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Elliptical Orbits Formulas

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List of 23 Elliptical Orbits Formulas

Elliptical Orbits

Elliptical Orbit Parameters

1) Angular Momentum in Elliptic Orbit Given Apogee Radius and Apogee Velocity

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

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2_img.jpg\)](#)

$$ex \quad 65750 \text{ km}^2/\text{s} = 27110 \text{ km} \cdot 2.425304316 \text{ km/s}$$

2) Angular Momentum in Elliptic Orbit Given Perigee Radius and Perigee Velocity

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

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

$$ex \quad 65749.99 \text{ km}^2/\text{s} = 6778 \text{ km} \cdot 9.7005 \text{ km/s}$$

3) Apogee Radius of Elliptic Orbit Given Angular Momentum and Eccentricity

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

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d_img.jpg\)](#)

$$ex \quad 27114.01 \text{ km} = \frac{(65750 \text{ km}^2/\text{s})^2}{[GM.Earth] \cdot (1 - 0.6)}$$



4) Apogee Velocity in Elliptic Orbit Given Angular Momentum and Apogee Radius

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

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 2.425304\text{km/s} = \frac{65750\text{km}^2/\text{s}}{27110\text{km}}$$

5) Azimuth-Averaged Radius Given Apogee and Perigee Radii

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

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 13555.5\text{km} = \sqrt{27110\text{km} \cdot 6778\text{km}}$$

6) Eccentricity of Elliptical Orbit given Apogee and Perigee

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

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 0.599976 = \frac{27110\text{km} - 6778\text{km}}{27110\text{km} + 6778\text{km}}$$

7) Eccentricity of Orbit

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

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

$$ex \quad 0.602125 = \frac{20400\text{km}}{2 \cdot 16940\text{km}}$$



8) Elliptical Orbit Time Period given Angular Momentum and Eccentricity



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

[Open Calculator](#)

$$\text{ex } 21954.4\text{s} = \frac{2 \cdot \pi}{[\text{GM.Earth}]^2} \cdot \left(\frac{65750\text{km}^2/\text{s}}{\sqrt{1 - (0.6)^2}} \right)^3$$

9) Radial Velocity in Elliptic Orbit given Radial Position and Angular Momentum



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

[Open Calculator](#)

$$\text{ex } 3.48529\text{km/s} = \frac{65750\text{km}^2/\text{s}}{18865\text{km}}$$

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



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

[Open Calculator](#)

$$\text{ex } 2.567101\text{km/s} = [\text{GM.Earth}] \cdot 0.6 \cdot \frac{\sin(135.11^\circ)}{65750\text{km}^2/\text{s}}$$



11) Semimajor Axis of Elliptic Orbit given Apogee and Perigee Radii

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

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

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

12) Specific Energy of Elliptic Orbit given Angular Momentum

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

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } -11760.722845\text{kJ/kg} = -\frac{1}{2} \cdot \frac{[\text{GM.Earth}]^2}{(65750\text{km}^2/\text{s})^2} \cdot (1 - (0.6)^2)$$

13) Specific Energy of Elliptic Orbit given Semi Major Axis

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

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$\text{ex } -11765.066169\text{kJ/kg} = -\frac{[\text{GM.Earth}]}{2 \cdot 16940\text{km}}$$



14) Time Period for One Complete Revolution given Angular Momentum



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

Open Calculator

$$ex \quad 21230.77s = \frac{2 \cdot \pi \cdot 16940km \cdot 13115km}{65750km^2/s}$$

15) Time Period of Elliptical Orbit given Angular Momentum

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

Open Calculator

$$ex \quad 21954.4s = \frac{2 \cdot \pi}{[GM.Earth]^2} \cdot \left(\frac{65750km^2/s}{\sqrt{1 - (0.6)^2}} \right)^3$$

16) Time Period of Elliptical Orbit given Semi-Major Axis

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

Open Calculator

$$ex \quad 21938.2s = 2 \cdot \pi \cdot (16940km)^2 \cdot \frac{\sqrt{1 - (0.6)^2}}{65750km^2/s}$$



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

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

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)

$$\text{ex } 135.1122^\circ = a \cos \left(\frac{\frac{(65750 \text{ km}^2/\text{s})^2}{[\text{GM.Earth}] \cdot 18865 \text{ km}} - 1}{0.6} \right)$$

Orbital Position as Function of Time

18) Eccentric Anomaly in Elliptic Orbit given True Anomaly and Eccentricity

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

[Open Calculator !\[\]\(3cb60d42b10e53f9522bb0b392c1c4cd_img.jpg\)](#)

$$\text{ex } 100.8744^\circ = 2 \cdot a \tan \left(\sqrt{\frac{1 - 0.6}{1 + 0.6}} \cdot \tan \left(\frac{135.11^\circ}{2} \right) \right)$$

19) Mean Anomaly in Elliptic Orbit given Eccentric Anomaly and Eccentricity

$$\text{fx } M_e = E - e_e \cdot \sin(E)$$

[Open Calculator !\[\]\(0d7ca0919e6c47bbd874bfa0189fe22e_img.jpg\)](#)

$$\text{ex } 67.1138^\circ = 100.874^\circ - 0.6 \cdot \sin(100.874^\circ)$$



20) Mean Anomaly in Elliptic Orbit given Time since Periapsis

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

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$\text{ex } 67.39726^\circ = \frac{2 \cdot \pi \cdot 4100\text{s}}{21900\text{s}}$$

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

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

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$\text{ex } 4275.452\text{s} = (100.874^\circ - 0.6 \cdot \sin(100.874^\circ)) \cdot \frac{21900\text{s}}{2 \cdot \Pi(6)}$$

22) Time since Periapsis in Elliptic Orbit given Mean Anomaly

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

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

$$\text{ex } 4091.042\text{s} = 67.25^\circ \cdot \frac{21900\text{s}}{2 \cdot \pi}$$



23) True Anomaly in Elliptic Orbit given Eccentric Anomaly and Eccentricity

[Open Calculator !\[\]\(666e09182d4cd268646ea700ea60dcdf_img.jpg\)](#)

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

$$\text{ex } 135.1097^\circ = 2 \cdot a \tan \left(\sqrt{\frac{1 + 0.6}{1 - 0.6}} \cdot \tan \left(\frac{100.874^\circ}{2} \right) \right)$$



Variables Used

- 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

- **Constant: pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Constant: [GM.Earth]**, 3.986004418E+14
Earth's Geocentric Gravitational Constant
- **Function: acos**, $\text{acos}(\text{Number})$
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.
- **Function: atan**, $\text{atan}(\text{Number})$
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.
- **Function: cos**, $\text{cos}(\text{Angle})$
Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- **Function: Pi**, $\text{Pi}(\text{Number})$
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.
- **Function: sin**, $\text{sin}(\text{Angle})$
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.
- **Function: sqrt**, $\text{sqrt}(\text{Number})$
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.
- **Function: tan**, $\text{tan}(\text{Angle})$
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 ($^{\circ}$)
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 (km^2/s)
Specific Angular Momentum Unit Conversion 



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