Canadian Space Agency / Agence spatiale canadienne

Teachers' Guide
Level: High School

The International Space Station in orbit (ISS)

Specs

Brightness	approximately -4 (less than Venus)
Launch Window	5-10 min.
Orbital Altitude	361 km at perigee 437 km at apogee
Mass	approx. 420 000 kg
Dimensions	111.08 m by 89.2 m
Speed	approx. 26720 km/h
Orbital Inclination	51.5947°
Estimated Cost	28 billions
Orbital Period	approx. 90 min.
Observational Visibility	btw 60 N & 60 S
Orbital Type	elliptical

Countries - Canada, Belgium, Brazil, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Russia, Spain, Sweden, Switzerland, the United Kingdom, the United States

Definitions

Altitude	Distance of orbit above the Earth's surface.
Apogee	An Earth - centered orbiting object's farthest point from Earth.
Brightness	Measured in magnitudes (as stars and planets are). Brightness depends on elevation above the horizon as well - objects appear dimmer when close to the horizon because of atmospheric interference.
Circular Orbit	An orbit that has no perigee or apogee.
Elliptical Orbit	An Earth - centered orbit having a perigee (closest approach to Earth) and an apogee (farthest distance from Earth). Most orbits are elliptical or "oval shaped".
Equatorial	Orbit which encompasses inclinations from approximately 0 – 70^{o} N or S (includes most satellites).
Launch Window	Best time of day for launch based on ISS position relative to launch site, among other things.
Orbital Inclination	Inclination is measured in degrees parallel to latitude. It is used instead of latitude to refer to objects in orbit, such as the ISS. It is an angular measurement taken from the Earth's equator.
Orbital Period	The time it takes for an object to complete one orbit.
Perigee	An Earth - centered orbiting object's closest approach to Earth.
Polar Orbit	An object which orbits around the poles. The object's orbital inclination is 90^{o}. The orbit can be circular or elliptical (example: weather satellites).
Viewing	Variations in time of day a satellite, space station or ISS passes. The time ISS

Windows	passes occur each day will vary because our 24-hour day is not evenly divisible by the ISSÆ 90-min. orbital period. The Space Station will appear in the sky a little earlier (or later) on subsequent days and thus move from daytime to nighttime passes cyclically.

Orbital Elements

Distances — Perigee of orbiting element
Apogee of orbiting element

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Orbital Period — The time it takes for an object to complete one orbit

Orbital Types

Circular Orbit — An orbit that has no perigee or apogee

Elliptical Orbit — An Earth - centered orbit having a perigee (closest approach to Earth) and an apogee (farthest distance from Earth). Most orbits are elliptical or "oval shaped"

Special Cases

Polar Orbit — An object which orbits around the poles. The object's orbital inclination is 90^{o}. The orbit can be circular or elliptical (example: weather satellites).

Equatorial — Orbit which encompasses inclinations from approximately 0 - 70^{o} N or S (includes most satellites)

Geostationary or geosynchronous - Satellites orbiting at altitudes of approx. 36 000 km take one day to orbit the Earth. Since they are moving at the speed the Earth rotates, they are positioned over the same location at all times (example: communications and meteorological satellites).

Activities

Junior High or High School

- Have the students trace out a ground track of the ISS orbit (between 51.6^o N and 51.6^o S) on a map. An example of the track on a Mercator Projection is given in the student handout. Because a map is not a three-dimensional projection of the Earth, the track will be an S-curve. Also, the altitude of the ISS will not be represented.
- Compare these two-dimensional representations to a track mapped out on a globe.
- Tie a string around the globe (again, between 51.6^o N and 51.6^o S). This will represent the inclination of the ISS as it orbits around the Earth. Also, the width of the string could adequately represent the altitude of the ISS (the scale is about right).

High School

- Have the students figure out why the ISS can be seen from higher latitudes if its altitude is increased. This concept is illustrated in the student handout (pgs. 2 & 3). In these illustration, we can see that the horizon is tangent to your point of latitude. (You can scale your own Earth from a full Earth, a half, a quadrant, etc.).
- Have the students draw lines from the center of a scaled Earth at angles representing their latitudes, the ISS inclination latitude, and other latitudes. All lines (except for the ISS line) should end at the surface of the Earth.
- Have them extend the ISS line above the surface to a 400 km altitude (based on your scale). The ISS, then, will be a point at the tip of this line.
- Next, have the students draw tangent lines to the points of all the angled lines, as in the illustration. These lines will be the horizons for each latitude. If the ISS (the tip of the point on the 51.6^o line) falls below the horizon lines, it will not be seen. If it is above, it will.

Expand on this activity

Having the students create an illustration like the one below will help them ascertain the altitude the ISS would need to be seen at latitudes outside its inclination limitations. The students can pick a latitude, follow the same procedures of drawing tangent lines, and find the length the hypotenuse line "H" (being the ISS line) would have to be to just meet with the horizon line for that latitude. The altitude at which the ISS would need to be to be seen at that latitude would have to be slightly greater than the length of "H".

Example

If an observer is at 80^o N, what altitude would the ISS have to be for the observer to see it?

In this case, we are looking at the inner triangle B, D, H in the diagram below. We know the length of B (Earth's radius) and the angle of A (angle of B (80^o) - angle of line H (51.6^o)). We also know the angle of P (180^o - (A + M)). Given the angle of P and the length of B, we can find the length of D (tan P = opposite (B) / adjacent (D)). Once we know the length of D, we can use it and B to find the length of H (Pythagorean). The length of H minus the length B (Earth's radius) will equal E - the altitude at which the ISS would have to be to just meet the 80° horizon. So, anything greater than this number would put the altitude right over the horizon to be seen at 80° N or S.

EXAMPLE – ISS VISIBILITY AT 80° N (or S)