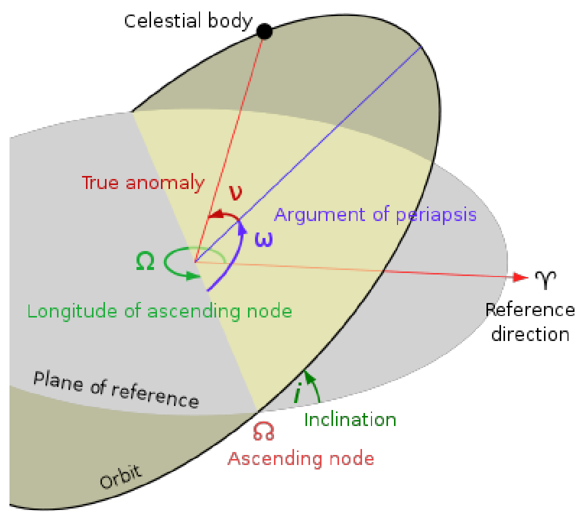
Kerbal Space Program Orbital Parameters:

A brief discussion of some of the parameters in the persistent.sfs file, and what they mean.

Note: Before editing any of the parameters in your persistence file, back it up to a safe location on your hard drive. If alterations made to the persistence file make it unreadable by Kerbal Space Program, the game will **erase the file**.

```
ORBIT {
        SMA = 300812.926347937
        ECC = 0.994822955342685
        INC = 0.10266814243514
        LPE = 90
        LAN = 105.611280243666
        MNA = 3.1415918271443
        EPH = 11.1999997496605
        REF = 1
        OBJ = 0
}
```



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Reference Direction: In the universe of Kerbal Space Program, at UT=0.0, a ray drawn from Kerbin to Kerbol points about 0.09° east of the Reference Direction.
Plane of Reference: The plane of Kerbin's orbit around Kerbol. In Version 0.15+ of KSP Kerbin and the Mun orbit in this plane. Hereafter referred to as the Ecliptic plane.

ECC = Orbital Eccentricity

Orbital Eccentricity is a parameter representing how far from circular the orbital path is. It is the ratio of the semimajor axis to half the distance between the foci of the orbit. For circular orbits, ECC=0. For elliptical orbits, 0 < ECC < 1. For parabolic orbits, ECC = 1. For hyperbolic orbits, ECC>1.

$$ECC = \frac{r_a - r_p}{r_a + r_p} = \frac{1}{cos(\frac{\varphi}{2})}$$

For ellipses, $\mathbf{r_a}$ = Apoapsis radius. $\mathbf{r_p}$ is periapsis radius. For hyperbolas, **φ**is the angle between the approach and departure directions.

Note that all in-game measurements that are shown to a player in Kerbal Space Program are altitudes above the effective surface of the body you are orbiting, not radius measurements from its center.

SMA = Semi-Major Axis (meters)

For a circle, the Semi-Major axis is the radius. For an ellipse, Semi-Major Axis is half the linear distance between periapsis and apoapsis points. In the case of hyperbolas, there are actually two lobes, one of which your spacecraft will never actually travel, and isn't displayed in orbital view. The value of **SMA** is half the minimum distance between these lobes, and is negative. Hyperbolic SMA can also be found by using the first equation below:

$$SMA = \frac{r_p}{1-ECC} = \frac{r_a}{1+ECC} = \frac{r_p + r_a}{2}$$

For elliptical orbits, semi-major axis can also be calculated from a desired orbital period.

$$SMA = \left(\frac{\mu T^2}{4\pi^2}\right)^{\frac{1}{3}}$$

T is the orbital period in seconds**. μ** is the Standard Gravitational Parameter, equal to the Newtonian Gravitational Constant multiplied by the mass of the central body.

LAN = Longitude of the Ascending Node (degrees)

The ascending node is the point in the spacecraft's orbit where it passes through the ecliptic plane in the northerly direction. The longitude of the ascending node is measured counterclockwise as seen from a point north of the ecliptic from the reference direction to the pericenter to the ascending node.

For equatorial orbits, Longitude of the Ascending Node is typically 0°.

LPE = Longitude of Periapsis (degrees)

Also known as Argument of Periapsis. Centered on the pericenter, this is the angle between the Ascending Node and the Periapsis. It is measured along the orbit in the direction of motion.

Since all points on a circular orbit are at the same radius, any value is technically valid for Longitude of Periapsis of a circular orbit. Conventionally, circular orbit Longitude of

Periapsis is typically set to 0°.

INC = Orbital Inclination (degrees)

Orbital inclination is the angle between the plane of the orbit and the plane of the ecliptic. It is measured between the Ecliptic and the orbital plane in a counterclockwise direction as viewed from a point radially outward from the ascending node.

Conventionally, Orbital inclination has a value between 0° and 180°. An object with an orbital inclination of 90° is in a polar orbit. An object with an orbital inclination of >90° is considered to have a retrograde orbit.

EPH = Epoch (seconds)

The time at which the measurements were taken, measured in seconds from UT=0. If you wish to set the position of your spacecraft at the present time, this must be equal to the UT value at the top of the Persistent.sfs file.

MNA = Mean Anomaly at Epoch (radians)

Mean Anomaly is a measure of time since periapsis in terms of the central angle swept by a hypothetical body in a circular orbit whose radius is the semimajor axis of your spacecraft's orbit.

If your spacecraft is traveling towards periapsis, MNA will be negative. If your spacecraft is traveling away from periapsis, MNA will be positive. If your spacecraft is at Periapsis, **MNA=0.** If your spacecraft is in an elliptical orbit and at apoapsis, **MNA=3.1415928**.

$$MNA = \Delta t\sqrt{\frac{\mu}{|SMA|^3}}$$

Δt is the time since periapsis in seconds. **μ** is the Standard Gravitational Parameter, equal to the Newtonian Gravitational Constant multiplied by the mass of the central body.

Body	Radius	Mass	Std. Grav. Parameter
Kerbin	600×10^3 m	5.29×10^{23} kg	3.523×10^{12} m^3 / s^2
Mun	200×10^3 m	9.76×10^{20} kg	6.179×10^{10} m^3 / s^2
Minmus	60×10^3 m	2.65×10^{19} kg	1.766×10^9 m^3 / s^2
Kerbol	261.6×10^6 m	1.75×10^{28} kg	1.168×10^{18} m^3 / s^2

Physical parameters for more v 0.17 bodies can be found here

REF = Reference Body

A parameter that determines which object your spacecraft is orbiting in Kerbal Space Program. Kerbol = 0, Kerbin =1, Mun = 2, Minmus = 3. In V 0.17, Moho =4, Eve = 5 (Gilly = 13), Duna =6 (Ike = 7), Jool = 8 (Laythe = 9, Vall = 10, Tylo=12, Bop = 11)

OBJ = Object Type

A parameter that determines whether your spacecraft is a Pilotable Object (0) or Unpilotable Debris (1).

Orbital Parameters of KSP Celestial Bodies in v0.16

	Kerbin	Mun	Minmus
SMA	13,599,840,256 m	12,000,000 m	47,000,000 m
ECC	0	0	0
INC	0°	0°	6°
LPE	0°	0°	38°
LAN	0°	0°	78°
MNA	3.14	0.9	1.7
EPH	0	0	0
REF	0	1	1
OBJ	-	-	-

Orbital Parameters for more v 0.17 bodies can be found here

Teleporting an object into orbit:

To teleport an object into orbit, you’ll need to pay attention to these parameters in the Persistent.sfs file;

```
sit = PRELAUNCH
landed = True
landedAt = LaunchPad
splashed = False
```

sit = Situation
A general description of what the object is currently doing. Valid values include (but are not limited to) PRELAUNCH, LANDED, SPLASHED, SUB_ORBITAL, ORBITING, and ESCAPING. Objects in space will typically be ORBITING if they're in elliptical or circular orbits, or ESCAPING if they're in hyperbolic orbits

landed = Landing Status (boolean)
An object with **landed = True** will be considered to be on the surface of its reference object, and KSP will ignore any orbital parameters you may have set, in favor of the latitude, longitude and altitude values. An object in space will have **landed = False**

landedAt = landing location. Can be left blank, or set to other valid values, including LaunchPad, KSC, and Runway. Any object that has the value **landedAt = LaunchPad** is believed by the game to be currently blocking the LaunchPad, and will trigger the "Launch pad currently occupied" dialogue. If you choose to clear the launchpad, the object will be deleted, regardless of its actual location. An object in space should have have a blank **landedAt =** value.

splashed = Splashdown Status (boolean)
An object that has **splashed = True** is considered to have splashed down, and will be at altitude 0. On Kerbin, if the Lat and Long attributes point towards land, this will put the object in the subterranean world ocean. An object in space, or on a terrestrial surface, will have **splashed = False**

Reversing an Orbit

To reverse an orbit, you must do three things:

1. Longitude of the Ascending Node must be placed on the other side of the central body.
LAN(new) = LAN(old) + 180 degrees.
2. Orbital Inclination must be rotated to point the orbit in the correct direction.
INC(new) = 180 degrees - INC(old)
3 Argument of Periapsis must be measured from the new LAN position.
LPE(new) = 180 degrees - LPE(old)

For circular, equatorial orbits, you can get away with just flipping the Inclination to 180 degrees.

Placing Object near Other Objects in orbit

To place an object in the same orbit as another orbit, at a general estimated distance, it can be helpful to assume that a spacecraft has the same orbital velocity over short periods in its orbit, to reduce calculation. Open Kerbal Space Program, and obtain the orbital velocity of the target object from the play screen, the map screen, or the tracking station screen, then exit to the space center to begin editing the persistence file.

Find the target's orbital parameters, and copy them to the new spacecraft's orbital parameters, making further adjustments as above to teleport it off the pad, if necessary. Decide the estimated distance you wish to place between the two objects (d), and use the orbital velocity (v) to calculate the travel time (delta t) between those two points:

$$\Delta t = \frac{d}{v}$$

Set your spacecraft's Epoch (EPH =) value to your target's Epoch value +/- delta-t. When the persistence file is loaded, your spacecraft will share an orbit with the target, but be approximately the desired distance behind or ahead of the target.

Faking Lagrangian Points:

The physics simulation of KSP does not actually support Lagrangian points, as an object in KSP only responds to the gravitational attraction of one object at any one time, and Lagrangian Points are the product of the interacting gravitational fields of an object and its satellite. Nevertheless, two of the Lagrangian Points: L4 (60 degrees ahead of the body), and L5 (60 degrees behind the body) are co-orbital with the satellite, and thus can be approximated.

Since the orbits Kerbin, the Mun, and Minmus are circular, the easiest way to edit objects into these points is to use the information above, but subtract 60 degrees from LPE for L4, and add 60 degrees to LPE for L5. Note that these points are not stable in Kerbal Space Program, and if the game is allowed to take the objects off rails, over extremely long periods of time, they will eventually drift from their assigned points.

L3 can also be faked by adding 180 degrees to LPE; however L3 is not stable in KSP or in reality.

Synchronous Orbits of Kerbin

For a synchronous Orbit, the satellite needs a period equivalent to Kerbin's sidereal rotation

period of six hours. That defines the Semimajor axis.
SMA = 3468232
ECC = 0
INC = 0
LPE = 0
LAN = 0
MNA = 0
EPH = 0
REF = 1

Quasi-Molniya Orbits of Kerbin

For a Molniya-style orbit, the satellite needs an orbit that has a period of 3 hours, which defines the semimajor axis.We don't want the satellite to hit Kerbin, so we'll place the periapsis at 100km altitude above its surface. As a result, the orbit will be highly eccentric, but not as eccentric as an Earthly Molniya.

SMA = 2184849
ECC = 0.679611726
INC = 63.4
LPE = -90
LAN = See below
MNA = 3.1415927
EPH = See Below
REF = 1
OBJ

To successfully cover an area with Molnaya orbits, there should be three spacecraft whose apoapses are separated by 120-degree angles, and who reach apoapsis as the target latitude passed beneath them, one third of a day apart. The easiest way to do this is to set their Epochs and their Ascending Node Longitudes in the following manner.

	Molniya 01	Molniya 02	Molniya 03
EPH	0	7200	14400
LAN	0	120	240

A Kerbal GPS Constellation

From wikipedia:

> The space segment (SS) is composed of the orbiting GPS satellites, or Space Vehicles (SV) in GPS parlance. The GPS design originally called for 24 SVs, eight each in three approximately circular orbits,[45] but this was modified to six orbital planes with four satellites each.[46] The orbits are centered on the Earth, not rotating with the Earth, but instead fixed with respect to the distant stars.[47] The six orbit planes have approximately 55° inclination (tilt relative to Earth's equator) and are separated by 60° right ascension of the ascending node (angle along the equator from a reference point to the orbit's intersection).[48] The orbital period is one-half a sidereal day, i.e. 11 hours and 58 minutes.[49] The orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on Earth's surface.[50] The result of this objective is that the four satellites are not evenly spaced (90 degrees) apart within each orbit. In general terms, the angular difference between satellites in each orbit is 30, 105, 120, and 105 degrees apart which, of course, sum to 360 degrees.

When translating this to Kerbin, half a sidereal day is 3 hours, which defines the semimajor axis.

SMA = 2184849
ECC= 0.0
INC = 55
LPE = 0.0
LAN = See below
MNA = See Below
EPH = 0
REF = 1
OBJ = 0 or 1, as appropriate.

For Longitude of the Ascending Node (LAN), there are six orbits whose longitudes are separated by 60 degrees. So four satellites each will have LAN values of 0,60,120,180,240, and 300.

For Mean Anomaly at Epoch(MNA), each of the four satellites in the each of the six orbits will have one of the following values (And yes, this means they're not evenly spaced) Since the orbit is circular, we can use the True Anomaly angles in radians. In degrees, they're at 0°, 30°, 135°, and -105° Converted to radians:

MNA = 0
MNA = 0.523598776
MNA = 2.35619449
MNA = -1.83259571

Quasi-Satellite Orbits

A quasi-satellite orbit is an orbit in a 1:1 orbital resonance with a second body that stays close to the second body for long periods. Both the quasi-satellite and the second body orbit a third body. The reason for the name “Quasi-Satellite” is because, when viewed in a rotating reference frame from the second body, the path of the quasi-satellite appears to be a retrograde orbit that is squashed, or even horseshoe-shaped.

To produce a quasi-satellite orbit in Kerbal Space program, there are two requirements: The quasisat’s orbit must have the same semi-major axis as the second body (which produces the 1:1 orbital resonance), and the quasisat’s orbit must be oriented in a way that prevents it from ever entering the second body’s sphere of influence.

Below are parameters for producing a Quasi-satellite orbit resonant with the Kerbin, the Mun, and Minmus that have the feature that the resonant body is directly below the satelite when the satelite is at apoapsis, and directly above it when the satellite is at periapsis, with close-to-minimal eccentricities on the quasi-satellite orbits.

	Kerbin-Resonant	Mun-Resonant	Minmus-Resonant
SMA	13,599,840,256 m	12,000,000 m	47,000,000 m
ECC	0.01	0.25	0.075
INC	0°	0°	6°
LPE	359.908748°	277.40282°	269.562°
LAN	0°	0°	78°
MNA	3.14159265359	3.14159265359	3.14159265359
EPH	0	0	0
REF	0	1	1
OBJ	(as appropriate)	(as appropriate)	(as appropriate)