

Deimos' Rotation Equations

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Constants

$f_R := 2791.826$	Free Rotation Constant
$i_M := 0.127036$	Maximum Influenced Rotation Constant (for planets and Deimos only)
$i_{St} := 1.0121647 \cdot 10^{-12}$	Start Influenced Rotation Distance Constant
$i_{Ma} := 5.6964797 \cdot 10^{-10}$	Maximum Influenced Rotation Distance Constant
$i_{Sp} := 1.0686849 \cdot 10^{-9}$	Stop Rotation Distance Constant

Facts

	<u>Deimos</u>	<u>Mars</u>	<u>Sun</u>
Mass (kg)	$m_m := 2.4 \cdot 10^{15}$	$m_m := 6.4185 \cdot 10^{23}$	$M := 1.9891 \cdot 10^{30}$
Density (g/cm ³)	$\rho_m := 1.75$		$\rho_s := 1.408$
Axis Tilt (deg)	$t_m := 0.897$	$t := 25.19$	$t_s := 7.25$
Semi-major Axis (km)	$a_m := 23459$	$a := 227920000$	
Orbit Eccentricity (deg)	$e_m := 0.0002$	$e_m := 0.09341233$	
Orbit Inclination (deg), with respect to equator	$i_m := 1.79$	$i := 5.65$	

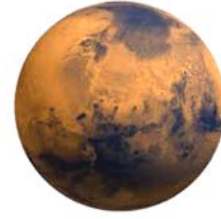
$$\omega_F := f_R \div \sqrt[6]{m_m} \cdot \sqrt[2]{\rho_m}$$

$$\omega_F = 10.0934313$$

Deimos' Free Rotational Speed (per day)

Part 1

Deimos' Influenced Rotation by the influence of the [Mars](#)



$$q := a_m \cdot (1 - e_m)$$

$$q = 23454.3 \quad \text{Deimos' Perihelion Distance (km)}$$

$$Q := a_m \cdot (1 + e_m)$$

$$Q = 23463.7 \quad \text{Deimos' Aphelion Distance (km)}$$

$$i_r := \left(\left| \cos\left(\frac{i_m \cdot \pi}{180}\right) \right| + 1 \right) \div 2$$

$$i_r = 0.99975601 \quad \text{Deimos' Orbit Inclination Reduction Factor}$$

$$\omega_{Mi} := \frac{\sqrt[6]{m_m \cdot i_r \div m} \div \sqrt[6]{\rho_m \div i_M}}{\sqrt[3]{M \div m}}$$

$$\omega_{Mi} = 0.00193763 \quad \text{Deimos' Maximum Influenced Rotational Speed by the Mars (p.d.)}$$

$$S_t := \frac{\sqrt[6]{m_m \cdot i_r \div m} \div i_{St}}{\sqrt[3]{M \div m}}$$

$$S_t = 266964230.6 \quad \text{Deimos' Start Influenced Rotation Distance to the Mars (km)}$$

$$M_a := \frac{\sqrt[6]{m_m \cdot i_r \div m} \div i_{Ma}}{\sqrt[3]{M \div m}}$$

$$M_a = 474348.7 \quad \text{Deimos' Maximum Influenced Rotation Distance to the Mars (km)}$$

$$S_p := \frac{\sqrt[6]{m_m \cdot i_r \div m} \div i_{Sp}}{\sqrt[3]{M \div m}}$$

$$S_p = 252845.1 \quad \text{Deimos' Stop Influenced Rotation Distance to the Mars (km)}$$

Calculating Deimos' average distance to the Mars, if $(q < S_p < Q)$

$$x := \text{if} \left(q < S_p, \text{if} \left(S_p < Q, \frac{S_p - a_m}{e_m}, 0 \right), 0 \right)$$

$$x = 0 \quad \text{X value at Deimos' orbit intersection with } S_p \text{ Boundary (km)}$$

$$b := a_m \sqrt{1 - e_m^2}$$

$$b = 23459 \quad \text{Deimos' Semi-minor Axis (km)}$$

$$y := b \sqrt{a_m^2 - x^2} \div a_m$$

$$y = 23459 \quad \text{Y value at the Deimos' orbit intersection with } S_p \text{ Boundary (km)}$$

$$\theta := \text{atan} \left(\frac{-x}{y} \right) + \frac{\pi}{2}$$

$$\theta = 1.57079633 \quad \text{Half-angle of the Deimos' orbit out of } S_p \text{ Boundary (rad)}$$

$$P_o := 2 \cdot a_m \cdot \int_0^\pi \sqrt{1 - e_m^2 \cdot \sin(\theta)^2} d\theta$$

$$P_o = 147397.24 \quad \text{Deimos' Orbital Perimeter (km)}$$

$$s_m := a_m \cdot \int_0^\theta \sqrt{1 - e_m^2 \cdot \sin(\theta)^2} d\theta$$

$$s = 36849.3 \quad \text{Half of the Deimos' orbit out of } S_p \text{ Boundary (km)}$$

$$a_a := \text{if} \left[q < S_p, \text{if} \left[S_p < Q, a_m \frac{\int_{\pi - (s \div a_m)}^\pi \frac{\sqrt{1 - e_m^2 \cdot \cos(E)^2}}{1 \div (1 - e_m \cdot \cos(E))} dE}{\int_{\pi - (s \div a_m)}^\pi \sqrt{1 - e_m^2 \cdot \cos(E)^2} dE}, 0 \right], 0 \right]$$

$$a_a = 0 \quad \text{Deimos' average distance outside } S_p \text{ Boundary (km)}$$

$$n := \frac{2 \cdot s}{P_o} \cdot \sqrt{\frac{a_a^3}{a^3}}$$

$$n = 0$$

Temporal ratio of the Deimos' orbit out of S_p Boundary to the whole orbit

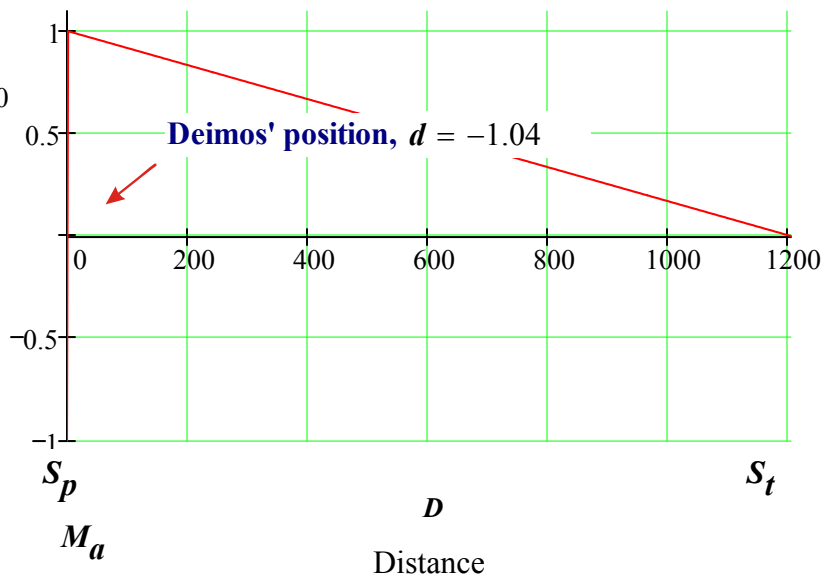
$$d := \text{if} \left(q < S_p, \text{if} \left(S_p < Q, \frac{a_a - S_p}{M_a - S_p}, \frac{a_m - S_p}{M_a - S_p} \right), \frac{a_m - S_p}{M_a - S_p} \right)$$

$$d = -1.03558662$$

Deimos' corresponding distance on x axis of the graph

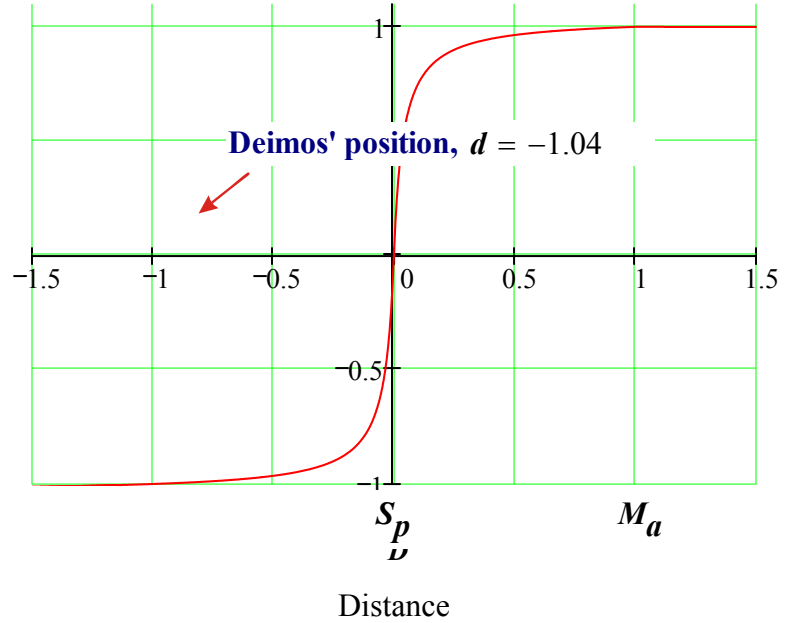
$$\text{Rotation} = \begin{cases} -1 - \frac{0.04}{D - (\sqrt{0.29} - 0.5)} - (\sqrt{0.29} - 0.5) & \text{if } D < 0 \\ \frac{-0.04}{D + (\sqrt{0.29} - 0.5)} + (0.5 + \sqrt{0.29}) & \text{if } 0 \leq D \leq 1 \\ \frac{-D + 1}{S_t - M_a} + 1 & \text{if } 1 < D \end{cases}$$

Non-proportional Rotation Graph



Left end of the Rotation Graph

$$\text{Rotation} \left| \begin{array}{l} -1 - \frac{0.04}{D - (\sqrt{0.29} - 0.5)} - (\sqrt{0.29} - 0.5) \text{ if } D < 0 \\ \frac{-0.04}{D + (\sqrt{0.29} - 0.5)} + (0.5 + \sqrt{0.29}) \text{ if } 0 \leq D \leq 1 \\ \frac{-D + 1}{S_t - M_a} + 1 \text{ if } 1 < D \\ \frac{M_a - S_p}{M_a - S_p} \end{array} \right.$$



$$\omega(d) := \left| \begin{array}{l} -1 - \frac{0.04}{d - (\sqrt{0.29} - 0.5)} - (\sqrt{0.29} - 0.5) \text{ if } d < 0 \\ \frac{-0.04}{d + (\sqrt{0.29} - 0.5)} + (0.5 + \sqrt{0.29}) \text{ if } 0 \leq d \leq 1 \\ \frac{-d + 1}{S_t - M_a} + 1 \text{ if } 1 < d \\ \frac{M_a - S_p}{M_a - S_p} \end{array} \right.$$

$\omega(d) = -1.00127611$ Deimos' corresponding Influenced Rotation by the Mars on the Y axis of the graph

$$t_r := \text{if} \left[a_m < M_a, \left(\text{if} \left(\omega_{Mi} > \omega_F, \frac{t_m \cdot \omega_F}{90}, \frac{t_m \cdot \omega_{Mi}}{90} \right) \right), \left(\text{if} \left(\omega(d) \cdot \omega_{Mi} > \omega_F, \frac{t_m \cdot \omega_F}{90}, \frac{t_m \cdot \omega(d) \cdot \omega_{Mi}}{90} \right) \right) \right]$$

$t_r = 0.00001931$ Deimos' Maximum and Free Rotational Speed Reduction by Axis Tilt Degree

$$\omega c_1 := \text{if} \left[a_m > M_a, \omega(d) \cdot \omega_{Mi} + \omega_F - t_r, \left[\omega(d) \cdot (\omega_{Mi} + \omega_F - t_r) \cdot \text{if} (q < S_p, \text{if} (Q > S_p, n, 0), 1) \right] \right]$$

$\omega c_1 = 0$ Deimos' end result Influenced Rotation by the Mars (p.d.)

Part 2

Deimos' Influenced Rotation by the influence of the Sun



$$q_v := a \cdot (1 - e)$$

$$q = 206629461.7 \quad \text{Deimos/Mars' Perihelion Distance to the Sun (km)}$$

$$Q_v := a \cdot (1 + e)$$

$$Q = 249210538.3 \quad \text{Deimos/Mars' Aphelion Distance to the Sun (km)}$$

$$i_r := \left(\left| \cos\left(\frac{i \cdot \pi}{180}\right) \right| + 1 \right) \div 2$$

$$i_r = 0.99757093 \quad \text{Deimos/Mars' Orbit Inclination Reduction Factor}$$

$$\omega_{Mi} := \frac{\sqrt[6]{m_m \cdot i_r \div M} \div \sqrt[6]{\rho_m}}{i_M}$$

$$\omega_{Mi} = 0.02338747 \quad \text{Deimos' Maximum Influenced Rotational Speed by the Sun (p.d.)}$$

$$S_t := \frac{\sqrt[6]{m_m \cdot i_r \div M}}{i_{St}}$$

$$S_t = 3222294387 \quad \text{Deimos' Start Influenced Rotation Distance to the Sun (km)}$$

$$M_a := \frac{\sqrt[6]{m_m \cdot i_r \div M}}{i_{Ma}}$$

$$M_a = 5725452.9 \quad \text{Deimos' Maximum Influenced Rotation Distance to the Sun (km)}$$

$$S_p := \frac{\sqrt[6]{m_m \cdot i_r \div M}}{i_{Sp}}$$

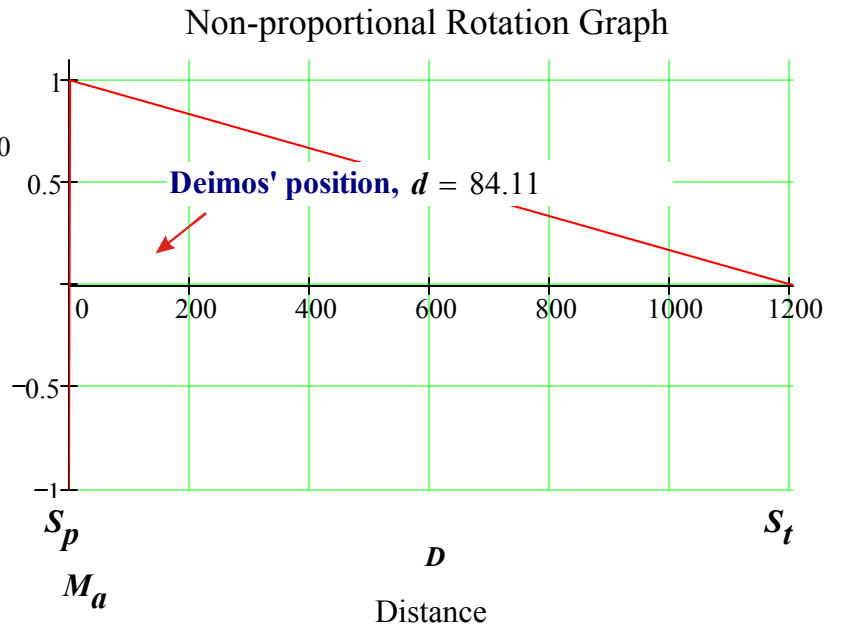
$$S_p = 3051874.9 \quad \text{Deimos' Stop Influenced Rotation Distance to the Sun (km)}$$

$$d := \frac{a - S_p}{M_a - S_p}$$

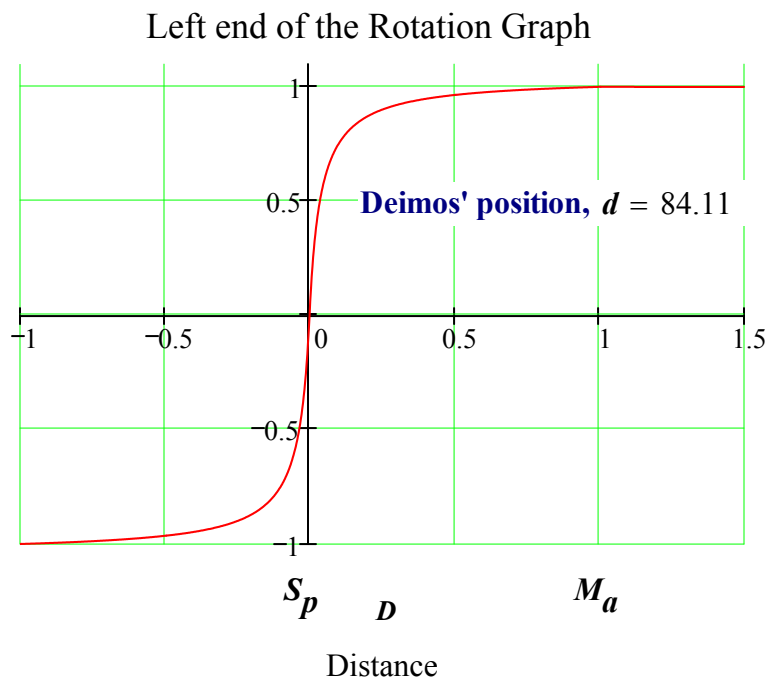
$$d = 84.10756087$$

Deimos' corresponding distance to the Sun relative to S_p on the X axis of the graph

$$\text{Rotation} = \begin{cases} -1 - \frac{0.04}{D - (\sqrt{0.29} - 0.5)} - (\sqrt{0.29} - 0.5) & \text{if } D < 0 \\ \frac{-0.04}{D + (\sqrt{0.29} - 0.5)} + (0.5 + \sqrt{0.29}) & \text{if } 0 \leq D \leq 1 \\ \frac{-D + 1}{S_t - M_a} + 1 & \text{if } 1 < D \end{cases}$$



$$\text{Rotation} = \begin{cases} -1 - \frac{0.04}{D - (\sqrt{0.29} - 0.5)} - (\sqrt{0.29} - 0.5) & \text{if } D < 0 \\ \frac{-0.04}{D + (\sqrt{0.29} - 0.5)} + (0.5 + \sqrt{0.29}) & \text{if } 0 \leq D \leq 1 \\ \frac{-D + 1}{S_t - M_a} + 1 & \text{if } 1 < D \end{cases}$$



$$\omega(d) := \begin{cases} -1 - \frac{0.04}{d - (\sqrt{0.29} - 0.5)} - (\sqrt{0.29} - 0.5) & \text{if } d < 0 \\ \frac{-0.04}{d + (\sqrt{0.29} - 0.5)} + (0.5 + \sqrt{0.29}) & \text{if } 0 \leq d \leq 1 \\ \frac{-d + 1}{S_t - M_a} + 1 & \text{if } 1 < d \\ \frac{M_a - S_p}{M_a - S_p} & \end{cases}$$

$\omega(d) = 0.93092188$ Deimos' corresponding Influenced Rotational Speed by the Sun on Y axis of the graph

$$t_{m2} := t_m + t$$

$t_{m2} = 26.087$ Deimos' Axis Tilt with respect to the Sun (deg)

$$t_r := \text{if} \left(a < M_a, \text{if} \left(\omega_{Mi} > \omega_F, \frac{t_{m2} \cdot \omega_F}{90}, \frac{t_{m2} \cdot \omega_{Mi}}{90} \right), \text{if} \left(\omega(d) \cdot \omega_{Mi} > \omega_F, \frac{t_{m2} \cdot \omega_F}{90}, \frac{t_{m2} \cdot \omega(d) \cdot \omega_{Mi}}{90} \right) \right)$$

$t_r = 0.00631071$ Deimos' Maximum and Free Rotational Speed Reduction by Axis Tilt

$$\omega_2 := \text{if} \left[a < M_a, \omega(d) \cdot (\omega_{Mi} - t_r), \text{if} \left(q < S_t, \omega(d) \cdot \omega_{Mi} - t_r, 0 \right) \right]$$

$\omega_2 = 0.0154612$ **Deimos' end result Influenced Rotation by the Sun (p.d.)**
(Negative number means the reduction amount from Deimos' Free Rotation)

Part 3

Deimos' Total Rotation

$$\omega_s := \sum_{i=1}^2 \omega_i$$

$$\omega_s = 0.0154612 \quad \text{Deimos' Total Rotation (p.d.)}$$

$$T := \text{if} \left(\omega_1 \leq 0, 0, \text{if} \left(t \leq 90, \frac{1}{\omega_s}, \frac{-1}{\omega_s} \right) \right)$$

$$T = 0.0000$$

Deimos' Sidereal Rotation Period (day)
If (T = 0 , Deimos' Synchronous Tropical Rotation)

Observation

$$T_o := 0.0000$$

Deimos' Sidereal Rotation Period (day)
If (T = 0 , Deimos' Synchronous Tropical Rotation)

$$\%Diff := \frac{(T - T_o) \cdot 200}{T + T_o}$$

$$\%Diff = 0.0000$$

Percentage difference between the calculation and the observation