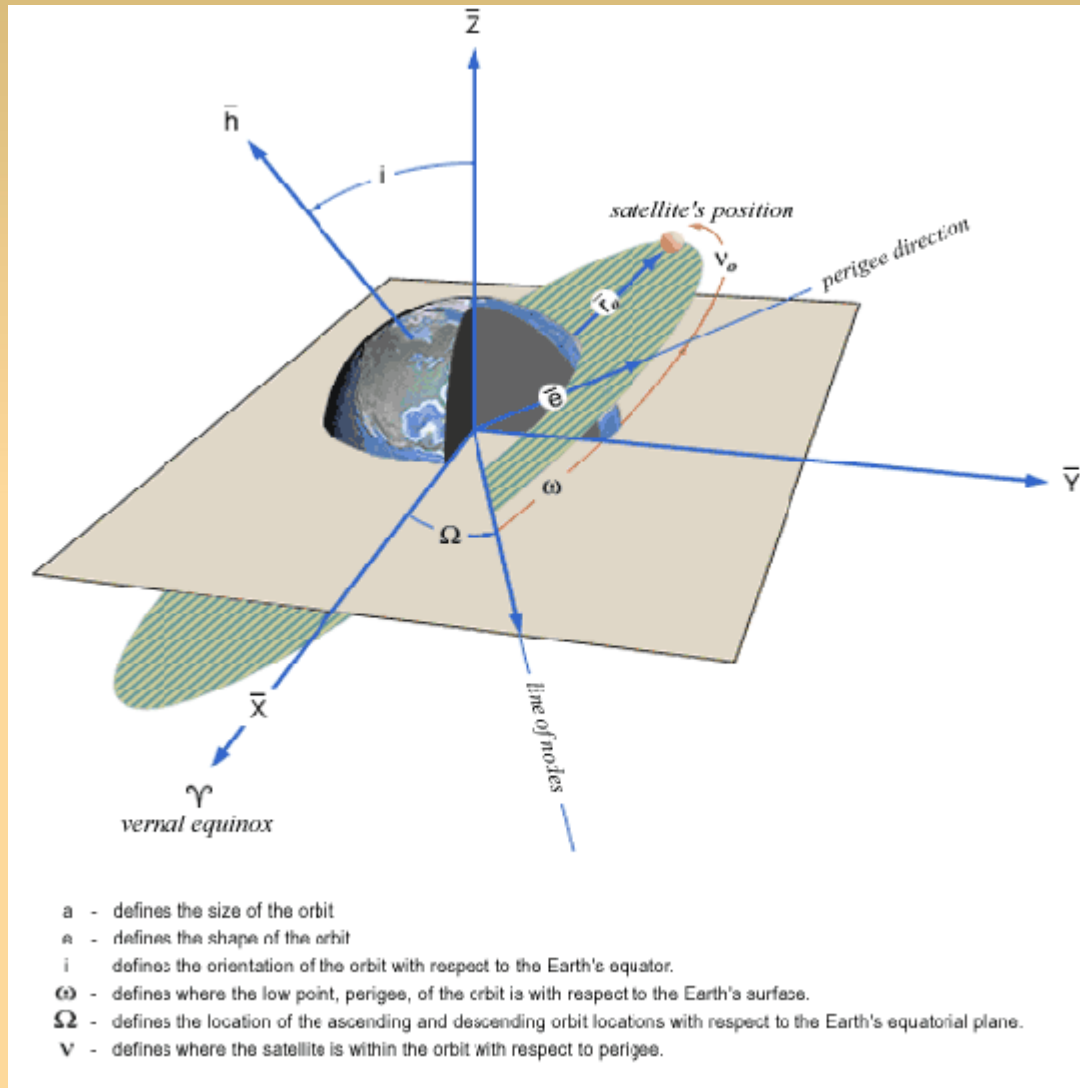


The 6 Classic Orbital Elements

- Topic: 6 classical orbital elements for a spacecraft
- Audience: Freshmen AE majors with mathematics background up to College Algebra and Trigonometry

presented by Alex "Sandy" Antunes, Ph.D.

The 6 Classic Orbital Elements

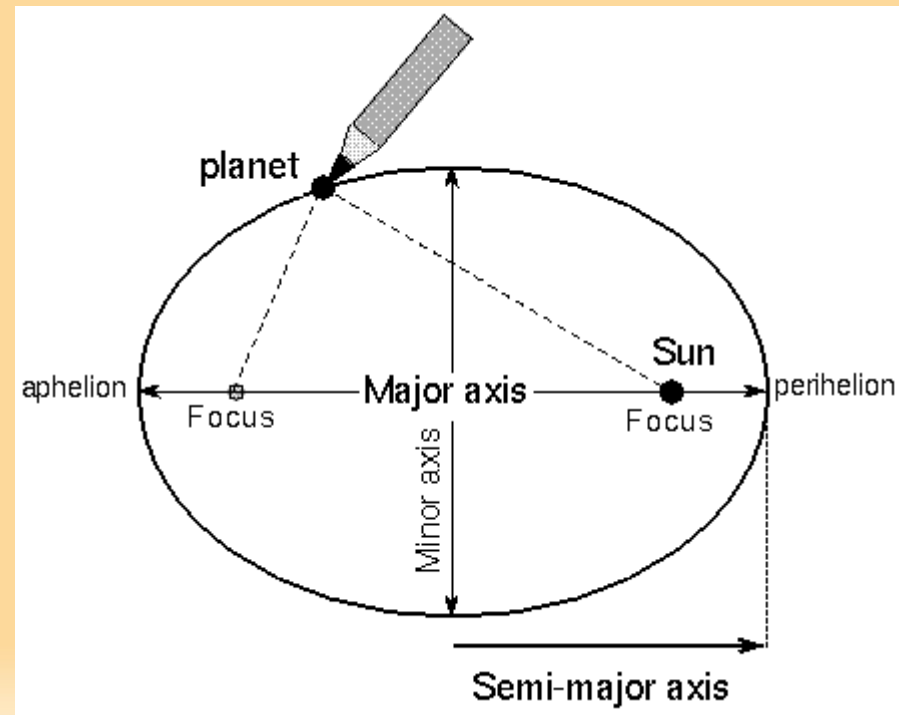


(courtesy of spaceflight.nasa.gov)

Theory

- 3-D -> 3 space, 3 velocity -> need 6 elements
- x, y, z, v_x, v_y, v_z ?
- spherical?
- Euler angles?
- gravity = ellipses!
$$x^2/a^2 + y^2/b^2 = 1$$

Encyclopedia of Science by David Darling

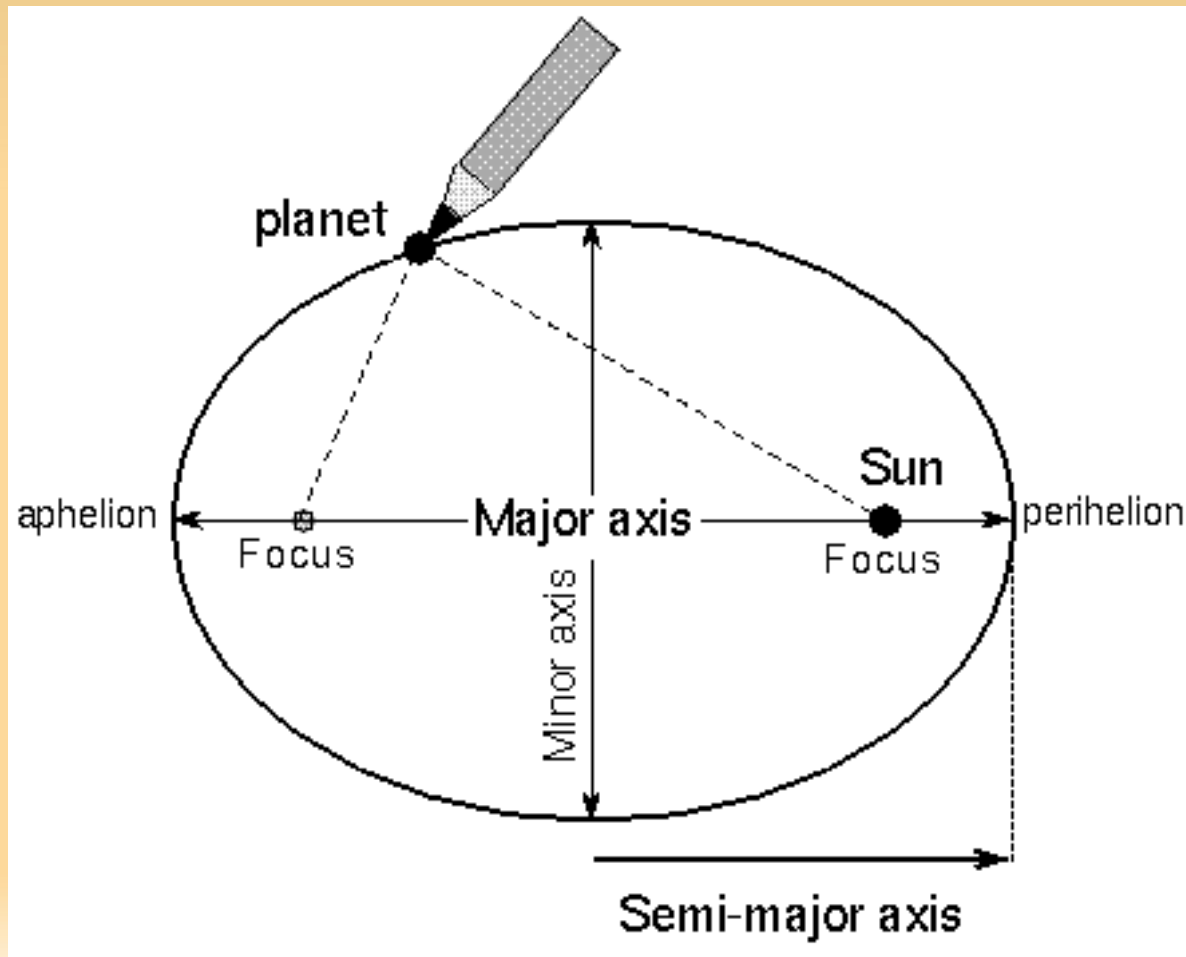


Implementation: The 6 elements

- 1) a = Semi-major axis = *size*
- 2) e = Eccentricity = *shape*
- 3) i = inclination = *tilt*
- 4) ω = argument of perigee = *twist*
- 5) Ω = longitude of the ascending node = *spin*
- 6) v = mean anomaly = *where in orbit*

a & e = 2D shape

- 1) a = Semi-major axis = *size*
- 2) e = Eccentricity = *shape*



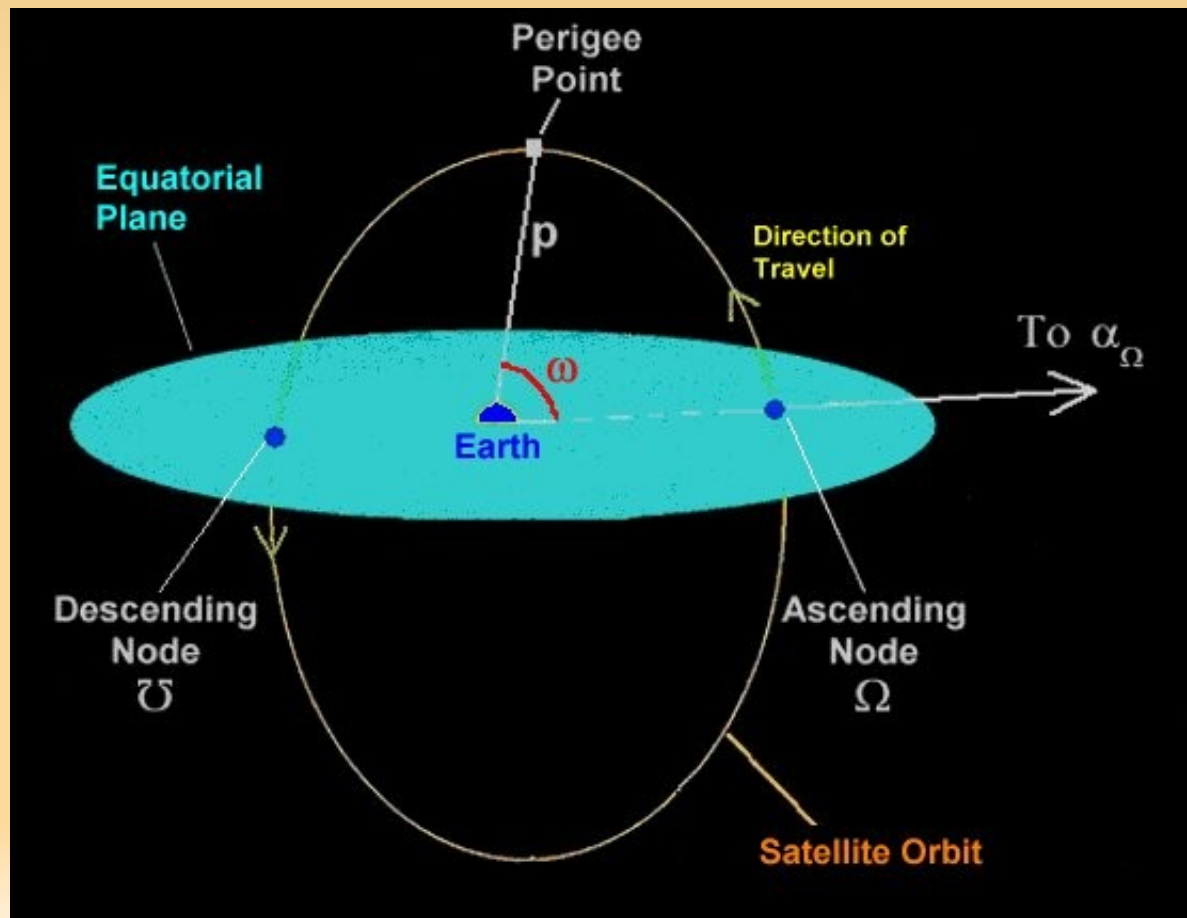
$$a^3 = p^2$$

i & ω = 3D orientation

3) i = inclination = *tilt*

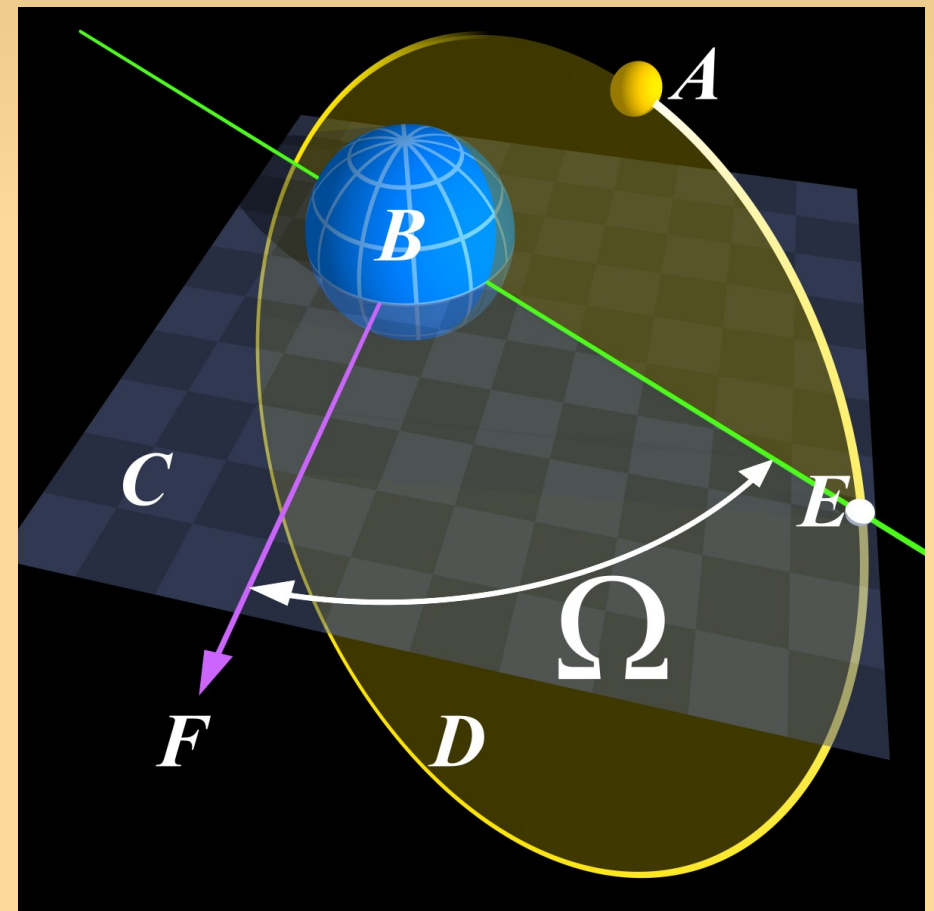
4) ω = argument of perigee = *twist*

(= arg. of periapsis or, (Sun orbit) arg. of perihelion)



Ω = ties it to Earth

- 5) Ω = longitude of the ascending node = *spin*
(= right ascension of the ascending node)

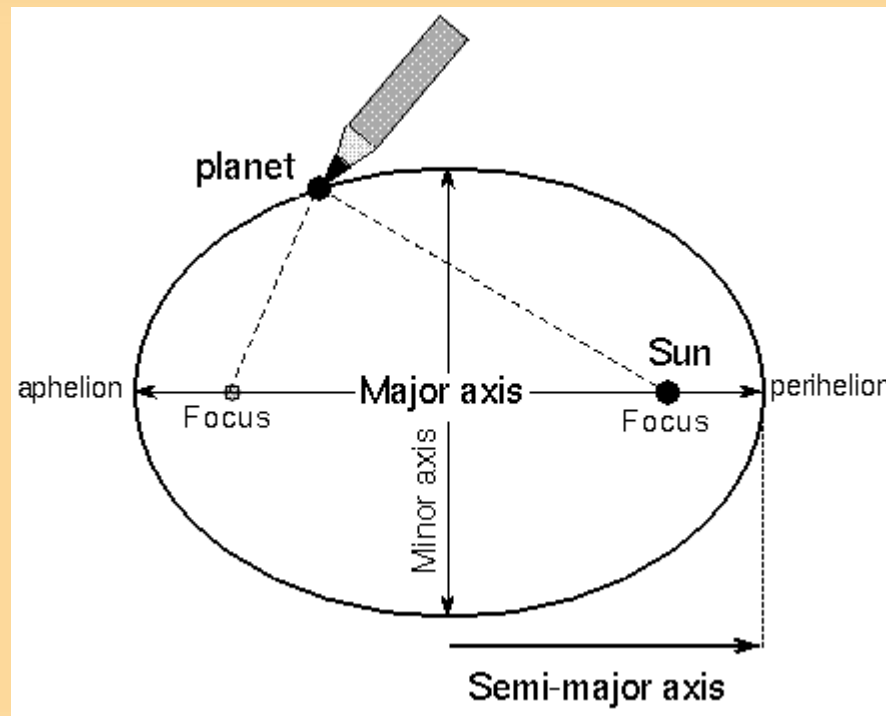


$v =$ where is it now?

6) $v =$ mean true anomaly = *where in orbit*

or, true anomaly = q

or, time of periapsis passage = T_p

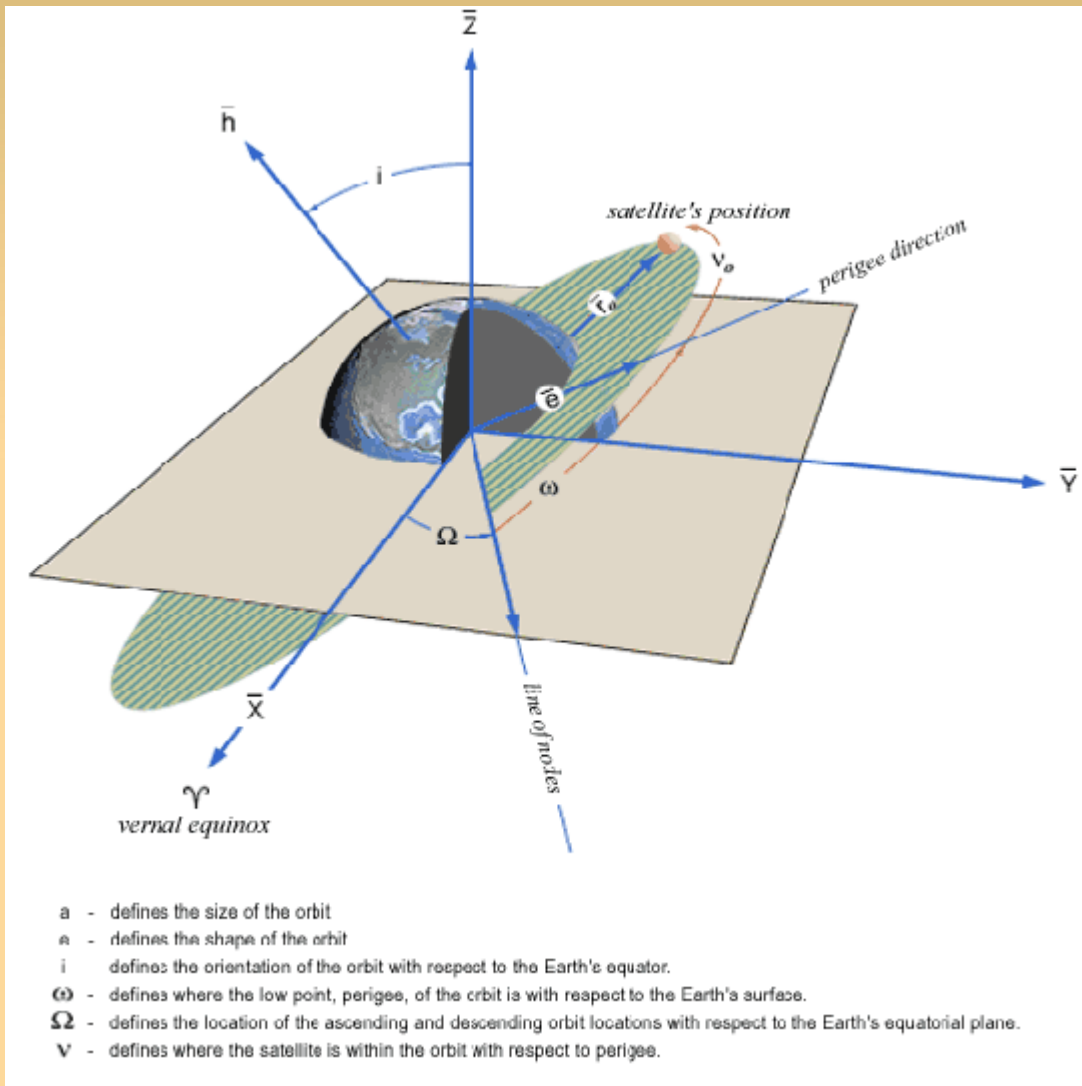


All Together Now

'mrg3' Animation for Physics and Astronomy, youtube channel, 'Orbital Elements'



Advantage: Predictive Power



- 1) a = Semi-major axis = *size*
- 2) e = Eccentricity = *shape*
- 3) i = inclination = *tilt*
- 4) ω = argument of perigee = *twist*
- 5) Ω = longitude of the ascending node = *spin*
- 6) v = mean anomaly = *where in orbit*

Next Interview

- How orbits are determined (launch, lasers, radar, radio Doppler, inertial, etc)
- What throws it off (tides, drag, solar, et cetera)
- Keplerian or Two-Line Element Sets (TLEs)