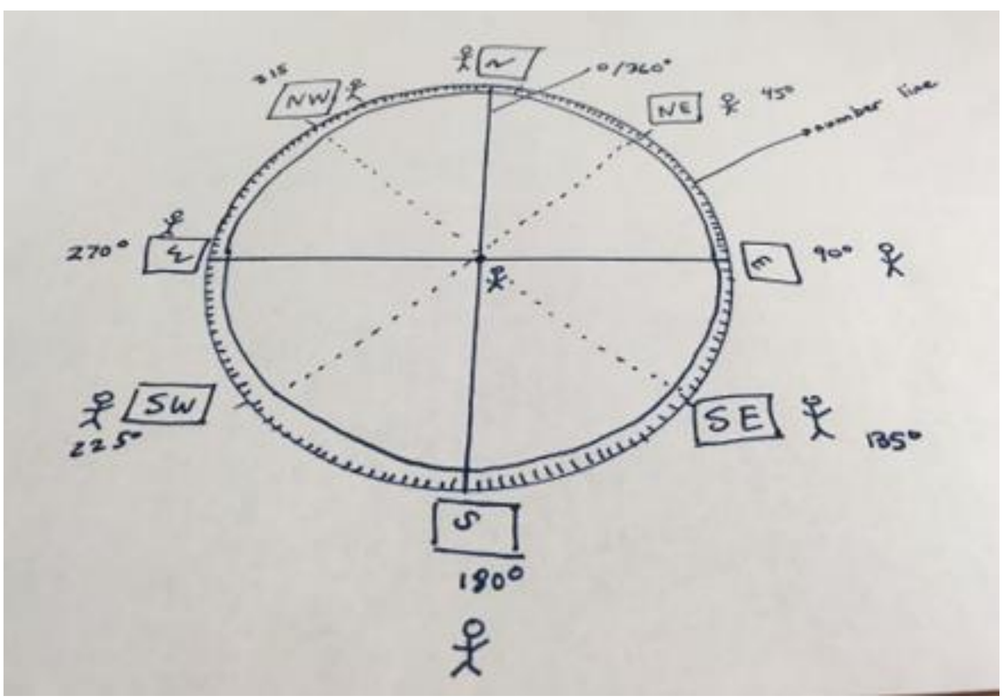
From the **Next Pass In** screen, students should note the **Duration**, **Az at Transit** and the **Max Alt** on their worksheet. The ISS-Above displays some pretty low passes of the ISS over your school… some where the ISS may only barely rise above your horizon. That is completely normal.

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, 0° to 45° 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)

7″	7″	7″	7″	3.5″	

0° 10° 20° 30° 40° 45°

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

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

3.5″	7″	7″	7″	7″	

50° 60° 70° 80° 90°

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.		
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
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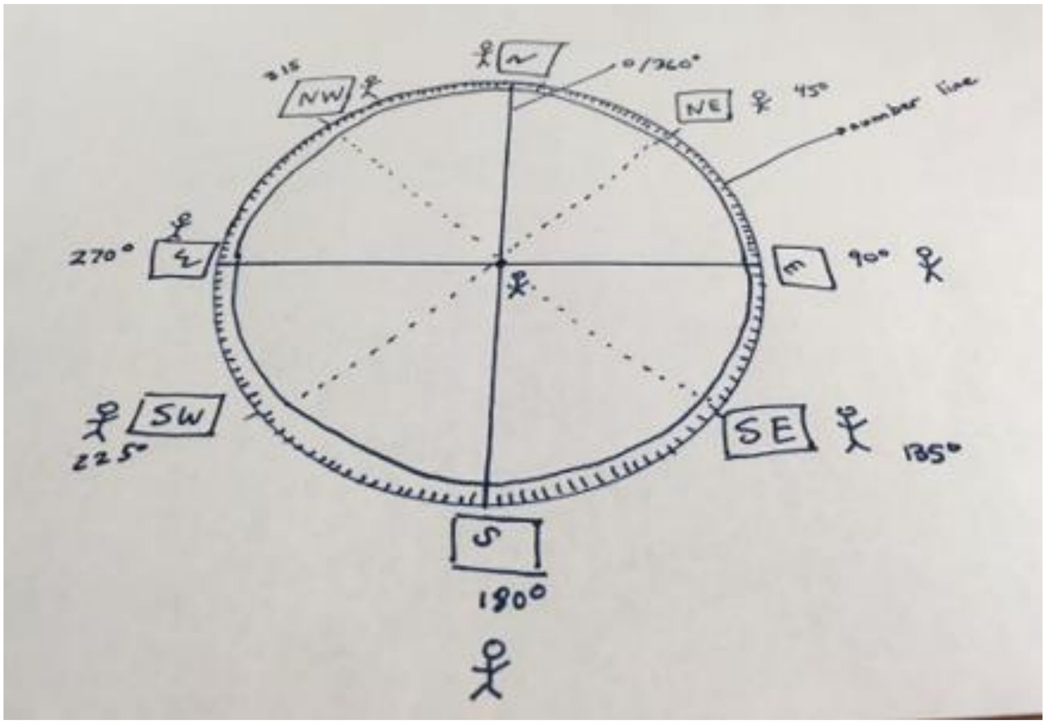
Oct 26	---	05:10:46 PM	WSW	05:12:14 PM	1°	05:13:42 PM	SW	1421 mi	daylight

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, 0° to 45° 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″	

0° 10° 20° 30° 40° 45°

The segment for NE to E, 45^{o} to 90^{o} 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)

3.5″	7″	7″	7″	7″	

50^{o} 60^{o} 70^{o} 80^{o} 90^{o}

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.

Orbiting Bodies

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	To create a not-to-scale model of the Earth, Moon, Sun and ISS illustrating the orbital relationships between multiple bodies. They will also learn about the practical limitations of scaled models.
Materials:	• Two-dimensional orbit handout • Scissors • Fasteners • Scientific calculators • Scratch paper
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	Handout for creating the orbital model including instructions on how to use it. RECOMMEND THIS IS SCALED ONTO LARGER PAPER WHEN PRINTING FOR THOSE STUDENTS TO HAVE MOTOR CHALLENGES.
Skills Needed	Students need to be able to scale values to fit a given space.

ENGAGEMENT

Orbits of the Earth, Moon and the ISS

The students will create a not-to-scale model of the systems.

Questions

1. If you think about the Sun, Earth, the Moon and the ISS, which bodies orbit around which? Draw a quick sketch on your scratch paper.
2. If you wanted to model the Sun, Earth, Moon and the ISS, what would you need to know? What measurements would you need?

EXPLORATION

Students will color and cut out representations of the bodies and attach them with fasteners to create a working model.

Students will explore the relative orbits of the bodies:

1. How many times will the ISS orbit the Earth in a day?
2. The Moon orbits the Earth in 27 days. How many times will the ISS orbit the Earth in the same time?
3. The Earth orbits the Sun every 365 days. How many times will the Moon orbit the Earth in that time? How many times will the ISS orbit the Earth in that time?

EVALUATION

Students should imagine they've been tasked to create a scale model of the Earth with the Moon and the ISS orbiting around the Earth for their local Science Center.

What type of a model would students create? What scale would they choose to make it a reasonable size? Give the students the following data:

Diameter of the Earth: 7,926 miles

Distance to the Moon: 250,000 miles

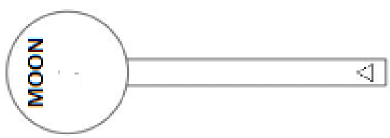
Diameter of the Moon: 2,159 miles

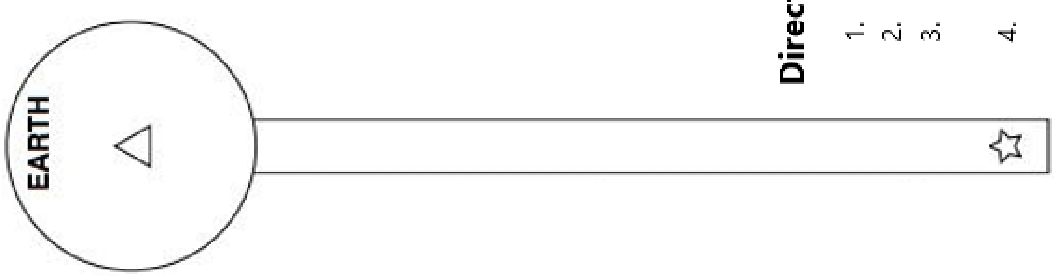
Distance to the ISS: 254 miles

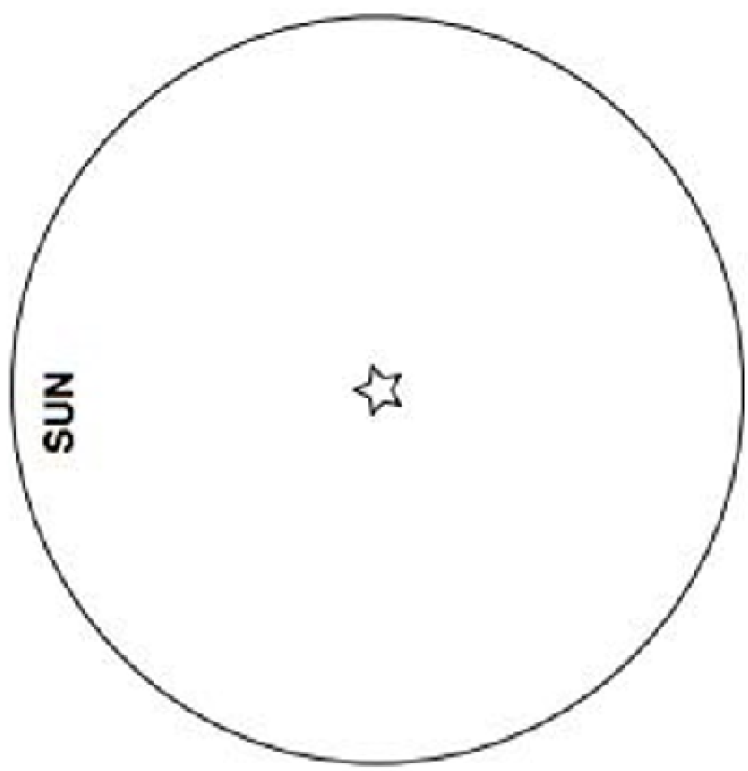
Size of the ISS: 356 ft. by 240 ft.

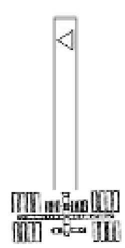
Students can sketch a blueprint for their model showing the dimensions for the actual model. The scale on the paper relative to the version in the Science Center should also be shown.

Student Worksheet 1







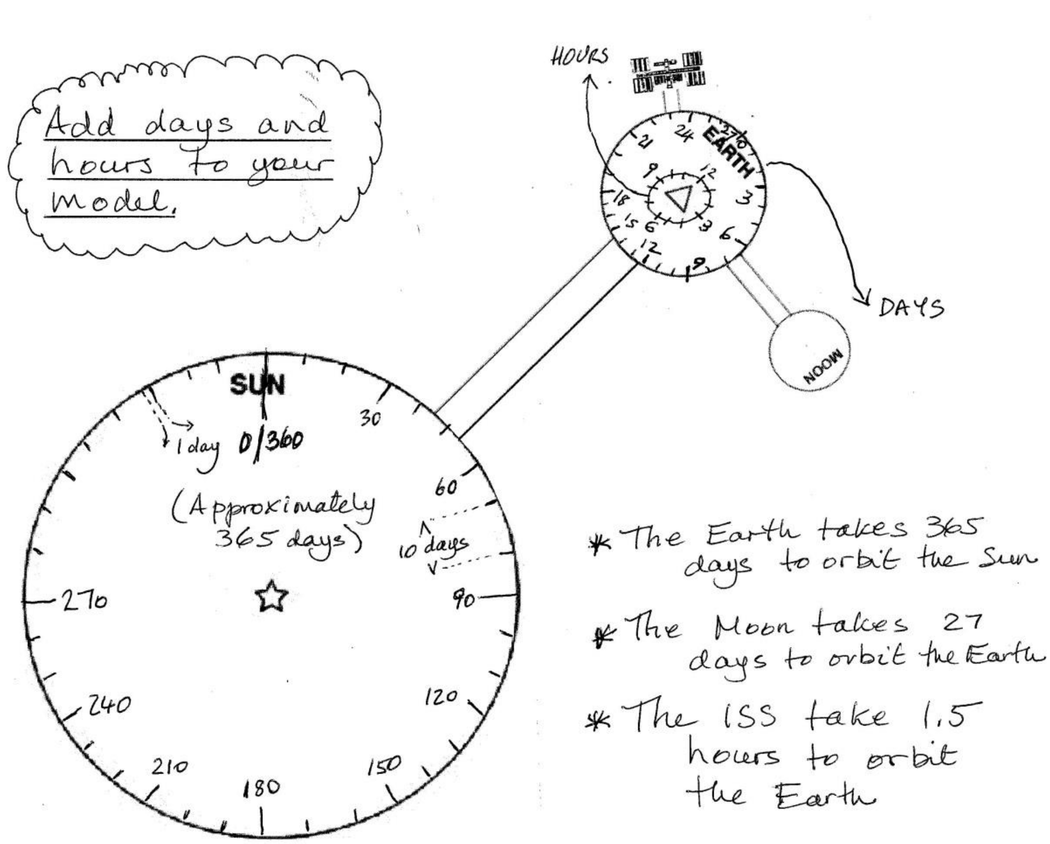


Directions:

1. Color the Sun, Earth, Moon and ISS
2. Cut out the objects
3. Connect the Earth to the Sun using a fastener on the star shapes
4. Connect the Moon and the ISS to the Earth using a fastener on the triangle shapes

Student Worksheet 2

Your completed model will look like the diagram below. Now add days and hours to your model as shown:



1. Now use your model to orbit the ISS around the Earth 16 times (1 day). The Moon will from one day's mark to the next for every 16 rotations of the ISS.
2. Meanwhile the Earth will move 1/10th of the way between one 10-day make and the next on the Sun.

Repeat the two steps above once or twice more to get an idea of the relative rotations of each of the bodies.

Orbital Scale of the Solar System

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	To understand the scale of the solar system and the relative scale of the planets.
Materials:	• Scissors, Fasteners • Scientific calculators • Scratch paper • Strips of card 11” x 2”. Three strips per team. • Objects to represent the planets ✓ Fruits and Vegetables, Tennis Balls, Beads, Marbles, Buttons, Pink Erasers, Jenga / other building blocks OR ✓ Compasses and coloring pencils
NGSS Essential Standards and Clarifying Objectives:	<u>*MS-ESS1-3:*</u> 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:	• <u>Think-pair-share</u>, for students that learn best when engaging with classmates. • <u>Multisensory learning</u>, to accommodate students that are auditory learners and visual learners, as well as encourage students to engage their senses in the learning process. • <u>Awareness of social and cultural backgrounds</u> of students to reinforce the real-life application of what they are learning.
Student Worksheet	Worksheet 1 with planetary data for completion. Worksheet 2 with the scale of the planets for completion
Skills Needed	Students need to be able to use a Scientific Calculator using basic mathematical functions.

ENGAGEMENT

Scale of the Solar System

Hand out Student Worksheet 1.

Review the table below with students.

Planet (or Dwarf Planet)	Distance from the Sun	Distance from the Sun	Period of Revolution Around the Sun	Period of Rotation	Mass	Diameter	**Ratio of Diameters	Temperature	Number of Moons
	*Astronomical Units	Miles	(1 planetary year)	(1 planetary day)	Kilograms	Miles	D of planet/ D of Earth	Degress Kelvin	
SUN	**0**	**0**	**N/A**	**27 Earth days*** **	**1.99×10^{30}**	**864,575 miles**	**100**	**5,778 K at the surface**	
Mercury	0.390 AU	36 million miles	87.96 Earth days	58.7 Earth days	3.3×10^{23}	3,031 miles		100-700 K	0
Venus	0.723 AU	67.2 million miles	224.68 Earth days	243 Earth days	4.87×10^{24}	7,521 miles		726 K	0
Earth	1 AU	93 million miles	365.26 days	24 hours	5.98×10^{24}	7,926 miles	1	260-310 K	1
Mars	1.524 AU	141.6 million miles	686.98 Earth days	24.6 Earth hours	6.42×10^{23}	4,222 miles		150-310 K	2
Jupiter	5.203 AU	483.6 million miles	11.862 Earth years	9.84 Earth hours	1.90×10^{27}	88,729 miles		120 K	67 (18 named)
Saturn	9.539 AU	886.7 million miles	29.456 Earth years	10.2 Earth hours	5.69×10^{26}	74,600 miles		88 K	62 (30 unnamed)
Uranus	19.18 AU	1,784.0 million miles	84.07 Earth years	17.9 Earth hours	8.68×10^{25}	32,600 miles		59 K	27 (6 unnamed)
Neptune	30.06 AU	2,794.4 million miles	164.81 Earth years	19.1 Earth hours	1.02×10^{26}	30,200 miles		48 K	13
Pluto (a dwarf planet)	39.53 AU	3,674.5 million miles	247.7 years	6.39 Earth days	1.29×10^{22}	1,413 miles		37 K	4

*1 AU (Astronomical Unit) is the ditance between the Earth and the Sun. 1AU equals 93 Million Miles

** Calculate and round to 1 significant figure

***The sun rotates faster at the equator than at the poles. 27 Days is the equatorial rotation

Questions

1. What is an astronomical unit? Why do you think astronomers use a unit like this?
2. What do students notice about the distances from the Sun and how the planets are spaced out?
3. What do they notice about the orbit time (one revolution around the Sun)?
4. What about the length of day? What would it be like to live on a planet like Venus or Saturn? When we get to Mars, what will that be like?
5. What about Mars would be familiar and what would be different?

NOTE: NASA has a good factsheet about Mars with some useful animations at:

https://mars.nasa.gov/allaboutmars/facts/#?c=inspace&s=distance

EXPLORATION

As an introductory activity, have students create a two-dimensional model including the Sun, Earth, Moon and the Planets in our Solar System. **Recommended**: Teams of 3.

Task 1:

Have students complete the table column for Ratio of Diameters (the 8th column in the table that's mostly blank). They'll divide each planet's diameter by the Earth's diameter.

Task 2:

Scale of the Solar System

Have the students represent the distances of the planets to the Sun to scale:

1. Calculate the scale needed to represent the Sun to Uranus along 3 connected strips of paper.
2. Draw the scale along the 3 strips but do not connect them yet.
3. Each student takes 1/3 of the distance from the Sun to Uranus.
4. Use AUs for the scale of the Solar System, just over 30 AU. Each student should plot a line with 0-9, 10-19, 20-30 AUs. When joined, they will represent the scale of the Solar System. How many million miles does each inch on your scale represent? (If they've maximized the scale to the total length of the strips it will be 1 inch : 93 million miles).
5. Mark the center of each planet on the line at the right AU distance from the Sun and write its name above. Tape the three pieces together to form a continuous scale.
6. Students will notice that all but two of the planets are crowded into the first 10AU from the Sun.
7. Can students draw the size of planets on the same scale? No. The planets would be a pinpoint on the scale of the Solar System. Students should observe that even the solar system, with so many planets and moons and even asteroids, is mostly empty space. They can, however, sketch an image of the planet and color it in if they choose.

TASK 3:

Scale of the Planets (either with objects or on paper as described below)

Have the students represent the scale of the planets to each other to scale:

1. Tape together two 8.5"x11" pieces of paper along the long edge.
2. Using the planetary size ratios for the size of the planets (don't include the Sun), draw a circle for the largest planet (Jupiter). They should choose a scale of 1 Inch = Earth's diameter, creating an 11" diameter circle for Jupiter.
3. Draw each planet in turn using the same center and starting with the next largest (Saturn) and so on to the smallest.

EVALUATION:

Hand out Student Worksheet 2.

Students will notice from task 3 above that the mass and diameter of the four (outer) large planets massively dominates the mass and diameter of the smaller (inner) four.

Planet	Mass	Mass to the same exponent	Diameter	Volume of Planets	Density
	Kilograms	**(Hint: change the masses to the same exponent - e.g. 23)**	**Miles (rounded to nearest 500)**	$V = \frac{4}{3}\pi r^3$ **in cubic miles**	**V / M in kg per cubic mile**
Mercury	3.3×10^{23}	3.3×10^{23}	3,000 miles	1.12×10^{12}	
Venus	4.87×10^{24}	48.7×10^{23}	7,500 miles		
Earth	5.98×10^{24}	59.8×10^{23}	8,000 miles	2.12×10^{12}	
Mars	6.42×10^{23}		4,000 miles		
Jupiter	1.90×10^{27}		89,000 miles		
Saturn	5.69×10^{26}		74,500 miles		
Uranus	8.68×10^{25}		32,500 miles		
Neptune	1.02×10^{26}		30,000 miles		

What is the total Mass of the 4 smallest planets? (Mind those exponents)	
What is the total Mass of the 4 largest planets?(Mind those exponents)	
Which is the DENSEST planet (has the highest Mass for the smallest volume):	

Students can complete the Worksheet to fill in the missing numbers.

Student Worksheet 1 – Calculating planetary diameters relative to the Earth

Planet (or Dwarf Planet)	Distance from the Sun	Distance from the Sun	Period of Revolution Around the Sun	Period of Rotation	Mass	Diameter	**Ratio of Diameters	Temperature	Number of Moons
	*Astronomical Units	Miles	(1 planetary year)	(1 planetary day)	Kilograms	Miles	D of planet/ D of Earth	Degress Kelvin	
SUN	**0**	**0**	**N/A**	**27 Earth days*** **	**1.99×10^{30}**	**864,575 miles**	**100**	**5,778 K at the surface**	
Mercury	0.390 AU	36 million miles	87.96 Earth days	58.7 Earth days	3.3×10^{23}	3,031 miles		100-700 K	0
Venus	0.723 AU	67.2 million miles	224.68 Earth days	243 Earth days	4.87×10^{24}	7,521 miles		726 K	0
Earth	1 AU	93 million miles	365.26 days	24 hours	5.98×10^{24}	7,926 miles	1	260-310 K	1
Mars	1.524 AU	141.6 million miles	686.98 Earth days	24.6 Earth hours	6.42×10^{23}	4,222 miles		150-310 K	2
Jupiter	5.203 AU	483.6 million miles	11.862 Earth years	9.84 Earth hours	1.90×10^{27}	88,729 miles		120 K	67 (18 named)
Saturn	9.539 AU	886.7 million miles	29.456 Earth years	10.2 Earth hours	5.69×10^{26}	74,600 miles		88 K	62 (30 unnamed)
Uranus	19.18 AU	1,784.0 million miles	84.07 Earth years	17.9 Earth hours	8.68×10^{25}	32,600 miles		59 K	27 (6 unnamed)
Neptune	30.06 AU	2,794.4 million miles	164.81 Earth years	19.1 Earth hours	1.02×10^{26}	30,200 miles		48 K	13
Pluto (a dwarf planet)	39.53 AU	3,674.5 million miles	247.7 years	6.39 Earth days	1.29×10^{22}	1,413 miles		37 K	4

*1 AU (Astronomical Unit) is the ditance between the Earth and the Sun. 1AU equals 93 Million Miles

** Calculate and round to 1 significant figure

***The sun rotates faster at the equator than at the poles. 27 Days is the equatorial rotation

Student Worksheet 2 – Calculating planetary density

Planet	Mass	Mass to the same exponent	Diameter	Volume of Planets	Density
	Kilograms	**(Hint: change the masses to the same exponent - e.g. 23)**	**Miles (rounded to nearest 500)**	$V = \frac{4}{3}\pi r^3$ **in cubic miles**	**V / M in kg per cubic mile**
Mercury	3.3×10^{23}	3.3×10^{23}	3,000 miles	1.12×10^{12}	
Venus	4.87×10^{24}	48.7×10^{23}	7,500 miles		
Earth	5.98×10^{24}	59.8×10^{23}	8,000 miles	2.12×10^{12}	
Mars	6.42×10^{23}		4,000 miles		
Jupiter	1.90×10^{27}		89,000 miles		
Saturn	5.69×10^{26}		74,500 miles		
Uranus	8.68×10^{25}		32,500 miles		
Neptune	1.02×10^{26}		30,000 miles		

What is the total Mass of the 4 smallest planets? (Mind those exponents)

What is the total Mass of the 4 largest planets?(Mind those exponents)

Which is the DENSEST planet (has the highest Mass for the smallest volume):

Changing the Location on the ISS-ABOVE

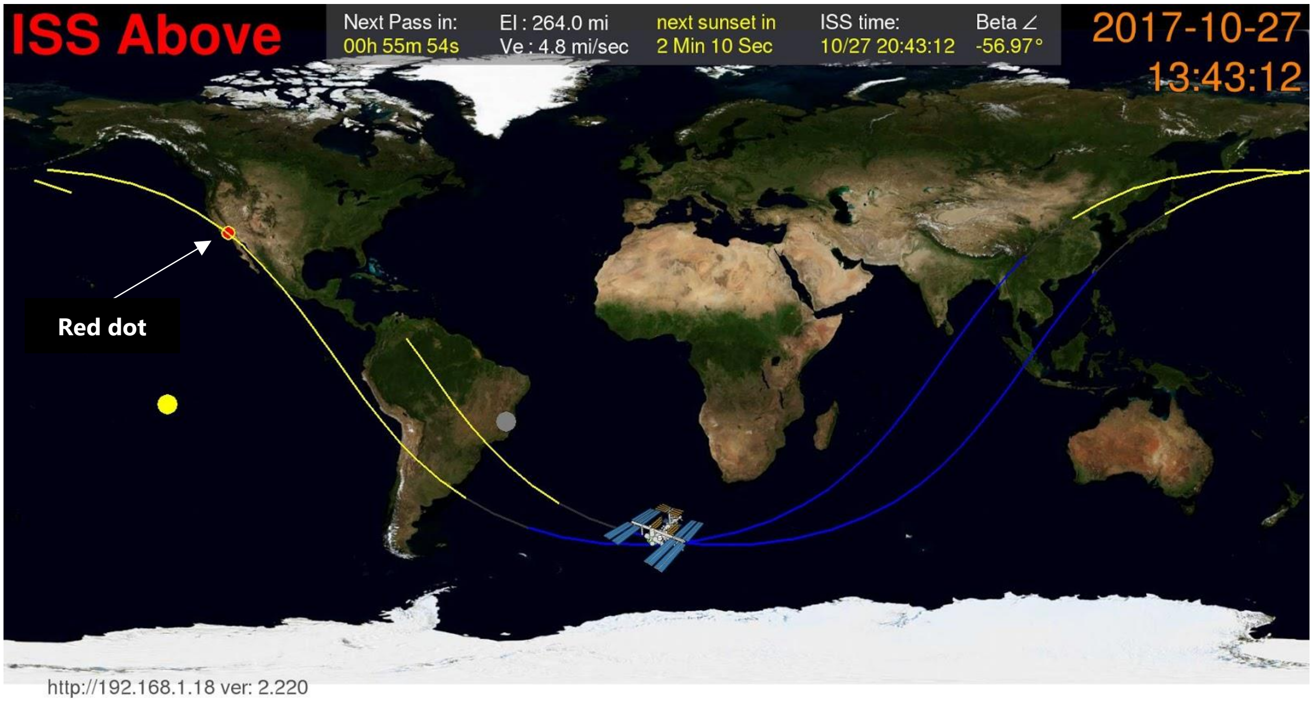
Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	Students will learn how the location of the ISS at various times of the day differs **relative to the location set on the ISS Above** (the location we are using to measure where the ISS is).
Materials:	• ISS Above (set up and ready to go) • Wall map of the world • Pushpins
NGSS Essential Standards and Clarifying Objectives:	*MS-ESS1-3:* **Analyze and interpret data to determine scale properties of objects in the solar system**. Emphasis is on the analysis of data from Earth-based instruments. **Science and Engineering Practices:** • Analyze and interpret data to determine similarities and differences in findings. **Disciplinary Core Ideas:** • 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.. **Crosscutting Concepts** • Scale, Proportion and Quantity ✓ Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • Interdependence of Science, Engineering, and Technology ✓ Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.
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 to capture data about the ISS-ABOVE in different locations.
Skills Needed	Students need to work with latitudes and longitudes, time zones and degrees. Extra information is provided on Latitude/Longitude in the **Additional Resources** section of this Handbook, if needed.

ENGAGEMENT

Location of the ISS-ABOVE

Hand out the Student Worksheet.

Move to the ISS-ABOVE world map/orbits screen:



Look on the map for the location of your school. It should show as a red dot. (In the screenshot above it's in Pasadena, CA.) You may also see a yellow dot for the Sun and a grey dot for the Moon. All of the data that the ISS-ABOVE displays is driven by the current location (the red dot, which is where the ISS-ABOVE 'thinks' it is).

Questions

1. What do the students notice about this map of the world? (For example, they may notice forest, deserts, snowy regions and oceans and that there are no boundaries between countries and people; only land and water masses.)
2. The ISS graphic moves from West to East updating very few seconds. Do the students notice that the ISS is moving?
3. Roughly how many time zones away is the ISS from your school? In the image above its looks like it's 8 hours ahead – the difference between, say, UK time (where it's nighttime) and the time in California (where it's daytime).
4. Do the students notice that there's a gray arc on the orbit between the yellow of daytime and the blue of the night? Those are the periods of sunrise and sunset, when the ISS has best visibility if it happens to be above you.

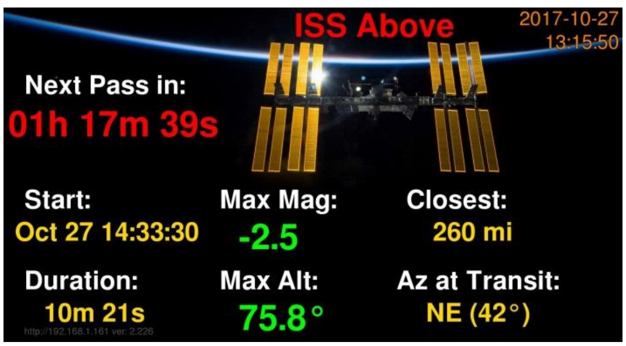
Pick a place on the map where the ISS will pass overhead (i.e. the place lies under the orbit arc).

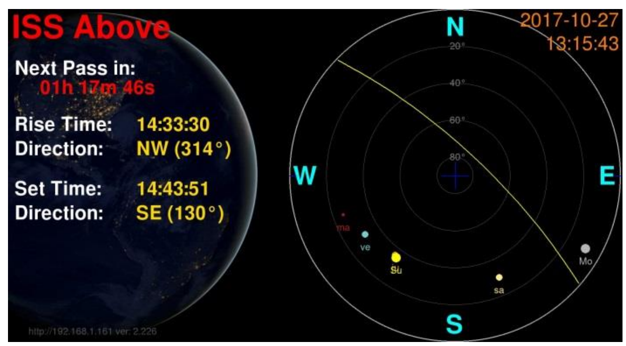
Questions

1. When would the ISS pass over that location? Students need to note the time and estimate where the ISS is and how many time zones ahead if the ISS the chosen county/city is. NOTE: The ISS takes 92 minutes to orbit the Earth.
2. When the live video from the ISS shows above the new location, would the camera feed be different? In what way?
3. What's the distance of the ISS when it's above you?
4. When will the ISS be above your country, or your family's country, or your ancestors' country?

EXPLORATION

On the Next Pass screen, the data is for the next pass over your location:





Ask students to use their Worksheet to note their location (City) in the Column marked Current Location and the Next Pass in, Start, Max Mag, Closest, Duration, Max Alt and Az at Transit details in the same column from the screen on the left as shown above.

On the Next Pass In screen, have the students sketch the fly by circle on the right-hand side of the screen (on the back of their Worksheet) from the screen on the right as shown above.

Changing the location of your ISS Above

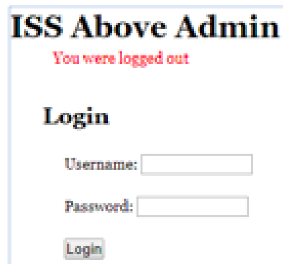
You're going to use a browser to access the Admin of the ISS-ABOVE and change the location. The students will note the differences on their worksheet.

Before you change to a browser, make a note of the ISS-ABOVE's IP address from the bottom left of one of the ISS-ABOVE screens:

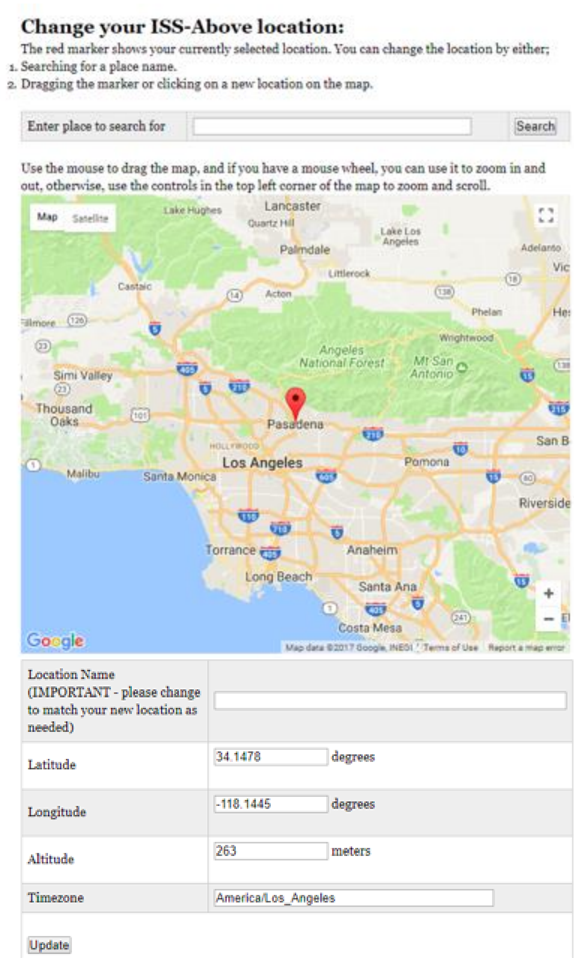
Now, use any browser on a desktop, laptop or tablet and type your IP address in the URL bar

http://(ip address)/login
e.g. http://192.168.1.84/login

The screen to the left appears.
Enter the username **admin** and the password **nasa**. Click **Login.**



Project your screen to the class if possible. The screen below will appear:



Students should note the Latitude and Longitude of your current location on their Worksheet table.

Now, in the **Enter place to search for** field, type *Amsterdam* and click **Search**. The screen below should appear:

Enter place to search for	Amsterdam	Search

Use the mouse to drag the map, and if you have a mouse wheel, you can use it to zoom in and out, otherwise, use the controls in the top left corner of the map to zoom and scroll.

Location Name (IMPORTANT - please change to match your new location as needed)	
Latitude	52.3702 degrees
Longitude	4.8952 degrees
Altitude	9 meters
Timezone	Europe/Amsterdam
Update	

Students should add the Latitude and Longitude for Amsterdam to their table.

Now, click Update. Some red text displays at the top of the screen:

Latitude changed

Longitude changed

Elevation changes

Timezone is now set to Europe /Amsterdam

Location name change to:

ISS Above code will be re-started now in order to accept the changes

The ISS Above should now be restarting.

Student Activity

In the second column of the student table, gather the same information for the Amsterdam location.

Questions

1. How can you tell you're really in Amsterdam?
2. How many hours difference is it between your school and Amsterdam?
3. What do you think people in Amsterdam are doing right now?
4. What time is it for the people on the ISS?
5. Can you work out which time zone the ISS is set to?
6. Why do you think the time on the ISS is the same whether it's over your school or over Amsterdam?
7. How long is it until the next pass over your school and over Amsterdam?
8. Will you be able to see a view of Amsterdam from the ISS during the school day?

ELABORATION

Time allowing, change the location again and use your World Map and push pins. A time zone map is provided in Unit 1 Lesson 1.

For each location you have chosen to change the ISS Above settings to, document it on a pushpin map. Or, make a chart to see if that location does or does not ever have a visible pass.

NOTE: You can also use an interactive push-pin map, but you must register first. It's free for one map and up to 30 pins. https://www.pinmaps.net/mymaps/

EVALUATION

Students can be assessed on their understanding of the relevant vocabulary terms for this lesson, as well as the relevant concepts:

Have students define in their own words:

1. Maximum Magnitude (Max Mag)
2. Maximum Altitude (Max Alt)
3. Azimuth (Az)

Questions

1. Explain why there are different time zones on Earth?
2. Do these time zones impact our ability to see an active pass of the ISS? *(really time zone is not the factor that determines whether the ISS will pass over a location. The ISS passes over 95% of the worlds populated areas every single day, but of course at different times)*
3. Where are some locations (e.g. countries) where you would never see an active pass of the ISS? What latitudes would not be able to see the ISS-ABOVE?
   hint: The ISS orbit is inclined by 51.6 degrees from the equator. That causes the ISS to move between about 52 degrees north and south. If any city is above 52 degrees north the ISS will still rise above the horizon several times per day but it will always be lower in the sky than locations closer to the equator. For example Fairbanks Alaska is at 64.8 degrees north the ISS will still rise above their horizon but will always be in the southern part of the sky and will never rise above about 9 degrees in their sky. Warning. ***DO NOT SET YOUR LOCATION*** *to extreme north or south (above 66 degrees). The result will be that your ISS-Above will not have ANY pass of the ISS – which would get rather confusing as there will never be ANY next pass information).*

Student Worksheet – Changing Location

	Current Location	New Location
City, Country	, USA	Amsterdam, Netherlands
Date and Time		
Time Zone (GMT +/- number of hours)		
ISS Time (top of the world map/orbit screen)		
Next Pass (h m s)		
Start		
Duration		
Closest		
Latitude*		
Longitude*		
Max Mag		
Max Alt		
Az at Transit		

*The latitude and longitude of the ISS Above can be found at the bottom of the browser screen (not on the ISS Above screens!)

Add the details for **your location** (from the Next Pass In screen) with the fly-by map:

Looking at the Earth

Draw the fly-by map for Amsterdam (once the location has changed):

Scratch(x) Coding for the ISS distance from you

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	Students will learn the basic principles of computer programming, and practice their coding skills in a hands-on activity. Students will use the Scratch ISS Tracker Extension interactive program to follow the progression of the ISS Above from different locations.
Materials:	• ISS-ABOVE hardware and software (set up and ready) • iPads/ Laptops/ access to the Internet • Stop watches or wall clock with second hand • Scratch paper • Scratchx ISS Tracker Extension: http://bit.ly/2DtqiUD
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 to capture data about the distance to the ISS at specific time intervals.
Skills Needed	Students need to work with latitudes and longitudes, time zones and degrees.

ENGAGEMENT

What is a computer program and why do we create them?

The students can be engaged in what they already know about programming:

Questions:

1. What is a computer program?
2. Where do you find computer programs (on what kinds of devices, appliances, domestic objects, industrial objects)?
3. What are different computer programs that you can name?
4. What different TYPES of computer programs are there?
5. Are computer programs important for space exploration? Why?

The ISS-ABOVE is an example of a program that helps us track the ISS by creating a model of where the ISS actually is at any given moment.

The computer it uses is called a 'single-board computer' known as a Raspberry Pi. (You can take the front cover off the ISS-ABOVE so students can see the board).

Inside an ISS-ABOVE you can see:

- The Raspberry Pi (computer)
- A PiGlow LED light
- Around the edge, a lot of ports for power, Wifi, HDMI, USP

All of this is hardware, but without a program, it doesn't do anything. The program for the ISS-ABOVE is on a tiny microSD card slotted into the side.

The Raspberry Pi can do a lot of different things, including running the ISS-ABOVE program. ISS-ABOVE is actually a computer program, a series of instructions to the computer to calculate something, display something, issue a command, control a sequence of instructions. ISS-ABOVE is written in a language called Python.

Question:

1. What other computer languages have you heard of?
2. Do you know why there are different languages (not just one)?
3. It can take a long time to learn a computer language. What are people who write computer programs called?

Best guesstimate is that there are roughly 20 million programmers worldwide and the number is growing.

EXPLORATION

You're going to use a programming language called Scratch to see what a computer program needs to look like to create just one of the screens of the ISS-ABOVE on a regular computer like a chromebook, mac or laptop. You're also going to try and build a program of your own.

Hand out the Student Worksheet. Pairs work well for the worksheet tasks.

The Worksheet is in two parts:

1. Part 1 uses the Scratchx ISS Tracker Extension (customized by ISS-ABOVE) which draws the orbit track of the ISS and calculates the distance of the ISS from a given city.
2. Part 2 uses a standard Scratch sample project to allow students to create a program of their own. They won't want to stop!

EXTENSION

Pairs visit with each other and each pair explains their program. If a program isn't working, they can try and troubleshoot together. They could give the other team a score.

EVALUATION

Students can explain the distinctions between (possibly by giving Scratch examples of):

- Data, both fixed and variable
- A command (move something, play something, draw etc.)
- A program loop (repeat of a sequence of instructions)
- A calculation

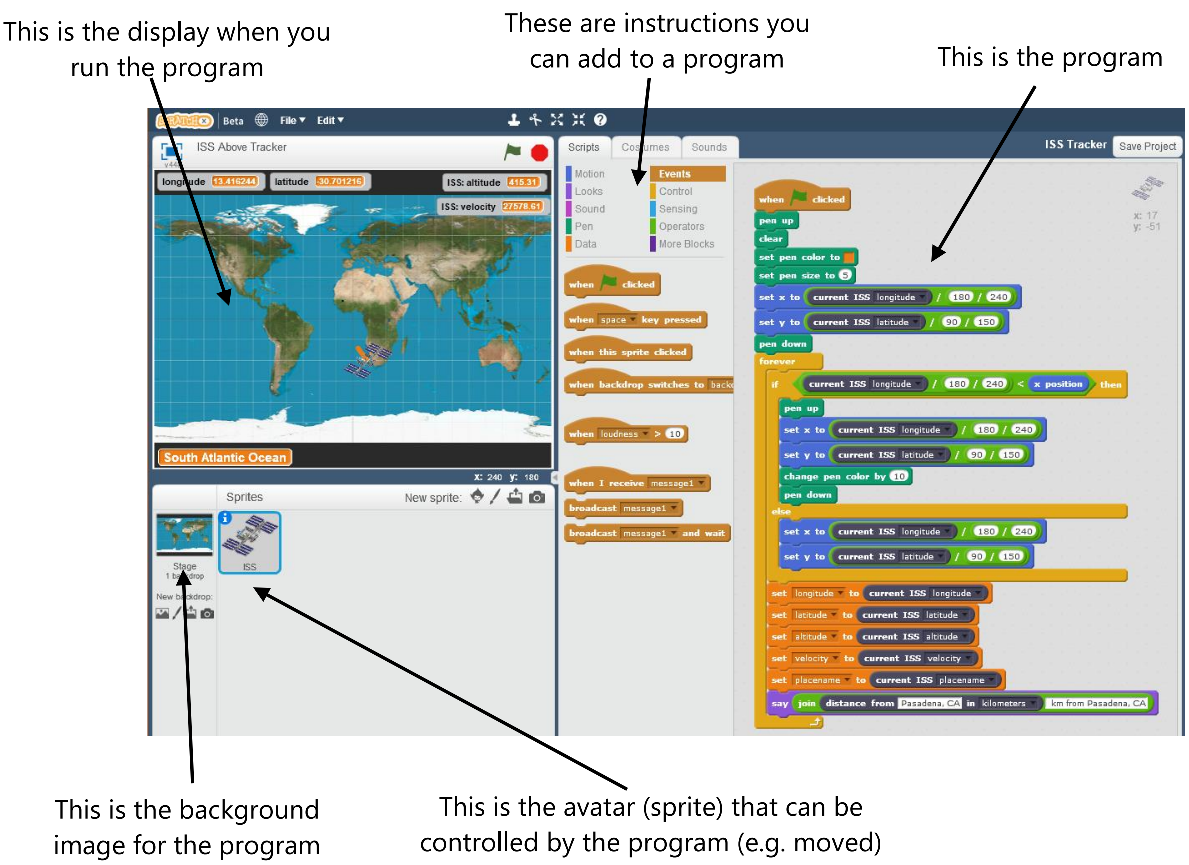
Students managed to complete a program and try to run it.

Student Worksheet Part 1 – The Scratch ISS Tracker

Part 1: First, you're going to look at a Scratch program and see how it works.

Go to your browser and type in the URL: http://issabove.com/scratchx

You'll see the screen below:



Answer these questions:

How do you think you can start the program? ....

....

What happens in the display panel when you run the program? (Let it run for a couple of minutes.)..

....

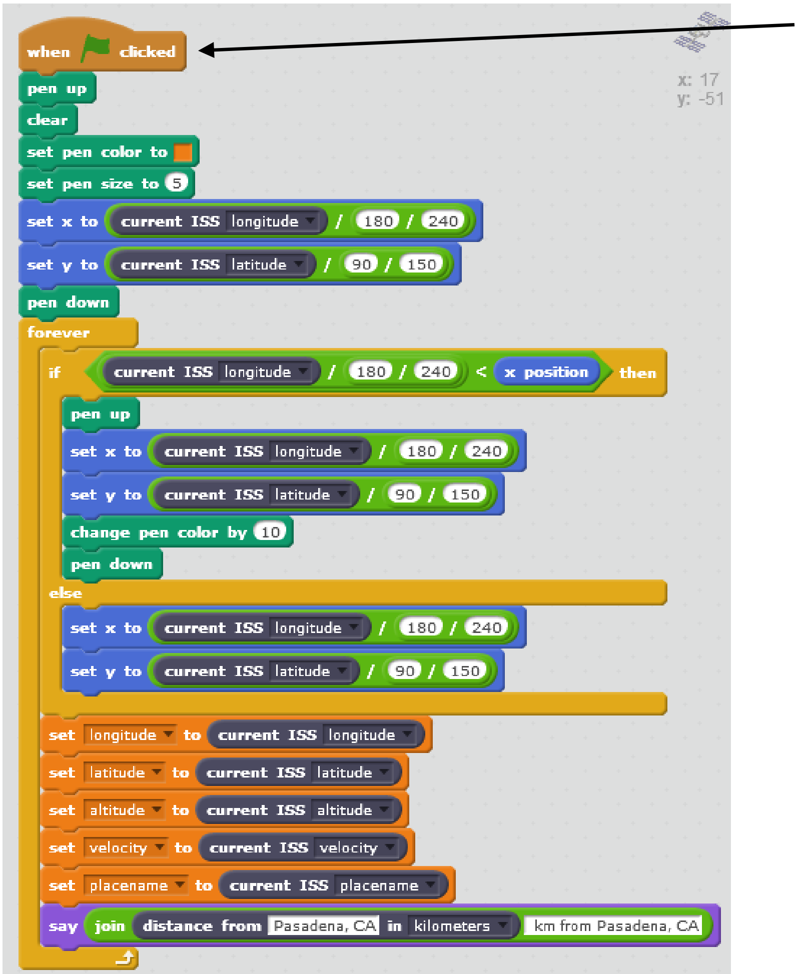
....

Now, stop the program.

The program in detail.

Look at the program on the left and find an item on the right. Draw arrows from the item on the right to an example on the left (the first one has been done for you).

HINT: looking at the display screen and watching what happens when the program is running can help you figure these out.



User action

Command

Calculate something

Do something over and over

Move something

Data (fixed – the value doesn't change

Data (variable – the value changes)

Display something

What do you think the x and y are (in the blue program lines/rows)? HINT: they have something to do with the display – think of graph paper. These blue rows do something else very important as well. What is that?

....

....

....

....

Using the program

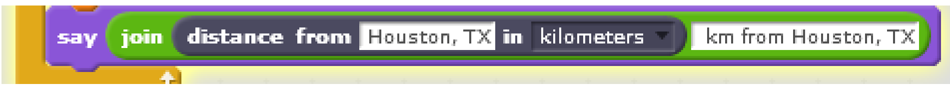
You can change some settings in the program and then run it again.

Task 1:

Change the location and units

Stop the program if it is running.

By default, the program uses Houston, TX as your location and shows how far from Houston the ISS is in kilometers. The last line in the program can be changed to set your real location:



- Click in the first white area to change Houston, TX to your city and state.
- Click to the right of where it says kilometers and change it to miles.
- Click in the second white area and change it to mi from city, state (insert your city and state, of course).

Start the program. The white speech bubble should now show the distance from your city to the current ISS position. Notice how quickly it changes.

NOTE: The distance is calculated between your city and the place on Earth that the ISS is directly above at that moment.

For 2 minutes, note the distance from your city every 15 seconds and write the results below:

Elapsed time	Distance in miles
0 seconds	
15 seconds	
30 seconds	
45 seconds	
1 minute	
1 minute 15 seconds	
1 minutes 30 seconds	
1 minute 45 seconds	
1 minutes	

Right now, is the ISS getting closer to you or further away? ....

....

How far is it between one measurement and the next? ....

How long would it take you to go this distance in a car or on a bus?..

Task 2:

Change the pen color.

Stop the program.

To change the pen color, you will need to swap out a command. You are going to remove the `set pen color to` and replace it with `set pen color to (0)`. You need to:

Make sure that you are on the **Pen** area in the instructions part of the screen. These are all the instructions for doing things with the pen.

Unlock the commands below `set pen color to`. You do this by clicking and holding (grab) the `set pen size to (5)` command and dragging it down the screen. The whole set of commands below it is now unlocked.

Drag the `set pen color to` from the program to the instructions area and drop it there.

Drag the `set pen color to (0)` from the instructions area to the place where the `set pen color to` was in the program. Click where it says zero and change it to a different number.

> You can choose a number from 0 to 200: for example, number 0 is color red, number 70 is green, number 130 is blue, and number 170 is magenta.

Grab the bottom part of the program at the `set pen size to (5)` command and drag it up to lock it to the new command.

Start the program. Wait a minute or two and see what color the orbit track of the ISS now is. Leave the program running and go to Part 2.

Student Worksheet Part 2 – Creating a Scratch program

Part 2: How, you're going to create your own program.

Go to a new browser tab and type in the URL: scratch.mit.edu

Click on the orange cat to TRY IT OUT. You'll see the same screen layout that you did in Part 1, but there's no program!

Start by choosing a backdrop for your cat.

Click and see a whole range of backdrops. Click the one you want twice to select it.

In the one on the right, I want to make the cat jump on the bed!

Now go to the instructions (Scripts tab):

The instructions are in different code blocks (these are the ones you'll probably use for this program):

- **Motion** will move your Sprite
- **Sound** allows you to play a sound (or create a new one to play)
- **Events** allows you to add the start the program event
- **Control** allows you to create a loop (run commands over and over)

HINT: if you want to find out what any instruction does, click the  in the grey bar abovce the scripts tab, then move your  pointer to the instruction you want to find out about. A help panel on the right of the screen slides out and tells you what that instruction does.

Create your program to make your cat do something. Make sure you have  at the top of your program.

Before you finish the lesson, go back to the ISS Tracker tab and see what your orbit track looks like now. It's doing what your ISS-ABOVE does on the world map screen.

Set a Table for the ISS Crew

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	Students learn how they can survive on the International Space Station.
Materials:	• ISS-ABOVE hardware and software (set up and ready). • Velcro, double sided sticky squares, sticky tape. • Foldable tables or stiff cardboards with room for 2-4 place settings. • Table cloth (optional). • Utensils (plastic or metal). Metal utensils will need magnets (not used on the ISS), so plastic utensils and Velcro are better. • Plastic (reusable) plates, cups/glasses. • Free-dried food packages, for example https://www.amazon.com/Harmony-House-Foods-Vegetable-Emergency/dp/B0039QW1HM/ref=sr_1_17_a_it?ie=UTF8&qid=1513924982&sr=8-17&keywords=dehydrated%2Bfood&th=1 (you can use these for Unit 6: lesson 2 also) OR Ziplocs filled with dry food items, with as little air in the bag as possible). • Highlighters (for Part 2 of the Student Worksheet).
NGSS Essential Standards and Clarifying Objectives:	*MS-ESS1.B* Objects are held in orbit around the sun by the gravitational pull upon them. **Science and Engineering Practices:** • Develop and use a model to describe phenomena. Analyze and interpret data to determine similarities and differences in findings. **Disciplinary Core Ideas:** • Objects, including satellites and the objects and people within them, are held in orbit around the Earth by its gravitational pull on them. Gravity gets weaker, the further from a body you are. **Crosscutting Concepts** • 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 for students' dinner place settings, with room for observations. Article on food in space.
Skills Needed	Students will solve problems that occur on the ISS due to microgravity (resulting in the apparent weightlessness of people and objects).

ENGAGEMENT

Set a Table for Dinner on the ISS

The students will examine how microgravity affects everyday life on the ISS. In this lesson the focus is on eating and food.

> **TASK:** Ask students to share with a partner how they set their table for dinner at home. What do they use to eat dinner? What plates, utensils, drinkware? How do they set them out? Where do they sit?

Hand out the Student Worksheet**.**

> **TASK:** Students should draw a sketch of their place setting on the first side of their worksheet and complete the questions about how they eat dinner at home.

Explain that students will be setting the table for a dinner on the ISS. Students should think about their Earth-based configurations and components and consider what would happen in a microgravity environment.

FYI: Information on microgravity is here: https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-microgravity-58.html

Class discussion on the difference that microgravity (objects appearing weightless) might make to a table set on Earth and one on the Space Station.

EXPLORATION

Activity: In groups, students construct a table layout such that none of the items 'float away'. This includes a table of large card, trays, food, utensils, tablecloth etc. Provide Velcro, magnets, 2-sided sticky squares, or have students get creative with materials you have around the classroom.

Once their initial setup is ready, test their 'table' by flipping it over. If everything stays attached, an award is in order!

An example is shown in the photos.

Students should add observations about how their table layout is different for the ISS to Part 1 of their Worksheet.

EXPLANATION

Ask the students for their thoughts on the following questions.

1. Does It matter whether a 'table' on the ISS is on the 'floor" or on the 'walls' or 'ceiling'?
2. When you tip <u>your</u> table upside down, what happens if the items aren't attached properly? What would happen on the ISS if any objects weren't attached properly?
3. What would be different about a table on the ISS compare with a table on Earth?
4. Do you think astronauts 'wash the dishes'?
5. How would you redesign an eating area for astronauts so that it would be a little more like eating on Earth?

Space food must be carefully contained so it doesn't float around in the microgravity environment. Even something as simple as a few crumbs can become deadly in low gravity. Condiments like ketchup, mustard and mayonnaise have their own packaging. Salt and pepper are stored in liquid form so that the crystals or granules don't float away. Salt is dissolved in water while pepper is suspended in oil.

The food must be light, well packaged, fast to serve and require minimal cleaning up.

(foods that tend to leave crumbs, for example, are ill-suited for space). Finally, foods require a minimum of energy expenditure throughout their use; they must store well, open easily and leave little waste behind.

EXTENSION – Now for the food

This section is a good lead-in to Unit 6: Lesson 2, which deals with food, exercise and sleep on the ISS.

Option 1: **Warning**: Video has slightly racy language (e.g. 'crap'). There's also a flyout that references sex in space, so be prepared! The students will love the video, though.

> ***What do astronauts eat on the ISS? A short history of food and space travel*** (3:30min).
>
> **https://youtu.be/mxavDn270to**

OR Option 2: **No warning needed!**

> ***Chris Hadfield shows how to make a space sandwich***. Video 2:30min:
>
> **https://www.youtube.com/watch?v=AZx0RIV0wss**
>
> ***The Myth Busters talk to Chris Hadfield and look into food on the Space Station*** Video 10:50min:
>
> **https://youtu.be/f8-UKqGZ_hs**

Students should now read the article in Part 2 of their worksheet (which covers a host of matters relating to food in space). Ask students to highlight things that they didn't know or were surprised by.

(Article is edited from **https://science.howstuffworks.com/astronauts-eat-in-space.htm**)

Additional resources:

Start the following video (it's a little dry) at 1:30min to 6:34 min to find out how Astronauts actually eat on the Space Station. Can also continue to the end, which includes vitamin use.

https://youtu.be/_4aWoZPEd2w

Photos of astronauts 'playing with their food' can be printed out and created as a collage:

https://www.space.com/12274-space-food-photos-astronauts-nasa-meals.html

And finally, what do astronauts eat over the holidays? Article from a UK newspaper:

https://www.eveningexpress.co.uk/news/what-do-astronauts-eat-at-christmas-on-the-iss/

EVALUATION

What did students notice about food, nutrition and eating habits on the ISS compared to Earth?

Prompt students to write a few paragraphs or bullet points summarizing similarities and differences between:

- The table they set at home and what they set on the ISS.
- How food is prepared at home and on the ISS.
- What meal time is like.

Student Worksheet – Dinner on the ISS

Part 1: Sketch your place setting or table layout at home for dinner.
Make sure you have plates, utensils, drinking vessels. What else might you have on the table?

What is dinner like in your home? Where do you sit? What do you most like to eat? Does everyone eat together?

Eating a Meal in Zero G

After you have constructed your ISS table settings, note below what's different about the ISS table and your table at home:

Part 2: Read the article below and highlight the things that surprise you.

European Space Agency astronaut Andre Kuipers (R) and his NASA colleague Michael Foale eat Dutch cheese for breakfast on the International Space Station.

If you asked the question, "How do astronauts eat in space?" about fifty years ago, the answer would be quite different than it is today. In space travel's early years, astronauts used straws to suck dehydrated, paste-like food out of tubes. Today, astronauts eat food in much the same way as they do here on Earth.

In a low-gravity environment, food and drinks would simply float away if they weren't handled correctly. To combat this problem, food and drinks are packaged as dehydrated powders.

Foods are either partially or completely dehydrated to prevent them from spoiling. Meats are exposed to radiation before they are put onboard the shuttle to give them a longer shelf life.

Astronauts eat three meals a day (plus periodic snacks), just as they do on Earth. Meals are organized by the order in which astronauts are going to eat them, and stored in locker trays held by a net so they won't float away. When mealtime rolls around, astronauts go into the galley area in the shuttle's middeck. There they add water to freeze-dried foods and dehydrated drinks from a rehydration station that dispenses both hot and cold water. They heat foods in a forced-air convection oven that's kept between 160 and 170 degrees Fahrenheit. It takes about 20 to 30 minutes to rehydrate and heat an average meal.

Astronauts attach their individual food containers to a food tray with fabric fasteners. The tray itself connects either to the wall or to the astronauts' laps. Astronauts open the food packages with scissors and eat with a knife, fork and spoon.

Each shuttle packs enough food to last the length of the mission, and then some. A **Safe Haven food system** provides every astronaut with an extra three weeks' worth of food -- 2,000 extra calories a day -- just in case the crew encounters an emergency. These foods are typically dehydrated for a longer shelf life.

Astronauts may have plenty of food to eat, but being in space can put a damper on their appetites. Without gravity, food aromas waft away before they make it to the nose. When you can't smell food very well, you can't really taste it, either. And because fluids tend to rise to the top half of astronauts' bodies, the crew members usually have perpetually stuffy noses. Salt, pepper, ketchup, mustard and mayonnaise are available to enhance the flavor of the food, but even then, the condiments are different from their terrestrial counterparts -- salt and pepper are suspended in liquid (water or oil) so the particles don't float away.

Food, Exercise and Sleep on the ISS

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	Students understand what it takes to maintain a healthy lifestyle on the International Space Station.
Materials:	• 4 stations with tables (details are provided under station setup). • 2 plastic tablecloths for Stations 1 and 2. • Poster with food groups (available for purchase at https://www.learningzonexpress.com/food-groups-poster-set.html or similar) • 6-7 dried foods: for example: http://amzn.to/2luHUHa • Dehydrator (optional). Sliced mushrooms. • Sticky tape or push pins. • Vacuum sealer. • Jug of warm water (potable). • Paper towels. • Plastic spoons. • Small ketchup cups or drinking cups for rehydrating dried food. • Blow up astronaut / large doll plus air pump. • Sleeping bag (or trash bag). • Sticky hooks and tethers (e.g. string). • 2 large safety pins.
Health Standards:	**CA Health Standards:** 1.1.N Describe the short-term and long-term impact of nutritional choices on health. 1.8.N Identify ways to prepare food that are consistent with current research-based guidelines for a nutritionally balanced diet. 1.15.N Explain that incorporating daily moderate or vigorous physical activity into one's life does not require a structured exercise plan or special equipment.
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	Each of the four stations has its own worksheet/instructions. There is a separate worksheet for the start and end of the lesson (engagement/evaluation).
Skills Needed	Time management, collaboration, critical thinking and analysis/interpretation.

ENGAGEMENT

The lesson starts by examining the components of a healthy lifestyle and comparing what it's like to stay healthy on Earth compared with what it's like for an astronaut on board the ISS.

Questions/discussion for students.

On Earth:

1. What does it mean to be healthy?
2. What happens to your body when it is healthy and when it is not?
3. Where does healthy food come from?
4. How much of different types of food should you be eating to be healthy?
5. Does a healthy life include exercise?
6. How often should you be exercising? For how long?
7. How much should you be sleeping to be healthy? How do you sleep/ where?

Compare this with the Space Station. There are many limitations in the microgravity environment of the International Space Station that make the everyday activities of eating healthy food, exercising and sleeping more challenging.

In pairs, students will now try to answer these same questions from an astronaut's perspective.

Hand out the first Worksheet.

> **TASK:** Using your worksheet, with your partner, imagine that you're both astronauts. Brainstorm and note your answers to the health questions on your worksheet.

EXPLORATION

Students are going to visit between **2 and 4 stations in turn** (dependent on time) to examine how being in space impacts everyday living for astronauts on the ISS. The 4 workstations are:

Workstation 1: Space Food Design and Preparation

Workstation 2: Vacuum Food Packaging and Rehydration

Workstation 3: Exercise in Space

Workstation 4: Sleeping in Space

Assign 2 students to each station to be the guides/experts. Give them the workstation setup sheets. They should pick up their materials/equipment and go to their stations to complete the setup, become familiar with the workstation and how to reset it between groups.

Divide the remaining students into 4 groups (even numbers) and into pairs within the groups. Dependent on numbers and time, students group can be direct to 1 or 2 workstations, or to tour all four.

Student should take pens/pencils to make notes on their Worksheets (which are available at each station).

Allow 6-8 minutes per workstation. Once done, reassemble the class.

ELABORATION/EVALUATION

Let's see what eating, exercising and sleeping is really like on the space station. Watch the videos:

Strange foods (and drinks) in space:
https://youtu.be/zOmOadxxEbs (2mins)

Astronauts exercise in space
https://youtu.be/87YxeKTv8Y8 (3:50min, but suggest stopping at 2:43min)

OR

Chris Hadfield exercises in space:
https://youtu.be/MQ0PxT7wnuU (2:40min)

Sunny Williams talk about sleeping on the ISS (first 2 minutes only)
https://youtu.be/SGP6Y0Pnhe4

Discussion

What do students think it means to say that the ISS is a closed system (regarding food, water, climate, bathroom, air, oxygen etc.) Have students consider alternate solutions to food, exercise and sleeping on the ISS.

Other resources:
For more resources, activities etc. check the following link:
https://www.nasa.gov/audience/foreducators/fitexplorer/home/index.html

There are 2 activities from the NASA website:
1. Hand/eye co-ordination exercise (assembling a jigsaw while wearing 2 pairs of gloves).
2. Creating an eating plan (using the food pyramid to plan individual eating plans for healthy living).

Student Worksheet – Food, exercise and sleep

Answer the questions below as if you were an astronaut on the ISS:

Why is it important for me to stay healthy?	
What happens if I have a health issue?	
How do I know my food is good for me?	
How much food should I be eating?	
Do I need to exercise? Why?	
How often should I be exercising? For how long?	
How much should I be sleeping to be healthy?	

Later, you will find out how accurate your answers are.

Setup for Station 1 (1 copy needed)

Meal Planning / Dehydration station

Materials
(on the wall)
1. Poster with food groups.

(on the table)
2. Tablecloth.
3. 3-5 dried food package samples (set out on the table).
4. Dehydrator (if available). Set the dehydrator on the table and set it going with the sliced mushrooms.
5. Worksheets for Workstation 1 (on the table).

Directions for students

When a group comes to the workstation, give them a Worksheet for Workstation 1. These are their tasks. Help them where needed.
1. In pairs, students create a healthy meal (breakfast, lunch, dinner and snack) from the poster and/or from the dried food on the table. They should consider which foods can be dehydrated or powdered. Is there anything on the poster that they think can't be prepared for the space station.
2. Do students think that fresh foods are available on the Space Station?
3. Review how the dehydrator works and what dried fruit looks like.

Between groups:

Check and reset the table. Make sure any used worksheets are set aside.

At the end:

Pack up and return all materials to the pick-up point.

Setup for Station 2 (1 copy needed)

Vacuum sealing / Food tasting

Materials
(on the table)

1. 2 types of dried food in plastic containers. Please a spoon in each.
2. Bags for vacuum sealing.
3. Vacuum sealing units (on the table).
4. 20 small plastic containers with spoons (add a couple of spoonfuls of the dried food to each).
5. Warm water in a jug (gradually add water to the first few plastic containers to rehydrate the food).
6. Paper towels (in case of spillage/mess).
7. Worksheets for Workstation 2.

Directions for students

When a group comes to the workstation, give them a Worksheet for Workstation 2. These are their tasks. Help them where needed.

1. In pairs, students spoon a small amount of dehydrated food into a bag. They vacuum seal their bag using the vacuum sealing unit(s).
2. Students sample the rehydrated food and record their impressions.

Between groups:
Check and tidy the table. Make sure any sealed bags and used worksheets are set aside. Add water to a few more cups of dried food.
At the end:
Pack up and return all materials to the pick-up point.

Setup for Station 3 (1 copy needed)

Exercise in Space

Materials
(on the table)

1. Worksheets for Workstation 3.

Equipment

2. Four chairs

Directions for students

When a group comes to the workstation, give them a Worksheet for Workstation 3. These are their tasks. Help them where needed.

1. Start by reading Peggy Whitson's journal about exercising in space: https://www.nasa.gov/mission_pages/station/expeditions/expedition16/journal_peggy_whitson_6.html (see student materials)
2. Students should do 2 out of 3 exercises.
   (a) Sitting on a chair, raise your legs and 'run' for 2 mins as if you were on a treadmill.
   (b) Sitting on a chair, raise your legs and 'pedal' for 2 mins as if you were on an exercise cycle.
   (c) Standing facing a wall, with your feet a little more than arms-length away, place your hands flat on the wall at shoulder height. Push outwards from the wall until you are upright, then release. Repeat for 2 mins.
3. On their Worksheets, students note what you think it would be like to do an hour of bike or treadmill and an hour of resistance exercises. How is Peggy's experience different from how students might exercise on Earth.

Between groups:

Check and tidy the table. Make sure used worksheets are set aside.

At the end:

Return all materials to the pick-up point. Put the chairs back.

Setup for Station 4 (1 copy needed)

Sleep

Materials
(on the table)

1. Worksheets for Workstation 4.
2. 2 sticky-backed hooks attached to the wall at shoulder height.
3. 2 tethers or string.
4. 2 large safety pins.
5. A sleeping bag or large trash bag.
6. A large astronaut doll and air pump if provided (blow it the doll with the air pump).

Directions for students

When a group comes to the workstation, give them a Worksheet for Workstation 4. These are their tasks. Help them where needed.

1. Start by tethering the 'sleeping bag' to the hooks on the wall.
2. Float your astronaut doll into the sleeping bag. Remember that he/she is weightless.
3. If the sleeping bag moves (starts floating away from the wall) what keeps it from floating off down along one of the ISS 'corridors'?
4. Remove the doll from the sleeping bag.
5. How hard would it be for a person to climb into a sleeping bag attached to the wall? (Don't try it).
6. In space, what difference would it make if the sleeping bag was tethered to the ceiling or to the floor?

Between groups:

Untether the sleeping bag. Remove the astronaut from the sleeping bag.

At the end:

Deflate your astronaut. Return all materials to the pick-up point.

Workstation for Station 1 (class set needed)

Meal Planning / Dehydration station

Pick up a Worksheet for Workstation 1.

These are your tasks.

In pairs, choose a different meal to design (breakfast, lunch, dinner or snack). Note the meal you are creating below.

....

From the poster and/or from the dried food on the table, choose items which would make a balanced, healthy meal.

....

....

....

Which foods on the poster can be dehydrated or powdered? Is there anything on the poster that you think can't be prepared for the space station? Note those below:

....

....

Do you think that fresh foods are available on the Space Station?

....

....

If there's a dehydrator, figure out how it works. What does food look like when it's dehydrated? What would you have to do before you could eat it?

....

....

....

Worksheet for Station 2 (class set needed)

Vacuum sealing / Food tasting

Pick up a Worksheet for Workstation 2.

Work in pairs. These are your tasks.

Spoon a small amount of dehydrated food into a bag. Then vacuum seal the bag using the vacuum sealing unit(s). How good is the air removal from the bag? How long do you think the food will keep?

....

....

There should be some rehydrated food in small containers for you to try. Can you tell by looking if the food is rehydrated? Try a little. How does it taste? Does it need more water?

....

....

How would you feel about eating dehydrated food every day?

....

....

Exercising in Space

Worksheet for Station 3 (class set needed)

Exercise in Space

Pick up a Worksheet for Workstation 3 and a copy of Peggy Whitson's journal entry.

Here are your tasks:
Start by reading Peggy Whitson's journal about exercising in space.

Now, there are 2 exercises to do. Try and do at least 2 of them.

1. Sitting on a chair, raise your legs and 'run' for 2 mins as if you were on a treadmill.
2. Sitting on a chair, raise your legs and 'pedal' for 2 mins as if you were on an exercise cycle.
3. Standing facing a wall, with your feet a little more than arms-length away, place your hands flat on the wall at shoulder height. Push outwards from the wall until you are upright, then release. Repeat for 2 mins.

Below, record, what you think it would be like to do an hour of bike or treadmill and an hour of resistance exercises every day.

....

....

....

How is Peggy's experience different from how you exercise on Earth?

....

....

....

....

Station 3 – Exercise in Space (class set needed)

Read Peggy Whitson's Journal Entry

Each Station crew member is scheduled **for an hour of cardio** (either treadmill or cycle ergometer) and **an hour of resistive exercise** (the equivalent of weightlifting) each day while we are on orbit. With these exercises, we are trying to minimize the negative physiological effects of living in a microgravity environment, where the lack of gravity for just the normal "walking or sitting around," means that our muscles and bone are deteriorating at faster than normal rates as compared to on Earth.

Image at right: Commander Peggy Whitson exercises in the Destiny laboratory on the International Space Station. Image Credit: NASA

I like to exercise, but the additional incentive to reduce these negative physiological impacts of living in space drive me to work out regularly. Returning to a normal gravity environment after a 6-month mission was challenging last time, in spite of the fact that I worked out routinely on my last mission as well. So, the desire to be able to walk and function normally when I return is a good motivator. A more real time motivator while I am up here is the need to be ready for a space-walk. For this mission I have been lucky enough to be able to participate in 3 space walks (EVAs). Being in the pressurized space suit for 7 hours, while trying to accomplish hand-intensive assembly or repair tasks, is another huge motivator for me (don't want to look weak while everyone is watching!). My motto when it comes to EVAs is that "you can never be too strong."

Successful long duration expeditions, whether to the poles of our Earth, the peak of a mountain, below the ocean, or up here in space, require a positive outlook. I advise rookie crew members that the self-knowledge of what things can keep you happy and help maintain a positive outlook is a critical aspect of preparation for long duration space flight. There is a psychological aspect of exercise that I value, both personally, as well as, for the overall mission goals. Both here on orbit or (even more so) on the ground, I use exercise as a stress reliever (Peggy gets cranky without exercise). I always feel more relaxed after working out. While I have never been a big believer in that whole endorphin thing, I do get a sense of satisfaction from working out that positively lifts my attitude. So, for me, exercise is not only a critical physical component to life up here, it has an important psychological component too.

Worksheet for Station 4 (class set needed)

Sleep

Pickup a Worksheet for Station 4.

These are your tasks.

1. Start by tethering the 'sleeping bag' to the hooks on the wall.
2. Float your astronaut doll into the sleeping bag. Remember that he/she is weightless.
3. If the sleeping bag moves (starts floating away from the wall) what keeps it from floating off down along one of the ISS 'corridors'?
4. Remove the doll from the sleeping bag.

How hard would it be for a person to climb into a sleeping bag attached to the wall (a) on Earth and (b) on the Space Station? (Don't try it. Just note your answer below):

....

....

....

In space, what difference would it make if the sleeping bag was tethered to the ceiling or to the floor?

....

....

....

The ISS: Who's Up There?

Subject/Grade Level:	Space and the Solar System / Middle School (Grades 6-8)
Lesson Objective(s):	Students use the information on the ISS-ABOVE to further research into the astronauts currently and formerly on the International Space Station.
Materials:	• ISS-ABOVE - connected and running • Access to the internet for students • Wall map of the world • Push pins
Standards and Objectives:	Human Environment Interaction: Explain how the physical and human characteristics of places and regions are connected to human identities and cultures. **Questioning:** • Develop compelling questions that promote inquiry around key disciplinary concepts and embedded enduring issues **Evaluating Sources:** • Identify and utilize evidence to seek solutions to questions. **Communicating** • Construct viable arguments, relevant explanations and/or public demonstrations that convey ideas and perspectives.
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 for students' research on astronauts currently or formerly on the ISS.
Skills Needed	Students will explore motivations and pathways that drive astronauts to take up a career in space exploration.

ENGAGEMENT

Make sure you have the ISS Above Installed so you can see the list of astronauts currently on the ISS above. For example, below is the image of the Expedition 54 Crew as of January 2018. The screen updates as crew members switch out every 3 months:

Questions

1. Where are the astronauts from? (Country – Space Agency: USA – NASA; Russia – Roscosmos; Japan – JAXA)
2. What's the significance of the badge with the yellow border? (This is a mission patch with the names of the astronauts and the mission number. The astronauts wear that patch)
3. There are 15 flags below the badge. What's the significance of those? (These are the 15 countries that collaborated to build the ISS)

EXPLORATION

Activity: Research backgrounds of each of the astronauts that are on the ISS.

In addition, the following prior ISS astronauts reflect diversity/have specific characteristics:

- Peggy Whitson (female Commander on the ISS)
- Jose Hernandez (11-time applicant)
- Scott Kelly (One-Year Mission, twin of Mark Kelly, astronaut)
- Sunita (Sunny) Williams (female Commander on the ISS)
- Anousheh Ansari (self-funded, first Iranian on the ISS)

Students work in pairs to complete the details on the worksheet for each astronaut they choose. Students should research a minimum of 3 astronauts and may use the additional sources to find astronauts other than those mentioned above that have been on ISS missions (they will have to really look at the bios to establish that).

Ideally, students will focus on NASA trained astronauts, so that they can go on the map.

They will:

- Research their background, careers, how long they have been in the program. https://www.nasa.gov/astronauts and https://en.wikipedia.org
- Uncover how many different educational and work backgrounds they come from: army, navy, air force, researchers, medical doctors, teachers.
- Use a pushpin map to mark where the crew members are from.
- Research what physical requirements are needed to be on the ISS? https://astronauts.nasa.gov/content/broch00.htm
- What's available from NASA for them? An exploration of https://www.nasa.gov/audience/forstudents/index.html

Additional sources:

https://en.wikipedia.org/wiki/List_of_astronauts_by_name

https://en.wikipedia.org/wiki/List_of_astronauts_by_year_of_selection#1997

http://www.cbsnews.com/network/news/space/home/flightdata/personnel.html

EXPLANATION

By researching the backgrounds of the astronauts, students can see what it takes to become one educationally and physically, and what other useful skills could be utilized in space.

ELABORATION

Have students pick the astronaut they best relate to. They can either:

1. Create a short presentation about their astronaut and why they believe they wanted to join the space program and why they relate to them.

OR

2. Write a letter to the astronaut they relate to the most.

Letters can be sent to:
Astronaut Office/CB
NASA Johnson Space Center
Houston, TX 77058

EVALUATION

Students can clearly articulate their analysis of the diversity of astronaut backgrounds (also including that astronauts come from many countries).

Ask students to write an essay about themselves in the future, when they've just been accepted on the astronaut training program at NASA. They should write their own bio up to that point. Also, they should cover what are they're now looking forward to.

Student Worksheet – Living in Space: Who's Up There?

Part 1: Review the following online sources and pick 2-3 astronauts to research. Record their details on the other side of the worksheet.

Some astronauts you can choose (pick 2-3 to research):

- The US astronauts on ISS right now (see your ISS-ABOVE screen.

Also consider:

- Peggy Whitson (female Commander on the ISS)
- Jose Hernandez (11-time applicant)
- Scott Kelly (One-Year Mission, twin of Mark Kelly, astronaut)
- Sunita (Sunny) Williams (female Commander on the ISS)
- Anousheh Ansari (self-funded, first Iranian)

Or, pick your own. Just make sure they're part of the NASA program (especially if your Russian isn't all that good).

URLs:

Places to look for lists of astronauts:

https://en.wikipedia.org/wiki/List_of_astronauts_by_name

https://en.wikipedia.org/wiki/List_of_astronauts_by_year_of_selection#1997

https://www.nasa.gov/astronauts (for the current ISS astronauts)

http://www.cbsnews.com/network/news/space/home/flightdata/personnel.html (bios from an earlier, recent, mission)

https://en.wikipedia.org (you'll need a name to search for them on Wikipedia, but most astronaut bios are out there)

Gather the details needed for the tables on the other side of the sheet.

If you have time, explore some more:

https://astronauts.nasa.gov/content/broch00.htm (what do astronaut candidates need to be considered for NASA training)

https://www.nasa.gov/audience/forstudents/index.html (how can I engage with NASA)

NOTE: More than 100,000 people work for space agencies around the world to support the ISS, as well as more than 500 contractor facilities in 37 US states and 16 countries. 68 countries have been involved in research onboard the station.

Student Worksheet – Living in Space: Who's Up There?

Part 2: Complete a bio synopsis for each astronaut you research in detail (you should do 2-3 bios). Your list of online sources is on the other side of the sheet.

Name		Name		Name	
Born (place, year)		Born (place, year)		Born (place, year)	
Education		Education		Education	
Career		Career		Career	
Year joined NASA		Year joined NASA		Year joined NASA	
Missions		Missions		Missions	
Family		Family		Family	
Hobbies		Hobbies		Hobbies	

Cut out your bio synopses and add them to the push pin map.

Activities

The following activities are provided for individual, small group or even class projects.

Activity 1: The brightness of astronomical objects

Activity 2: Other Satellites (Iridiums)

Activity 3: Journey to the ISS

Activity 4: Students Experiments on the ISS

Activity 5: What do ISS Astronauts Do All Day

Activity 6: The One-Year Mission

Activity 7: Design Your Space Bedroom

Activity 8: Views of the Earth and the ISS

The activities are for student use (namely, no teacher notes are provided). Students should be able to follow the activity notes, assuming they have all the required resources to hand.

Activity #1

What you need for this activity

- Graph paper.
- Activity #1 Worksheet and information sheet.

Topic: How is brightness of astronomical objects measured?

Activity:
Read **Astronomical Objects – Brightness/Distance from Earth** on the other side of this sheet.

Worksheet:
What surprised you about the brightness scale or the brightness of individual objects?

....

....

....

The ISS is often VERY bright. At the right time of day (dawn or dusk) if it is passing overhead, it will be the brightest object in the sky (unless the Moon is up).

Copy the brightness scale and extend it to -13 on the left. Try and make it as wide as possible inside the box. Now write in all the objects in the table on your graph (you can leave the Sun out).

Astronomical Objects – Brightness/Distance from Earth

How is brightness measured?

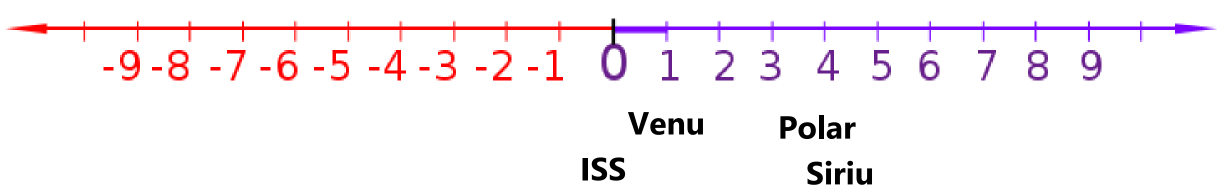
Major objects in the sky are given a brightness number. For example, the Sun is -26.74 – that's its <u>magnitude</u>, Venus is -4.89. The Pole Star (Polaris) is 1.47.
Does that seem strange to you? The Sun is the brightest object in the sky but has the lowest number.

The scale appears to work 'in reverse' - objects with a negative magnitude (on the left of the scale) are brighter than those with a positive magnitude (on the right of the scale. The 'larger' the negative value, the brighter the object is.

It's even weirder than that. Let's take two objects that are about 1 number apart – Venus at -4.89 and the ISS at -5.90. Which is brighter? The ISS. And how much brighter is it? 2.5 times brighter. Each point on the scale is 2.5 time brighter than the one to the right.

The brightness scale is not LINEAR (not a straight line on a graph). It's LOGARITHMIC and grows steeply (just like exponents do – 10^1, 10^2, 10^3 – each is bigger than the number before by a factor of 10). On the brightness scale, the factor is 2.5 (not 10).

Bright -- Dim



Have you ever seen Venus in the sky (look near the horizon close to the Sun at sunrise or sunset)? At its brightest, it's bright. The International Space Station at its brightest is even brighter.

Activity #2

What you need for this activity:

- Access to the internet
- Scratch paper

Topic: Iridium Flares

There are satellites orbiting the Earth called Iridiums. They are communications satellites and when their solar panels catch the sunlight at just the right angle they "flare" up and become really bright for just a few seconds. The photo shows an Iridium flare with the Milky Way in the background.

PHOTOGRAPH BY BABAK TAFRESHI FOR NATIONAL GEOGRAPHIC

Activity:

If you want to find out when you might next see one, go to
www.heavens-above.com/IridiumFlares.aspx

In the top right-hand corner is a box for your location (it usually says **Unspecified**). Click and enter the city nearest your location. The page will calculate your latitude and longitude.

Note your longitude and latitude on your scratch paper.

At the bottom, click the **Update** button. The table will now show when and how bright a flare will be in your sky. Look for the highest and second highest negative number (e.g. -3.8 is brighter than -2.4).

From the example below, which might be easier to see?

Time	Brightness	Altitude	Azimuth	Satellite
Nov 18, 18:20:59	-2.4	32°	166° (SSE)	Iridium 68
Nov 21, 04:46:35	-3.8	22°	176° (S)	Iridium 98
Nov 22, 18:05:50	-0.3	33°	178° (S)	Iridium 72
Nov 23, 17:59:47	-3.7	33°	177° (S)	Iridium 62
Nov 24, 17:53:44	1.0	33°	177° (S)	Iridium 65

If you live in a built-up area, it might be easier to spot the one on Nov 23rd as it's higher in the sky and it's in the early evening. The one on Nov 21st is slightly brighter but it's at 4:46am!

> Note your chosen iridium flare on your scratch paper. Write down the Day and Time, Altitude and Azimuth.
>
> Draw a circle and mark the compass positions for N, S, E and W. On your circle mark which way to look for the appearance of the flare. Draw a line from the center of your circle and mark roughly where you will look in the sky (in the example above, Nov 23 is about 1/3 the way between the horizon (your circle) and the straight up position (the center of the circle), so your mark would be about 1/3 of the way from the circle edge to the center.

If you click on the day/time you will see a sky map of where the flare will appear.

On the Day

Make sure you know which way is North from your home. If you don't know, how would you work that out without a compass?

To see the flare, you'll have to look in the right direction in the sky (Azimuth). Use your circle diagram with your N pointing towards North. You need to look in the direction of your line and up at the Altitude angle.

About 2 minutes before the flare, take your family outside and have them look in the right direction. Tell them that they'll see something very special. It only lasts a few seconds, so keep them focused!

Wow, there's the flare. Now you can tell them what it is and what causes it.

Activity #3

What you need for this activity

- Access to the internet.
- Scratch paper or a Worksheet for your notes.

Topic: Journey to the ISS

Currently, astronauts travel to the ISS in a Soyuz module. When the live video shows on your ISS-ABOVE, the rear-facing camera shows two docking stations. The one in the front is the Russian Soyuz module (for transporting astronauts to and from the ISS) and the one at the back is a Russian Progress module (very similar to the Soyuz, but used for resupplying the ISS with food and taking trash away.

Soyuz launch preparation

Read the article below about the Soyuz and its component parts:

https://www.nasa.gov/mission_pages/station/structure/elements/soyuz/launch.html

Watch a Soyuz launch

Real-time launch of a manned Soyuz flight to the ISS:

https://www.youtube.com/watch?v=X5BD8mLa0Nk (10:12min)

Follow the docking with the ISS (you may occasionally see a docking on your ISS-ABOVE).

https://www.youtube.com/watch?v=scGc1NS_IV8 (8 min)

Going home

Sunny climbs into the Soyuz as if she was going home.

https://youtu.be/SGP6Y0Pnhe4 Start the video at 24:30min (close to the end)

Undocking and landing

https://youtu.be/1jAHScJe0u0 (2:51min)

When is the next Soyuz flying to the ISS?

Find the next Soyuz lunch – is it carrying people? What about the one after that?

https://spaceflightnow.com/launch-schedule/

Worksheet

See if you can answer these questions.

1. Where does the Soyuz launch from when it's bringing new crew to the ISS?

2. How many people can it carry?

3. What happens during the flight from the point of take-off?

4. Where is the Soyuz module on the rocket?

There are many other docking points on the ISS, other than the two you can see on the ISS-ABOVE (HDEV) video. There is an additional Soyuz module on the Russian side of the ISS, plus other resupply vehicles.

The future

In the next year or so, the US will have capability to take astronauts to the Space Station, but it's a race against time, because the contract between NASA and ROSOSMOS (the Russian Space Agency) comes to an end in 2018:

https://blogs.nasa.gov/commercialcrew/category/international-space-station/

The good news is that the docking station that will be receive new US Commercial Crew modules from SpaceX and Boeing, was reconfigured in 2016 and will have additions made to it shortly in readiness for test flights in 2018.

Activity #4

What you need for this activity:

- Access to the internet
- Scratch paper, drawing paper or card

Topic: School/student experiments on the ISS

The ISS is a huge, orbiting laboratory. As well as research into how humans can survive in space and how to prepare for long-distance space missions, the ISS hosts a wide range of science and technology experiments. Companies, Universities and Schools can apply to NASA to put an experiment on the Space Station.

The experiments usually spend a fixed amount of time on the ISS and they may even be returned to Earth for further research. The ISS has data collection and communication capabilities to monitor experiments and convey the data to Earth for scientists and researchers to work with that data.

In some ways, it's just like conducting an experiment in your school lab, except that it's conducted in microgravity and you can't actually touch it! The good news is that the astronauts are trained to install and run the experiments – it's an important part of their job.

Experiments in general

Read the article below about 12 cool experiments on the ISS. Which one is your favorite?

http://mentalfloss.com/article/59639/12-cool-experiments-done-international-space-station

One experiment that you're connected to through your ISS-ABOVE is the HDEV (High-Definition Earth Viewing experiment). These are the four commercial cameras (you could buy them in a store or online) that are fixed to the underside of the ISS and provide the video of the Earth that you see on your ISS-ABOVE. The 'experiment' was designed to test the cameras to see if they could stand up to cosmic radiation. They launched in 2015, so they're doing pretty well.

Worksheet

Design your experiment

On a typical resupply vehicle, there will be some experiments going to the ISS. In the article below, see if you can find the two experiments designed by school students:

> https://www.wired.com/story/iss-resupply-saturday-science/
>
> Here's the technical description of one of those experiments:
>
> https://www.nasa.gov/mission_pages/station/research/experiments/2717.html

For students to get an experiment to the ISS, they have to go through the same application process as anyone else. This is as close as doing 'real' science as you can get – competing for space on the ISS with commercial companies.

A number of experiments come from Middle Schools!

Activity: What experiment would you send to the ISS if you could?

Remember that it's important that there's a good reason why you would want to run the experiment in microgravity.

For example, a number of experiments look at how well plants grow in space. Why might this be important?

Brainstorm some ideas for an experiment on your scratch/drawing paper.

1. What would the experiment be designed to find out?
2. What would you need to send to the ISS?
3. How would you measure the results of your experiment? Do you need hourly or daily measurement, or just at the end of the experiment?
4. Does the experiment need to come back to Earth? (If not, it will be placed in a returning resupply vehicle with trash, which burns up completely on re-entry.)
5. Draw a diagram of your experiment. Don't forget that experiments on the ISS are always contained in a sealed box.

Activity #5

What you need for this activity:

- Access to the internet.
- ISS-ABOVE online and working.
- Scratch paper or a Worksheet for your notes.

How do Astronauts take baths in Space

Topic: What do astronauts on the ISS do all day?

Let's start with what <u>you do all day</u>. Think of a typical school day and then, on the Activity Worksheet, fill in the timetable for your day from when you get up to when you go to bed. Include time at home, what you're doing, travel, school hours, maybe some after-school activity or clubs, homework, what you do in the evenings.

What about astronauts?

Planning an astronaut's day on the ISS is quite hard. Because they are orbiting every 92 minutes, they see a day and night cycle in that timeframe, just over 1½ hours for a complete 'day' or 15 ISS 'days' per Earth day. Of course, astronauts need to use a normal 24-hour day for their schedule, so that they get regular hours for work, meals, relaxation and sleep, regardless of whether they happen to be in daylight or darkness.

ISS Mission Control, Houston

The ISS is also managed from control centers operated in different countries. It's not the International Space Station for nothing. There are currently 7 mission control centers, but the most important ones are in the US (at NASA Johnston in Houston, TX) and one in Russia (at Roscosmos, located in Korolyov, quite close to Moscow).

If you look at your ISS-ABOVE world map screen you can see what time it is on the ISS (at the top of the screen above the map). How many hours ahead of you are they? What time zone is that? If you guessed UTC (or GMT) for the time zone, you're right. The ISS operates on the 0^{o} longitude time zone, mainly because it's in between those two major mission control centers in the US and Russia.

Also look at the orbit track. Roughly how much of their day is in sunlight and how much is in darkness (this varies a lot – sometimes the ISS is in sunlight almost all the time). Based on where they are, can you guess roughly when daylight/dark will start and finish?

Now, go back to your worksheet to create your astronaut's schedule.

Activity #5 Worksheet

Part 1: Create your schedule

Note whether it's light or dark at each time, based on when sunrise and sunset is. Now fill in the left-hand side of the schedule with your timetable for a typical school day.

Part 2: Create your astronaut's schedule

One of your family friends is an astronaut on the ISS. Create his/her schedule for tomorrow. Make sure you align their time with yours (for example, if you're on Eastern time and it's 6am, it's 5 hours ahead on UTC/ISS time, so 11am). Note how many hours ahead they are in **Their Time zone**. Now list the equivalent times in their **Time** column for the whole day.

For the **Light/Dark*** column, figuring out if the ISS in darkness or light at any given time is tricky. See the notes on the prior page and use the ISS-ABOVE world map to make your best guess. (Hint: there are usually about 15 light/dark periods every 24 hours!)

Spending Free Time

On their schedule, you'll need to include time for meals, meetings with Mission Control, maintenance of the space station, experiment management, photography of the Earth, exercise (not too close to mealtimes), health-checks, journaling, down-time. Hint: astronauts wake at 6am and go to bed at 9:30pm UTC time.

When will you be able to talk with them during your day?

Follow up:

When you've completed your timetable, read some additional information below:

Dressing to Go Outside and Play

- Space walks to work on the outside of the Space Station, can take up to 7 hours and require that the astronauts re-compress for an hour afterward.
- Astronauts are also often asked to give interviews to update those of us back home of their progress and to help us understand what life is like for them on the Station.
- They also must take account of when certain satellites are "up" so that they can communicate with home and use certain equipment.
- They photograph changes on Earth including fires/storms and other changes.
- They study how humans behave in isolation and confinement.
- Of course, astronauts do get some free time, during which they usually like to call their families, watch movies and check their e-mail, or social media!

Now find out what the astronauts did on a single day recently:
https://blogs.nasa.gov/stationreport/

Here are some extra activities that were part of the One-Year Mission (Activity 6):
https://www.nasa.gov/mission_pages/station/research/research_information.html

Our schedule (Complete in pencil!)

My Name:		**My Time zone:**	**My Astro Buddy's Name:**		**Their Time zone:**
					UTC (my time zone + ____ hours)
Time	**Light/Dark**	**Task**	**Time**	**Light/Dark***	**Task**
6:00am					
7:00am					
8:00am					
9:00am					
10:00am					
11:00am					
12:00 noon					
12:30pm					
1:00pm					
2:00pm					
3:00pm					
4:00pm					
5:00pm					
6:00pm					
7:00pm					
8:00pm					
9:00pm					
10:00pm					
11:00pm					
12 midnight					
1:00am					
2:00am					
3:00am					
4:00am					
5:00am					

Activity #6

What you need for this activity:

- Access to the internet
- Scratch paper

Topic: One Year Mission – Scott Kelly and Mikhail Kornienko

Astronauts usually spend 6 months on the ISS before they fly back to Earth. Every 3 months, 3 of the crew return to Earth and three new crew members fly up on the Soyuz to the Space Station. This allows an overlap of 3 months for crew members who have already been on the ISS for 3 months, with 3 new ones.

However, a mission to Mars would be around 30 months, so 5 times longer than an ISS tour of duty. Although much is known about the physical effects of staying in space for 6 months, it is less clear what happens over longer periods.

The One-Year mission used 2 astronauts, Scott Kelly of the USA and Mikhail Kornienko of Russia, staying on the ISS for 12 months, to gather data about their physical and behavioral wellness.

So, what are the risks?

https://www.nasa.gov/hrp/bodyinspace

Name the 5 risks:

Which of these are most serious (from your point of view)?

It's no co-incidence that Scott Kelly was chosen for the One-Year mission. He has a twin! This meant that Scott and his twin, Mark, could take the same measurements and provide the same samples at the same time, so that they could be compared.

The full results for the One-Year mission are not yet in, but this document shows what tests were selected and how often they are being done:

Mark and Scott Kelly

https://blogs.nasa.gov/ISS_Science_Blog/wp-content/uploads/sites/207/2016/03/One-Year-Return_20160307_large.jpg

It will be a while until all the data is collected and we see results.

Read the commentary below by one of the managers in the Human Research Program. There's also a video of Scott Kelly talking about the mission:

https://www.space.com/32160-one-year-mission-astronaut-science-continues.htm

Being on the Space Station, even for a year, is not the same as going to Mars, so NASA plans to add 15-18 new projects to further explore this issue, building on the results from the One-Year mission.

If you could go to Mars, would you go? What would interest you about the experience? What would you miss in leaving Earth for so long?

....

....

....

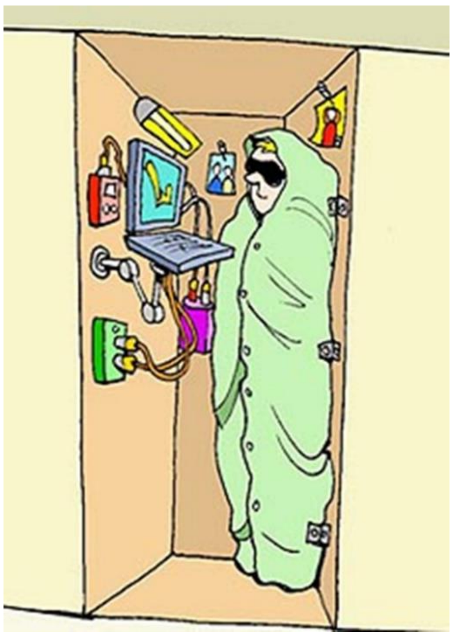
....

Activity #7

What you need for this activity:

- Access to the internet.
- Scratch paper or card or drawing paper, pencils, crayons, other art materials.
- Activity #7 Worksheet.

Topic: Going to Mars: design your space bedroom



Cartoon by kind permission of Fred Sayers

Imagine being away from home for 6 months. Imagine being on an orbiting satellite, where every pound of payload costs money to get up there.

Up to now, astronauts have been allowed up to 1.5lbs of personal items, although some things such as Chris Hadfield's guitar or Scott Kelly's gorilla suit were transported specially, so not part of their packing!

Sunny Williams shows you her room on the ISS:

https://youtu.be/SGP6Y0Pnhe4 (play the first 2 minutes).

Maybe, by the time you journey to Mars, you'll get a little more room. The journey to Mars (6-9 months) will take a little longer than a typical stay on the ISS (6 months).

Activity: You're going to choose what to take with you on your journey to Mars that will help you enjoy your non-working times, remind you of home and keep you connected to your fellow travelers and your family and friends.

Go to your **Worksheet** and complete the Design Your Space Bedroom task.

After you complete your bedroom design, you can watch some more of Sunny's video to see how astronauts brush their hair and teeth, go to the toilet, use their kitchen to prepare food and take care of exercise and fitness. If you have time, watch the whole of Sunny's video. She's a great tour guide!

Activity #7 Worksheet

Part 1: What are you going to take with you?

List the twenty most important things you want with you for the journey. (Assume that things like toothbrushes, computers, food etc. are all provided).

1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	14.
15.	16.
17.	18.
19.	20.

Part 2: Design your bedroom

OK, now you have to fit all that into your room. Use your scratch paper or a piece of drawing paper to **sketch your room**.

Don't forget that you'll have 3 walls, a ceiling, even the floor for storage and don't forget your tethered sleeping bag! You can assume you'll have light, folding doors, for privacy.

Write a description of how your items are stored (so that they don't float away!)

....

....

....

Activity #8

What you need for this activity:

- The ISS-ABOVE connected and working
- Access to the internet.
- A world map.
- Activity #8 Worksheet.

Topic: Views of the Earth and the ISS

If you've been keeping an eye on your ISS-ABOVE, you've probably seen some stunning images of the Earth, sunrises and sunsets, shots with parts of the ISS in view, maybe even the robotic Canada arm, moving into position, or a Soyuz module docking or undocking.

Every few seconds, the location that is directly below the ISS with display in the bottom left corner of the screen (see below).

Make sure you can tell the difference between the forward-facing camera shots, the down-facing views and the rear-facing video (this is the one where you see the Soyuz docking stations).

Given that $^{2}/_{3}$rds of the Earth is covered with oceans, you'll see a lot of water and a lot of clouds, but you'll also get great views of land and coastlines.

Apart from video from HDEV (the High-Definition Earth Viewing experiment) which shows on your ISS-ABOVE, there are other cameras on the outside of the ISS and astronauts take photos from the cupola (see right), either for their own interest, or because of specific requests from scientists and researchers.

Activity 8 Worksheet:

Part 1: Where is the ISS?

The HDEV system doesn't display video at night, so the images are useful for identifying terrain and weather patterns, snow and ice.

Below is an image the HDEV wouldn't capture: a nighttime view of the Earth (photos like these are taken by astronauts by using a Nikon camera set to about ½ second exposure).

Write down everything you notice about this photo:

....

....

....

....

What part of the world is this a picture of (HINT: it's upside down from how you'd normally see it and it's not in the US).

....

....

Part 2: Images of the Earth online

Google **Images of the earth from the space station**

Take a look at the full-screen images (most are high-resolution and very detailed). See what you can identify from a few of these photos.

Part 3: Using your ISS-ABOVE to look at the Earth

Use your ISS-ABOVE to view live video from the HDEV. This is what it looks like traveling 5 miles per second 250 miles up.

Is it cloudy? Are you over oceans? Can you see land? Are there interesting cloud types? Take your time and look very closely at the images and see what you can identify.

Your notes:

Where was the ISS over during your observation? ....

What did you see? ....

....

....

....

Additional Resources

About the ISS

- The International Space Station (ISS) is a habitable human-made satellite that orbits Earth at an altitude of between 330 km (205mi) and 435 km (270 mi).

- The ISS comprises pressurized modules for astronauts to live in, external trusses for propulsion, solar arrays for power and many other amazing components.

- The first part of the ISS sent to space was the module called Zarya. It was launched into space on a Russian Proton rocket on November 20th, 1998. Zarya provided propulsion, attitude control, communications and electrical power.

- Two weeks later, NASA launched a module called Unity aboard Space Shuttle Endeavour, successfully attaching it to the Zarya module. The Unity module was equipped with all the requirements for long-term human living.

- The ISS is now the largest artificial body in orbit. It is 357 ft. (109 m) in length, making the space station's area span about the size of an American football field.

- The space station weighs nearly 925,000 pounds (419,500 kg's).

- The ISS has 2 bathrooms, a gym and more room than a 6-bedroom house.

- The space station is nearly 4 times bigger than the Russian space station Mir and about 5 times as large as the U.S. Skylab.

- The ISS was built to be a space environment research laboratory and observatory, where crew members could conduct experiments in many scientific fields including: biology, human biology, physics, astronomy, and meteorology.

- The station also provides valuable opportunities to test spacecraft systems and equipment and act as a staging base for possible missions to the Moon or Mars.

- Approximately 3.3 million lines of computer code on the ground supports over 1.8 million lines of flight software code for the ISS.

- Over eight miles of wire connects the electrical power system on the ISS.

- The first ISS crew mission called 'Expedition 1' launched on a Russian Soyuz, October 31, 2000. The 3 Russian cosmonauts docked and entered the ISS on November 2nd, 2000. The space station has been continuously occupied since, making it the longest continuous human presence in space.

- The ISS has been visited by astronauts and cosmonauts from 15 different nations. An expedition can last up to six months with crew numbers typically 6 people.

- On average the ISS travels at 27,724 kilometers (17,227 mi) per hour.

- The space station completes 15.5 orbits a day, which means the crew members on board the station experience a sunrise or sunset every 92 minutes.

- The ISS program is a joint project that involves 5 space agencies. NASA, of USA, Roskosmos of Russia, JAXA of Japan, CSA of Canada and ESA made up of agencies from France, Brazil, Malaysia, South Korea and Italy.

- The Cupola module in the ISS has a 7-window observatory area which has been compared to the 'turret' of the Millennium Falcon in the movie Star Wars.

- The ISS is arguably the most expensive single item ever built. As of 2010, the cost of the station is believed to be $150 billion.

- With the naked eye, the ISS can be seen from nearly every area of Earth at some point in time, it appears as a slow moving bright white dot in the night sky.

Courtesy of http://www.sciencekids.co.nz/

Brightness/distance table

Also included in Activity 1.

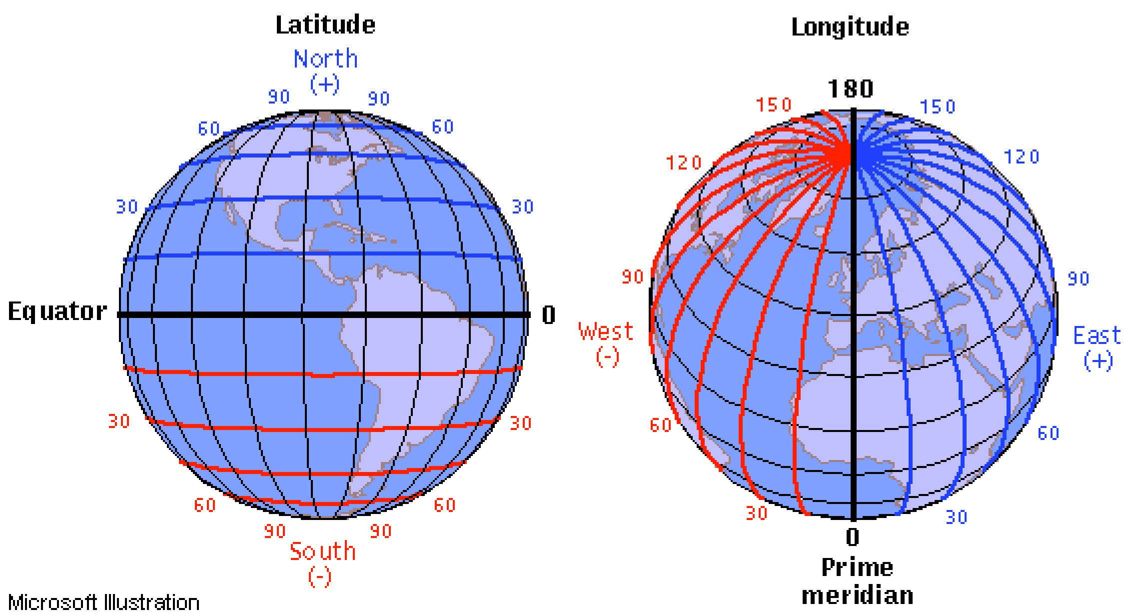
Object	Magnitude (brightness)	Distance at its closest (from Earth)
Sun	-26.74 (about 400,000 times brighter than the full Moon)	93 million miles
Full Moon	-12.90 (when at its closest)	238,900 miles
An Iridium flare (see Activity 2)	-9.50 maximum. Iridium flares are satellites in Earth orbit. When their solar panels reflect sunlight, they “flare” up for a few seconds and then fade away again – very dramatic. These satellites are being replaced with new ones that are less reflective by 2018. Now’s the time to see one. (See Activity #2).	483 miles
International Space Station (ISS)	-5.90 when closest to Earth and illuminated by the Sun. Can be seen at dawn and dusk only	254 miles
Venus	-4.89 maximum brightness as a crescent	24 million miles
Jupiter	-2.94	365 million miles
Mercury	-2.45 when on the far side of the Sun	48 million miles
Sirius	-1.47 Sirius is the brightest star (other than the Sun of course)	50.62 trillion miles or 8.61 light years
Vega	0.3	147.3 trillion miles or 25.05 light years
Polaris	1.98 (the Pole Star)	2,550 trillion miles 533.8 light years

Latitude and Longitude

Latitude (from the Latin 'latus' meaning broad or wide)
Longitude (from the Latin 'longus' meaning long)

Reproduced from Journey North:
www.learner.org

Latitude and Longitude: Your Global Address
Every location on earth has a global address. Because the address is in numbers, people can communicate about location no matter what language they might speak. A global address is given as two numbers called coordinates. The two numbers are a location's latitude number and its longitude number ("Lat/Long").



Credit: Illinois State University

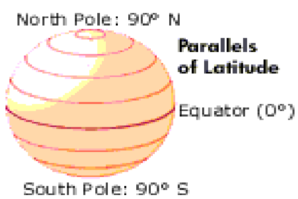
Grid Mapping
Using Lat/Long is different from using a street address. Instead of having a specific street address, Lat/Long works with a numbered grid system, like what you see when you look at graph paper. It has horizontal lines and vertical lines that intersect. A location can be mapped or found on a grid system simply by giving two numbers which are the location's horizontal and vertical coordinates; or, to say it another way, the "intersection" where the place is located).

Grid Mapping a Globe:

Latitude and Longitude lines are a grid map system too. But instead of being straight lines on a flat surface, Lat/Long lines encircle the Earth, either as horizontal circles or vertical half circles.

Latitude

Horizontal mapping lines on Earth are lines of latitude. They are known as "parallels" of latitude, because they run parallel to the equator. One simple way to visualize this might be to think about having imaginary horizontal "hula hoops" around the earth, with the biggest hoop around the equator, and then progressively smaller ones stacked above and below it to reach the North and South Poles. (Can you think of other ways to visualize the parallels of Latitude?)

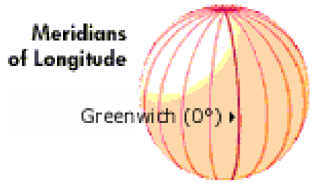


Think about having imaginary horizontal "hula hoops" around the earth, with the biggest hoop around the equator, and then progressively smaller ones stacked above and below it to reach the North and South Poles

Latitude lines are a numerical way to measure how far north or south of the equator a place is located. The equator is the starting point for measuring latitude--that's why it's marked as 0 degrees latitude. The number of latitude degrees will be larger the further away from the equator the place is located, all the way up to 90 degrees latitude at the poles. Latitude locations are given as __ degrees North or __ degrees South.

Longitude

Vertical mapping lines on Earth are lines of longitude, known as "meridians". One simple way to visualize this might be to think about having hula hoops cut in half, vertically positioned with one end at the North Pole and the other at the South Pole.



Visualize hula hoops cut in half, vertically positioned with one end at the North Pole and the other at the South Pole.

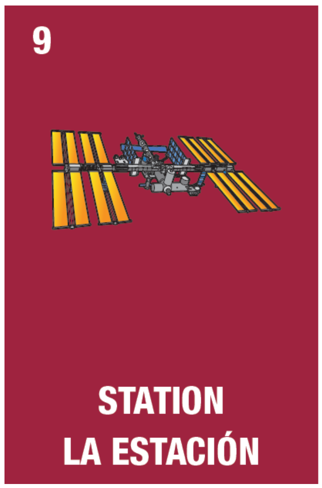
Longitude lines are a numerical way to show/measure how far a location is east or west of a universal vertical line called the Prime Meridian. This Prime Meridian line runs vertically, north and south, right over the British Royal Observatory in Greenwich England, from the North Pole to the South Pole. As the vertical starting point for longitude, the Prime Meridian is numbered 0 degrees longitude.

To measure longitude east or west of the Prime Meridian, there are 180 vertical longitude lines east of the Prime Meridian and 180 vertical longitude lines west of the Prime Meridian, so longitude locations are given as __ degrees east or __ degrees west. The 180-degree line is a single vertical line called the International Date Line, and it is directly opposite of the Prime Meridian.

Astronomical Loteria/Bingo

The Lotería/Bingo was created by the HDEV team at NASA especially for middle school grades! Is consists of bingo boards and cards with space facts on the back of the cards in both English and Spanish. The game needs to be printed in color.

A typical card looks like this (front and back):



A student game board looks like this:

You will find Lotería/Bingo resources at:

https://www.txstate-epdc.net/epdc-post/space-loteria/ (board and card links at the bottom of the page).

Reference and Resource Websites

Check out Space Station Explorers (of which ISS-ABOVE is a proud member) for further engagement with the ISS:

Amateur Radio on the ISS (ARISS)	www.spacestationexplorers.org/ariss
Ants in Space	www.spacestationexplorers.org/antsinspace
Dreamup	www.spacestationexplorers.org/dreamup
Magnitude.io Exolab on ISS	www.spacestationexplorers.org/exolab
ISS-ABOVE	www.spacestationexplorers.org/issabove
Orion's Quest	www.spacestationexplorers.org/orionsquest
Sally Ride EarthKAM at Space Camp	www.spacestationexplorers.org/earthkam
Space Station Academy	www.spacestationexplorers.org/spacestationacademy
Story Time from Space & Science Time from Space	www.spacestationexplorers.org/storytimefromspace
Tomatosphere	www.spacestationexplorers.org/tomatosphere
Zero Robotics	www.spacestationexplorers.org/zerorobotics

Join Space Station Ambassadors, part of Space Station Explorers at:
www.spacestationexplorers.org/partner-programs/spacestationambassadors/

Other sites:

www.nasa.gov/mission_pages/station/main/index.html

www.spotthestation.nasa.gov/sightings/

www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-the-iss-58.html

www.heavens-above.com

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