Satellite Lab

SPH4UN

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Purpose:

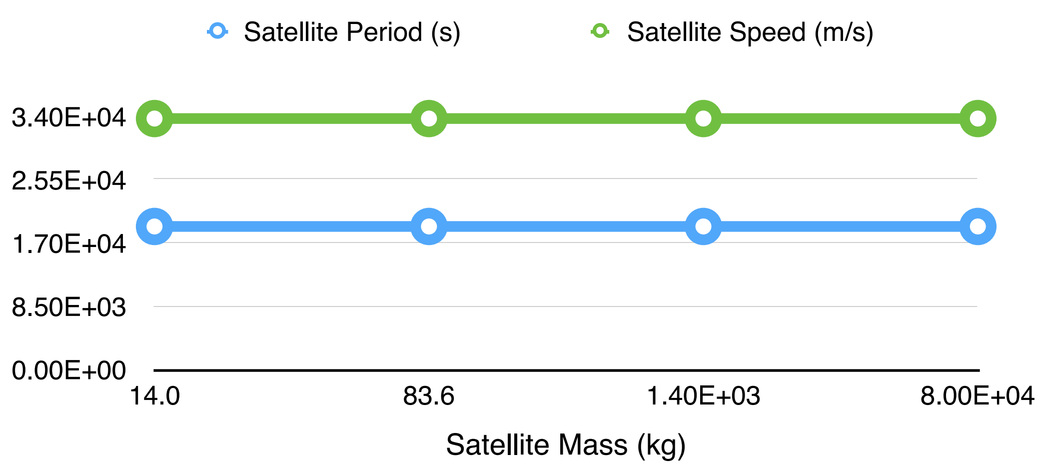
Examining the factors that affect the speed of a satellite around a planet. Rediscovering one of the historically important laws of orbital motion. Looking at what it means for an orbit to be geostationary.

Procedure:

Part 1: Satellite Mass and Speed

Central Planet: Jupiter
Radius : 7.15x10^7m
Circumference : 647168086.6m
*The datas below were collected when other variables remained the same.

Satellite Name	Satellite Mass (Kg)	Satellite Period (s)	Satellite Speed (m/s)
Explore 1	14.0	1.92E+04	3.37E+04
Sputnik	83.6	1.92E+04	3.37E+04
Mercury Capsule	1.40E+03	1.92E+04	3.37E+04
Shuttle	8.00E+04	1.92E+04	3.37E+04

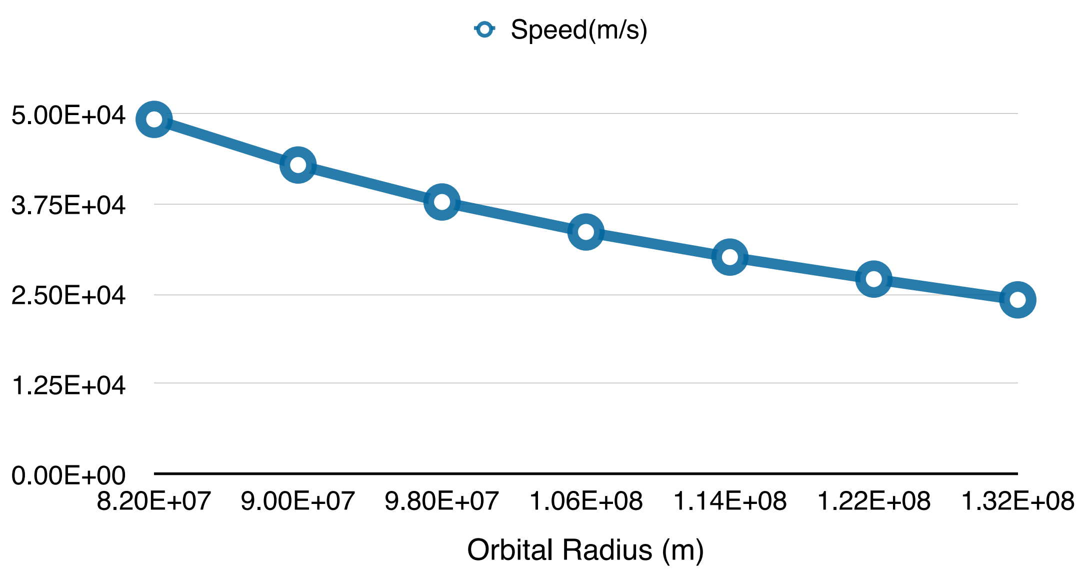


Based on the graph above, with the increasing of the satellite mass, there's no noticeable change in the satellite period and speed. Therefore, satellite mass does not affect its orbiting period and speed.

Part 2: Orbital Radius and Speed

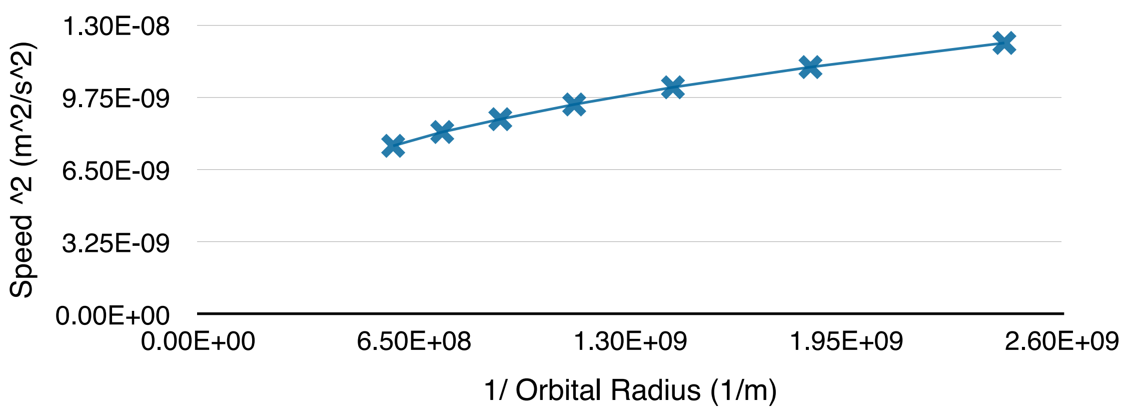
*The datas below were collected when other variables remained the same.

Radius (m)	Period(s)	Speed(m/s)
8.20E+07	1.31E+04	4.93E+04
9.00E+07	1.51E+04	4.29E+04
9.80E+07	1.71E+04	3.78E+04
1.06E+08	1.92E+04	3.36E+04
1.14E+08	2.15E+04	3.01E+04
1.22E+08	2.39E+04	2.71E+04
1.32E+08	2.67E+04	2.42E+04



Notice that the speed decreases when the satellite's orbiting radius increases. In order to derive an equation, linearizing the datas is required.

Radius (m)	Speed(m/s)	Period(s)	Speed ^2 (m^2/s^2)	1/ Radius (1/m)	Constant k (m^3/s^2)
8.20E+07	4.93E+04	1.31E+04	2.43E+09	1.22E-08	1.99E+17
9.00E+07	4.29E+04	1.51E+04	1.84E+09	1.11E-08	1.66E+17
9.80E+07	3.78E+04	1.71E+04	1.43E+09	1.02E-08	1.40E+17
1.06E+08	3.36E+04	1.92E+04	1.13E+09	9.43E-09	1.20E+17
1.14E+08	3.01E+04	2.15E+04	9.09E+08	8.77E-09	1.04E+17
1.22E+08	2.71E+04	2.39E+04	7.34E+08	8.20E-09	8.96E+16
1.32E+08	2.42E+04	2.67E+04	5.86E+08	7.58E-09	7.74E+16



As shown the graph above, 1/r and v^2 form a linear equation, with a slope k. Take the average of k: 1.28E+17 (m^3/s^2). Therefore,

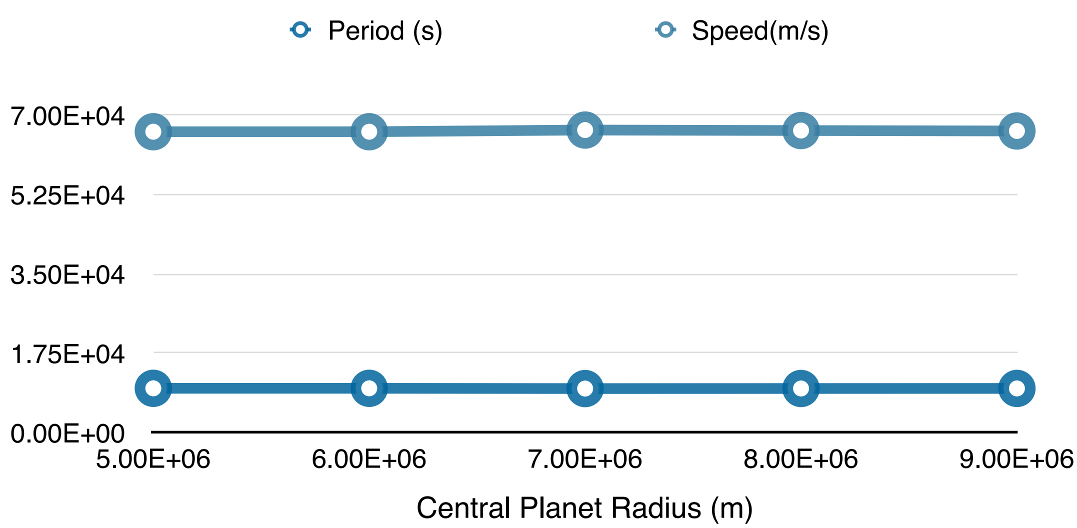
$$v^2 = (1.28E+17)\cdot\frac{1}{r}$$

$$v = \sqrt{\frac{(1.28E+17)}{r}}$$

Part 3: Central Body Radius and Speed

*The datas below were collected when other variables remained the same.

Central Body Radius(m)	Period (s)	Speed(m/s)
5.00E+06	9.76E+03	6.63E+04
6.00E+06	9.76E+03	6.63E+04
7.00E+06	9.70E+03	6.67E+04
8.00E+06	9.72E+03	6.66E+04
9.00E+06	9.73E+03	6.65E+04

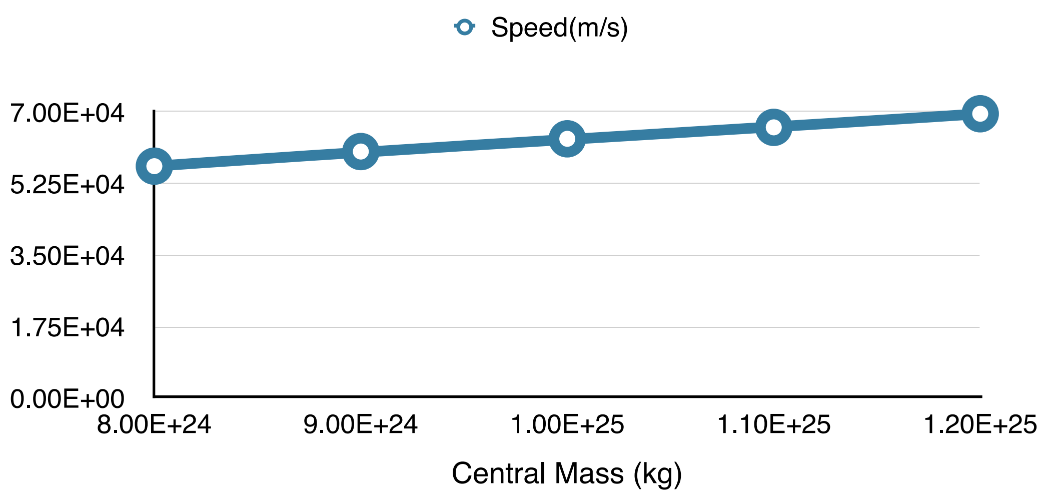


The graph show the change in the central body radius would not affect the satellite's orbital period and speed.

Part 4: Central Body Mass and Speed

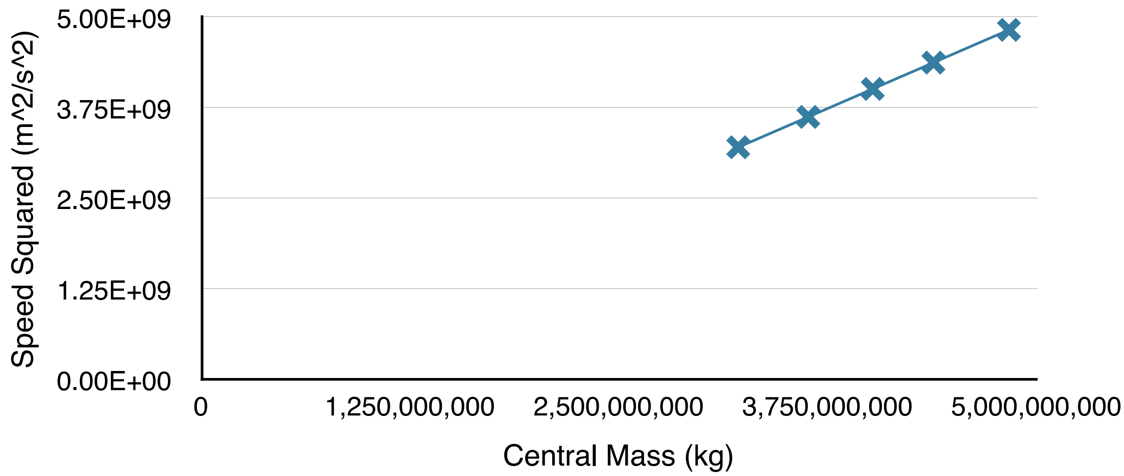
*The datas below were collected when other variables remained the same.

Central Mass (kg)	Speed(m/s)	Period(s)
8.00E+24	5.67E+04	1.14E+04
9.00E+24	6.03E+04	1.07E+04
1.00E+25	6.34E+04	1.02E+04
1.10E+25	6.62E+04	9.77E+03
1.20E+25	6.95E+04	9.31E+03



Notice that the speed decreases when the Central planet's mass increases. In order to derive an equation, linearizing the datas is required.

Central Mass (kg)	Speed Squared (m^2/s^2)	Constant k (m^2/kg*s^2)	Speed(m/s)	Period(s)
8.00E+24	3.22E+09	4.02E-16	5.67E+04	1.14E+04
9.00E+24	3.64E+09	4.04E-16	6.03E+04	1.07E+04
1.00E+25	4.02E+09	4.02E-16	6.34E+04	1.02E+04
1.10E+25	4.38E+09	3.99E-16	6.62E+04	9.77E+03
1.20E+25	4.84E+09	4.03E-16	6.95E+04	9.31E+03



Based on the graph above, V^2 is directly proportional to Central Mass. Take the average of slope k: 4.02E+09. Therefore,

$$v^2 = (4.02E{+}09)M$$

$$v = \sqrt{(4.02E{+}09)M}$$

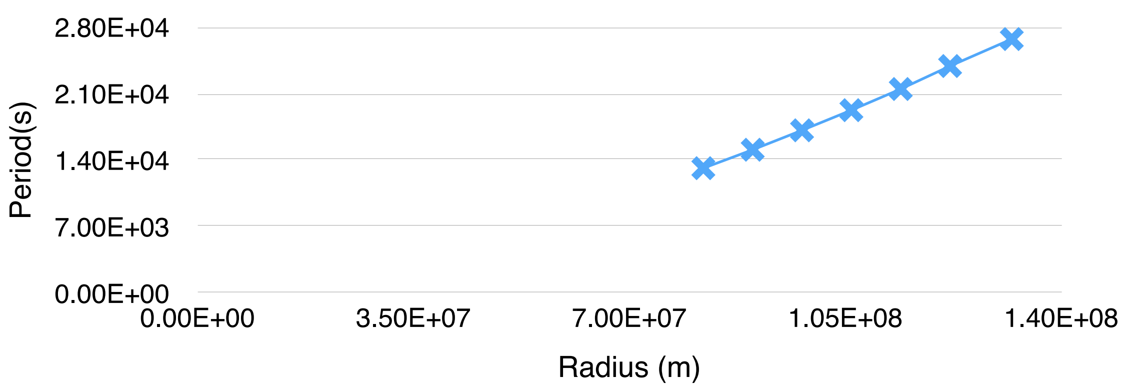
Part 5: Geostationary Satellite

Satellite: Sputnik
Central body: Vesta
Change the orbital radius until finding the position that will cause the satellite to always stay over the exact same spot of Vesta's surface.
When the distance is 535km, the Sputnik moves as a geostationary Satellite.

Part 6: Kepler's Third Law of Satellite Motion

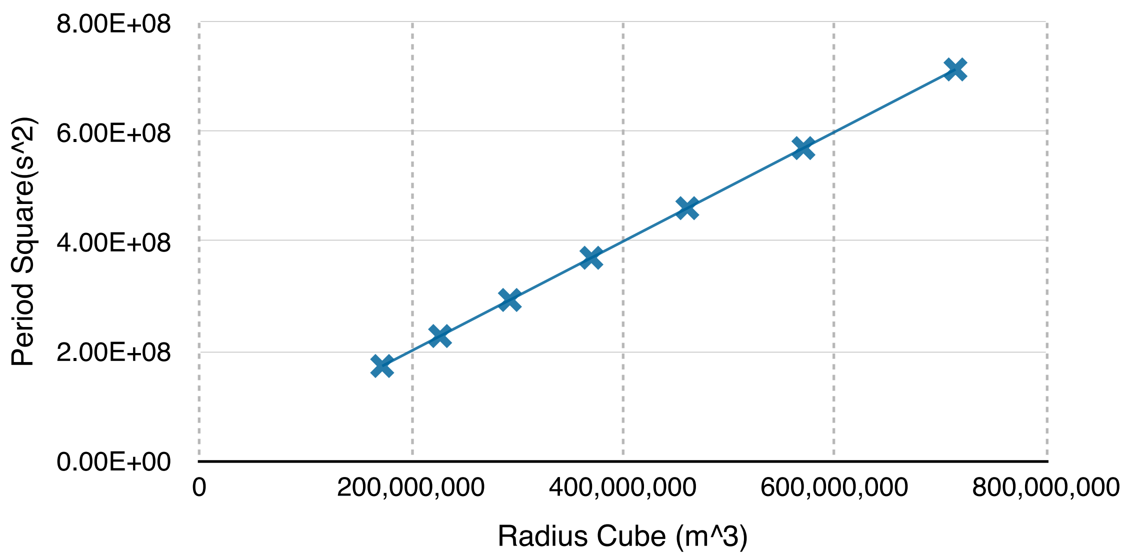
Using the date from part 2 to find the relationship between orbital radius and period. However, based on the graph below, there's no simple relationship fit in this data

Radius (m)	Period(s)
8.20E+07	1.31E+04
9.00E+07	1.51E+04
9.80E+07	1.71E+04
1.06E+08	1.92E+04
1.14E+08	2.15E+04
1.22E+08	2.39E+04
1.32E+08	2.67E+04



Therefore, linearize this data by plotting a graph of orbital period squared vs. orbital radius cubed :

Radius (m)	Period(s)	r^3	t^2	k
8.20E+07	1.31E+04	5.51E+23	1.73E+08	3.19E+15
9.00E+07	1.51E+04	7.29E+23	2.27E+08	3.21E+15
9.80E+07	1.71E+04	9.41E+23	2.93E+08	3.21E+15
1.06E+08	1.92E+04	1.19E+24	3.70E+08	3.22E+15
1.14E+08	2.15E+04	1.48E+24	4.61E+08	3.21E+15
1.22E+08	2.39E+04	1.82E+24	5.71E+08	3.18E+15
1.32E+08	2.67E+04	2.30E+24	7.14E+08	3.22E+15
Average:				3.21E+15



Notice that the Period Square is directly proportional to the radius cube with a constant slope k, 1/ 3.21E+15 . Therefore,

$$\frac{r^3}{T^2} = 3.21E{+}15$$