Important Elliptical Orbits Formulas PDF

Formulas
Examples
with Units

List of 23
Important Elliptical Orbits Formulas

1) Elliptical Orbit Parameters Formulas

1.1) Angular Momentum in Elliptic Orbit Given Apogee Radius and Apogee Velocity Formula

Evaluate Formula

Formula

$$h_e = r_{e,apogee} \cdot v_{apogee}$$

Example with Units

$$65750\,\mathrm{km^2/s} = 27110\,\mathrm{km} \cdot 2.425304316\,\mathrm{km/s}$$

1.2) Angular Momentum in Elliptic Orbit Given Perigee Radius and Perigee Velocity Formula

Evaluate Formula

Formula

$$h_e = r_{e,perigee} \cdot v_{perigee}$$

Example with Units

$$65749.989\,\mathrm{km^2/s} = 6778\,\mathrm{km} \cdot 9.7005\,\mathrm{km/s}$$

1.3) Apogee Radius of Elliptic Orbit Given Angular Momentum and Eccentricity Formula

Evaluate Formula

Formula

$$r_{e,apogee} = \frac{h_e^{\,2}}{[GM.Earth] \cdot \left(1 - e_e\right)}$$

Example with Units

$$27114.0097\,\mathrm{km} = \frac{\left(65750\,\mathrm{km^2/s}\right)^2}{4E{+}14\,\mathrm{m^3/s^2} \cdot \left(1 - 0.6\right)}$$

1.4) Apogee Velocity in Elliptic Orbit Given Angular Momentum and Apogee Radius Formula

Evaluate Formula

Formula

$$v_{apogee} = \frac{h_e}{r_{e,apogee}}$$

Example with Units

$$2.4253\,\mathrm{km/s} = \frac{65750\,\mathrm{km^2/s}}{27110\,\mathrm{km}}$$

1.5) Azimuth-Averaged Radius Given Apogee and Perigee Radii Formula

Evaluate Formula

Formula

$$r_\theta = \sqrt{r_{e,apogee} \cdot r_{e,perigee}}$$

Example with Units

$$13555.5\,\mathrm{km} = \sqrt{27110\,\mathrm{km} \cdot 6778\,\mathrm{km}}$$

1.6) Eccentricity of Elliptical Orbit given Apogee and Perigee Formula

Evaluate Formula

Formula

$$e_e = \frac{r_{e,apogee} - r_{e,perigee}}{r_{e,apogee} + r_{e,perigee}}$$

Example with Units

$$0.6 = \frac{27110\,\text{km} - 6778\,\text{km}}{27110\,\text{km} + 6778\,\text{km}}$$

1.7) Eccentricity of Orbit Formula

Evaluate Formula

Formula

$$e_e = \frac{d_{foci}}{2 \cdot a_e}$$

Example with Units

$$0.6021 = \frac{20400\,\text{km}}{2 \cdot 16940\,\text{km}}$$

1.8) Elliptical Orbit Time Period given Angular Momentum and Eccentricity Formula

Evaluate Formula

Formula

$$T_e = \frac{2 \cdot \pi}{[GM.Earth]^2} \cdot \left(\frac{h_e}{\sqrt{1 - e_e^2}} \right)^3$$

Example with Units

$$21954.4028\,\text{s} = \frac{2 \cdot 3.1416}{4E+14\,\text{m}^3/\text{s}^2{}^2} \cdot \left(\frac{65750\,\text{km}^2/\text{s}}{\sqrt{1 - 0.6^2}} \right)^3$$

1.9) Radial Velocity in Elliptic Orbit given Radial Position and Angular Momentum Formula

Evaluate Formula

Formula

$$v_r = \frac{h_e}{r_e}$$

Example with Units

$$3.4853\,\text{km/s} = \frac{65750\,\text{km}^2/\text{s}}{18865\,\text{km}}$$

1.10) Radial Velocity in Elliptic Orbit given True Anomaly, Eccentricity, and Angular Momentum Formula

Evaluate Formula

Formula

$$v_r = [GM.Earth] \cdot e_e \cdot \frac{\sin(\theta_e)}{h_e}$$

Example with Units

$$2.5671\,\text{km/s} = 4E+14\,\text{m}^3/\text{s}^2 \cdot 0.6 \cdot \frac{\sin(135.11°)}{65750\,\text{km}^2/\text{s}}$$

1.11) Semimajor Axis of Elliptic Orbit given Apogee and Perigee Radii Formula

Evaluate Formula

Formula

$$a_e = \frac{r_{e,apogee} + r_{e,perigee}}{2}$$

Example with Units

$$16944\,\text{km} = \frac{27110\,\text{km} + 6778\,\text{km}}{2}$$

1.12) Specific Energy of Elliptic Orbit given Angular Momentum Formula

Evaluate Formula

Formula

$$\varepsilon_e = -\frac{1}{2} \cdot \frac{[GM.Earth]^2}{h_e^2} \cdot \left(1 - e_e^2\right)$$

Example with Units

$$-11760.7228\,\text{kJ/kg} = -\frac{1}{2} \cdot \frac{\left(4E+14\,\text{m}^3/\text{s}^2\right)^2}{\left(65750\,\text{km}^2/\text{s}\right)^2} \cdot \left(1 - 0.6^2\right)$$

1.13) Specific Energy of Elliptic Orbit given Semi Major Axis Formula

Evaluate Formula

Formula

$$\varepsilon_e = -\frac{[GM.Earth]}{2 \cdot a_e}$$

Example with Units

$$-11765.0662\,\text{kJ/kg} = -\frac{4E+14\,\text{m}^3/\text{s}^2}{2 \cdot 16940\,\text{km}}$$

1.14) Time Period for One Complete Revolution given Angular Momentum Formula

Evaluate Formula

Formula

$$T_e = \frac{2 \cdot \pi \cdot a_e \cdot b_e}{h_e}$$

Example with Units

$$21230.7733\,\text{s} = \frac{2 \cdot 3.1416 \cdot 16940\,\text{km} \cdot 13115\,\text{km}}{65750\,\text{km}^2/\text{s}}$$

1.15) Time Period of Elliptical Orbit given Angular Momentum Formula

Evaluate Formula

Formula

$$T_e = \frac{2 \cdot \pi}{[GM.Earth]^2} \cdot \left(\frac{h_e}{\sqrt{1 - e_e^2}}\right)^3$$

Example with Units

$$21954.4028\,\text{s} = \frac{2 \cdot 3.1416}{\left(4E+14\,\text{m}^3/\text{s}^2\right)^2} \cdot \left(\frac{65750\,\text{km}^2/\text{s}}{\sqrt{1 - 0.6^2}}\right)^3$$

1.16) Time Period of Elliptical Orbit given Semi-Major Axis Formula

Evaluate Formula

Formula

$$T_e = 2 \cdot \pi \cdot a_e^2 \cdot \frac{\sqrt{1 - e_e^2}}{h_e}$$

Example with Units

$$21938.1959\,\text{s} = 2 \cdot 3.1416 \cdot \left(16940\,\text{km}\right)^2 \cdot \frac{\sqrt{1 - 0.6^2}}{65750\,\text{km}^2/\text{s}}$$

1.17) True Anomaly in Elliptic Orbit Given Radial Position, Eccentricity, and Angular Momentum Formula

Evaluate Formula

Formula

$$\theta_e = acos\left(\frac{\frac{h_e^2}{[GM.Earth] \cdot r_e} - 1}{e_e}\right)$$

Example with Units

$$135.1122° = acos\left(\frac{\frac{\left(65750\,\text{km}^2/\text{s}\right)^2}{4E+14\,\text{m}^3/\text{s}^2 \cdot 18865\,\text{km}} - 1}{0.6}\right)$$

2) Orbital Position as Function of Time Formulas

2.1) Eccentric Anomaly in Elliptic Orbit given True Anomaly and Eccentricity Formula

Evaluate Formula

Formula

$$E = 2 \cdot atan\left(\sqrt{\frac{1 - e_e}{1 + e_e}} \cdot \tan\left(\frac{\theta_e}{2}\right)\right)$$

Example with Units

$$100.8744° = 2 \cdot atan\left(\sqrt{\frac{1 - 0.6}{1 + 0.6}} \cdot \tan\left(\frac{135.11°}{2}\right)\right)$$

2.2) Mean Anomaly in Elliptic Orbit given Eccentric Anomaly and Eccentricity Formula

Evaluate Formula

Formula

$$M_e = E - e_e \cdot \sin(E)$$

Example with Units

$$67.1138° = 100.874° - 0.6 \cdot \sin(100.874°)$$

2.3) Mean Anomaly in Elliptic Orbit given Time since Periapsis Formula

Evaluate Formula

Formula

$$M_e = \frac{2 \cdot \pi \cdot t_e}{T_e}$$

Example with Units

$$67.3973° = \frac{2 \cdot 3.1416 \cdot 4100\,\mathrm{s}}{21900\,\mathrm{s}}$$

2.4) Time since Periapsis in Elliptic Orbit given Eccentric Anomaly and Time Period Formula

Evaluate Formula

Formula

$$t_e = (E - e_e \cdot \sin(E)) \cdot \frac{T_e}{2 \cdot \Pi(6)}$$

Example with Units

$$4275.4522\,\mathrm{s} = (100.874° - 0.6 \cdot \sin(100.874°)) \cdot \frac{21900\,\mathrm{s}}{2 \cdot \Pi(6)}$$

2.5) Time since Periapsis in Elliptic Orbit given Mean Anomaly Formula

Evaluate Formula

Formula

$$t_e = M_e \cdot \frac{T_e}{2 \cdot \pi}$$

Example with Units

$$4091.0417\,\mathrm{s} = 67.25° \cdot \frac{21900\,\mathrm{s}}{2 \cdot 3.1416}$$

2.6) True Anomaly in Elliptic Orbit given Eccentric Anomaly and Eccentricity Formula

Evaluate Formula

Formula

$$\theta_e = 2 \cdot atan\left(\sqrt{\frac{1 + e_e}{1 - e_e}} \cdot \tan\left(\frac{E}{2}\right)\right)$$

Example with Units

$$135.1097° = 2 \cdot atan\left(\sqrt{\frac{1 + 0.6}{1 - 0.6}} \cdot \tan\left(\frac{100.874°}{2}\right)\right)$$

Variables used in list of Elliptical Orbits Formulas above

- **a_e** Semi Major Axis of Elliptic Orbit *(Kilometer)*
- **b_e** Semi Minor Axis of Elliptic Orbit *(Kilometer)*
- **d_{foci}** Distance Between Two Foci *(Kilometer)*
- **E** Eccentric Anomaly *(Degree)*
- **e_e** Eccentricity of Elliptical Orbit
- **h_e** Angular Momentum of Elliptic Orbit *(Square Kilometer per Second)*
- **M_e** Mean Anomaly in Elliptical Orbit *(Degree)*
- **r_e** Radial Position in Elliptical Orbit *(Kilometer)*
- **$r_{e,apogee}$** Apogee Radius in Elliptic Orbit *(Kilometer)*
- **$r_{e,perigee}$** Perigee Radius in Elliptic Orbit *(Kilometer)*
- **r_θ** Azimuth Averaged Radius *(Kilometer)*
- **t_e** Time since Periapsis in Elliptical Orbit *(Second)*
- **T_e** Time Period of Elliptic Orbit *(Second)*
- **v_{apogee}** Velocity of Satellite at Apogee *(Kilometer per Second)*
- **$v_{perigee}$** Velocity of Satellite at Perigee *(Kilometer per Second)*
- **v_r** Radial Velocity of Satellite *(Kilometer per Second)*
- **ε_e** Specific Energy of Elliptical Orbit *(Kilojoule per Kilogram)*
- **θ_e** True Anomaly in Elliptical Orbit *(Degree)*

Constants, Functions, Measurements used in list of Elliptical Orbits Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **[GM.Earth]**, 3.986004418E+14 *Earth's Geocentric Gravitational Constant*
- Functions: **acos**, acos(Number) *The inverse cosine function, is the inverse function of the cosine function. It is the function that takes a ratio as an input and returns the angle whose cosine is equal to that ratio.*
- Functions: **atan**, atan(Number) *Inverse tan is used to calculate the angle by applying the tangent ratio of the angle, which is the opposite side divided by the adjacent side of the right triangle.*
- Functions: **cos**, cos(Angle) *Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.*
- Functions: **Pi**, Pi(Number) *The prime-counting function is a function in mathematics that counts the number of prime numbers that are less than or equal to a given real number.*
- Functions: **sin**, sin(Angle) *Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.*
- Functions: **sqrt**, sqrt(Number) *A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- Functions: **tan**, tan(Angle) *The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.*
- Measurement: **Length** in Kilometer (km) *Length Unit Conversion*
- Measurement: **Time** in Second (s) *Time Unit Conversion*
- Measurement: **Speed** in Kilometer per Second (km/s)

Speed Unit Conversion

- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Specific Energy** in Kilojoule per Kilogram (kJ/kg)
  Specific Energy Unit Conversion
- Measurement: **Specific Angular Momentum** in Square Kilometer per Second (km²/s)
  Specific Angular Momentum Unit Conversion

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