Important Hyperbolic Orbits Formulas PDF

Formulas
Examples
with Units

List of 11
Important Hyperbolic Orbits Formulas

1) Hperbolic Orbit Parameters Formulas

1.1) Aiming Radius in Hyperbolic Orbit given Semi-Major Axis and Eccentricity Formula

Evaluate Formula

Formula

$$\Delta = a_h \cdot \sqrt{{e_h}^2 - 1}$$

Example with Units

$$12161.9179\,\text{km} = 13658\,\text{km} \cdot \sqrt{1.339^2 - 1}$$

1.2) Perigee Radius of Hyperbolic Orbit given Angular Momentum and Eccentricity Formula

Evaluate Formula

Formula

$$r_{perigee} = \frac{{h_h}^2}{[GM.Earth] \cdot (1 + e_h)}$$

Example with Units

$$4629.8054\,\text{km} = \frac{\left(65700\,\text{km}^2/\text{s}\right)^2}{4E+14\,\text{m}^3/\text{s}^2 \cdot (1 + 1.339)}$$

1.3) Radial Position in Hyperbolic Orbit given Angular Momentum, True Anomaly, and Eccentricity Formula

Evaluate Formula

Formula

$$r_h = \frac{{h_h}^2}{[GM.Earth] \cdot (1 + e_h \cdot \cos(\theta))}$$

Example with Units

$$19198.3717\,\text{km} = \frac{\left(65700\,\text{km}^2/\text{s}\right)^2}{4E+14\,\text{m}^3/\text{s}^2 \cdot (1 + 1.339 \cdot \cos(109°))}$$

1.4) Semi-Major Axis of Hyperbolic Orbit given Angular Momentum and Eccentricity Formula

Evaluate Formula

Formula

$$a_h = \frac{{h_h}^2}{[GM.Earth] \cdot \left({e_h}^2 - 1\right)}$$

Example with Units

$$13657.2432\,\text{km} = \frac{\left(65700\,\text{km}^2/\text{s}\right)^2}{4E+14\,\text{m}^3/\text{s}^2 \cdot \left(1.339^2 - 1\right)}$$

1.5) True Anomaly of Asymptote in Hyperbolic Orbit given Eccentricity Formula

Evaluate Formula

Formula

$$\theta_{inf} = acos\left(-\frac{1}{e_h}\right)$$

Example with Units

$$138.3162° = acos\left(-\frac{1}{1.339}\right)$$

1.6) Turn Angle given Eccentricity Formula

Evaluate Formula

Formula

$$\delta = 2 \cdot asin\left(\frac{1}{e_h}\right)$$

Example with Units

$$96.6324° = 2 \cdot asin\left(\frac{1}{1.339}\right)$$

2) Orbital Position as Function of Time Formulas

2.1) Hyperbolic Eccentric Anomaly given Eccentricity and True Anomaly Formula

Evaluate Formula

Formula

$$F = 2 \cdot atanh\left(\sqrt{\frac{e_h - 1}{e_h + 1}} \cdot \tan\left(\frac{\theta}{2}\right)\right)$$

Example with Units

$$68.2207° = 2 \cdot atanh\left(\sqrt{\frac{1.339 - 1}{1.339 + 1}} \cdot \tan\left(\frac{109°}{2}\right)\right)$$

2.2) Mean Anomaly in Hyperbolic Orbit given Hyperbolic Eccentric Anomaly Formula

Evaluate Formula

Formula

$$M_h = e_h \cdot \sinh(F) - F$$

Example with Units

$$46.2925° = 1.339 \cdot \sinh(68.22°) - 68.22°$$

2.3) Time since Periapsis in Hyperbolic Orbit given Hyperbolic Eccentric Anomaly Formula

Evaluate Formula

Formula

$$t = \frac{{h_h}^3}{[GM.Earth]^2 \cdot \left({e_h}^2 - 1\right)^{\frac{3}{2}}} \cdot \left(e_h \cdot \sinh(F) - F\right)$$

Example with Units

$$2042.5091\,\text{s} = \frac{{65700\,\text{km}^2/\text{s}}^3}{{4E+14\,\text{m}^3/\text{s}^2}^2 \cdot \left(1.339^2 - 1\right)^{\frac{3}{2}}} \cdot \left(1.339 \cdot \sinh(68.22°) - 68.22°\right)$$

2.4) Time since Periapsis in Hyperbolic Orbit given Mean Anomaly Formula

Evaluate Formula

Formula

$$t = \frac{h_h^{3}}{[GM.Earth]^{2} \cdot \left(e_h^{2} - 1\right)^{\frac{3}{2}}} \cdot M_h$$

Example with Units

$$2042.3973\,\mathrm{s} = \frac{65700\,\mathrm{km^2/s}^{3}}{4E{+}14\,\mathrm{m^3/s^2}^{2} \cdot \left(1.339^{2} - 1\right)^{\frac{3}{2}}} \cdot 46.29^{\circ}$$

2.5) True Anomaly in Hyperbolic Orbit given Hyperbolic Eccentric Anomaly and Eccentricity Formula

Evaluate Formula

Formula

$$\theta = 2 \cdot atan\left(\sqrt{\frac{e_h + 1}{e_h - 1}} \cdot \tanh\left(\frac{F}{2}\right)\right)$$

Example with Units

$$108.9995^{\circ} = 2 \cdot atan\left(\sqrt{\frac{1.339 + 1}{1.339 - 1}} \cdot \tanh\left(\frac{68.22^{\circ}}{2}\right)\right)$$

Variables used in list of Hyperbolic Orbits Formulas above

- a_h Semi Major Axis of Hyperbolic Orbit *(Kilometer)*
- e_h Eccentricity of Hyperbolic Orbit
- **F** Eccentric Anomaly in Hyperbolic Orbit *(Degree)*
- h_h Angular Momentum of Hyperbolic Orbit *(Square Kilometer per Second)*
- M_h Mean Anomaly in Hyperbolic Orbit *(Degree)*
- r_h Radial Position in Hyperbolic Orbit *(Kilometer)*
- $r_{perigee}$ Perigee Radius *(Kilometer)*
- **t** Time since Periapsis *(Second)*
- **δ** Turn Angle *(Degree)*
- **Δ** Aiming Radius *(Kilometer)*
- **θ** True Anomaly *(Degree)*
- θ_{inf} True Anomaly of Asymptote in Hyperbolic Orbit *(Degree)*

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

- 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: **asin**, asin(Number)
  The inverse sine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given 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: **atanh**, atanh(Number)
  The inverse hyperbolic tangent function returns the value whose hyperbolic tangent is a number.
- 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: **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: **sinh**, sinh(Number)
  The hyperbolic sine function, also known as the sinh function, is a mathematical function that is defined as the hyperbolic analogue of the sine function.
- 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.

- Functions: **tanh**, tanh(Number)
  The hyperbolic tangent function (tanh) is a function that is defined as the ratio of the hyperbolic sine function (sinh) to the hyperbolic cosine function (cosh).
- Measurement: **Length** in Kilometer (km)
  Length Unit Conversion
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Specific Angular Momentum** in Square Kilometer per Second (km^2/s)
  Specific Angular Momentum Unit Conversion

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