ΘΕΜΑ :

Βλήμα ***P*** εκτοξεύεται από τόπο **Γεωγραφικού Πλάτους** ($\frac{Pi}{2} - \theta$) και ύψος **H** έτσι ώστε η αρχική του ταχύτητα u_0 να σχηματίζει **γωνία α** με το οριζόντιο επίπεδο($\hat{\theta}\,B\,\hat{\phi}$) και **β** με το κατακόρυφο επίπεδο($\hat{\theta}\,B\,\hat{r}$)
και να διευθύνεται πρός ΒΑ .
Να βρεθεί η θέση πρόσκρουσης στην Επιφάνεια της ΓΗΣ .

Παραδοχές :

Η τιμή g της επιτάχυνσης της βαρύτητας διατηρείται σταθερή .
Λαμβάνεται υπ΄όψη η Coriolis η κάθετη στο επίπεδο του Μεσημβρινού .

ΠΑΡΑΤΗΡΗΣΗ :
Για οποιοδήποτε Διάνυσμα Α (Θέσεως, Ταχύτητας , Ροπής , Επιταχύνσεως ,κλπ.) που είναι συνάρτηση του χρόνου t ισχύει η σχέση .:

$$O \equiv \Omega \qquad \left.\frac{d\vec{A}}{dt}\right|_{\Omega} = \left.\frac{d\vec{A}}{dt}\right|_{O} + \vec{\omega} \times \vec{A}$$

Ω Αδρανειακό Σύστημα,Αδρανειακός παρατηρητής
Ο <u>ΜΗ</u> Αδρανειακό Σύστημα ,ΜΗ Αδρανειακός παρατηρητής

ΒΑΣΙΚΟ : Γιά ΑΔΡΑΝΕΙΑΚΟ παρατηρητή τα Μοναδιαία Διανύσματα Μεταβάλλονται Συναρτήσει του Χρόνου . Επομένως πρέπει να Υπολογίζουμε τις Παραγώγους των Μοναδιαίων Διανυσμάτων Συναρτήσει του Χρόνου .

Το Maple Υπολογίζει τις παραγώγους ΜΟΝΟ των Μοναδιαίων Διανυσμάτων : $\widehat{r(t)}$, $\widehat{\theta(t)}$, $\widehat{\phi(t)}$.!

```
with(Physics[Vectors]) :
Setup(mathematicalnotation = true) :
r_ := r(t)·_r(t)
```

$$\vec{r} := r(t)\,\hat{r}(t)$$

```
diff(r_, t)
```

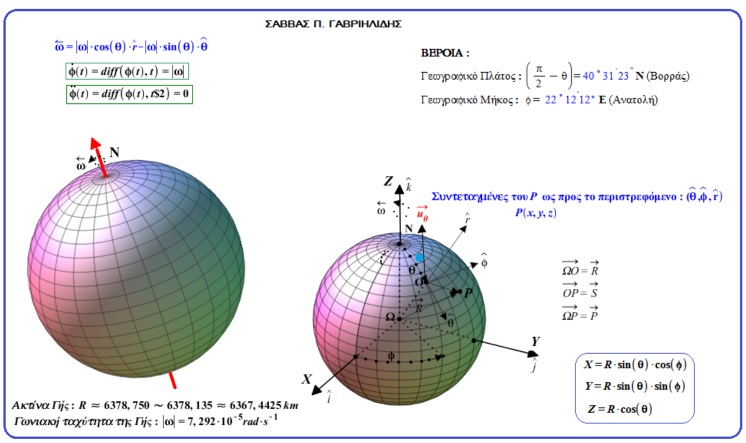
$$\dot{r}(t)\,\hat{r}(t) + r(t)\left(\dot{\theta}(t)\,\hat{\theta}(t) + \sin(\theta(t))\,\dot{\phi}(t)\,\hat{\phi}(t)\right)$$

```
R_ := x(t)·_i(t) + y(t)·_j(t) + z(t)·_k(t)
```

$$\vec{R} := x(t)\,\hat{i}(t) + y(t)\,\hat{j}(t) + z(t)\,\hat{k}(t)$$

```
diff(R_, t)
```

$$\dot{x}(t)\,\hat{i}(t) + x(t)\,\dot{\hat{i}}(t) + \dot{y}(t)\,\hat{j}(t) + y(t)\,\dot{\hat{j}}(t) + \dot{z}(t)\,\hat{k}(t) + z(t)\,\dot{\hat{k}}(t)$$



$$\hat{r} = \sin(\theta)\cos(\phi)\,\hat{i} + \sin(\theta)\sin(\phi)\,\hat{j} + \cos(\theta)\,\hat{k}$$

$$\hat{\theta} = \cos(\theta)\cos(\phi)\,\hat{i} + \cos(\theta)\sin(\phi)\,\hat{j} - \sin(\theta)\,\hat{k}$$

$$\hat{\phi} = -\hat{i}\sin(\phi) + \hat{j}\cos(\phi)$$

> restart

$$\begin{bmatrix}\vec{e1}\\ \vec{e2}\\ \vec{e3}\end{bmatrix} = \begin{bmatrix}\cos(a)\,\hat{i} + \cos(b)\,\hat{j} + \cos(c)\,\hat{k}\\ \cos(d)\,\hat{i} + \cos(e)\,\hat{j} + \cos(f)\,\hat{k}\\ \cos(g)\,\hat{i} + \cos(h)\,\hat{j} + \cos(i)\,\hat{k}\end{bmatrix}$$

$$\vec{e1} = \cos(a)\,\hat{i} + \cos(b)\,\hat{j} + \cos(c)\,\hat{k}$$

$$\vec{e2} = \cos(d)\,\hat{i} + \cos(e)\,\hat{j} + \cos(f)\,\hat{k}$$

$$\vec{e3} = \cos(g)\,\hat{i} + \cos(h)\,\hat{j} + \cos(i)\,\hat{k}$$

$$\begin{bmatrix}\hat{i}\\ \hat{j}\\ \hat{k}\end{bmatrix} = \begin{bmatrix}\cos(a)\,\vec{e1} + \cos(d)\,\vec{e2} + \cos(g)\,\vec{e3}\\ \cos(b)\,\vec{e1} + \cos(e)\,\vec{e2} + \cos(h)\,\vec{e3}\\ \cos(c)\,\vec{e1} + \cos(f)\,\vec{e2} + \cos(i)\,\vec{e3}\end{bmatrix}$$

$$\hat{i} = \cos(a)\,\vec{e1} + \cos(d)\,\vec{e2} + \cos(g)\,\vec{e3}$$

$$\hat{j} = \cos(b)\,\vec{e1} + \cos(e)\,\vec{e2} + \cos(h)\,\vec{e3}$$

$$\hat{k} = \cos(c)\,\vec{e1} + \cos(f)\,\vec{e2} + \cos(i)\,\vec{e3}$$

ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΣ ΣΥΣΤΗΜΑΤΩΝ

$$A_x = A_{e1}\cos(a) + A_{e2}\cos(d) + A_{e3}\cos(g)$$

$$A_y = A_{e1}\,coa(b) + A_{e2}\cos(e) + A_{e3}\cos(h)$$

$$A_z = A_{e1}\cos(c) + A_{e2}\cos(f) + A_{e3}\cos(i)$$

$PX := x(t)\cdot cosa + y(t)\cdot cosd + z(t)\cdot cosg$ $\qquad PX := x(t)\cos(\theta)\cos(\phi) - y(t)\sin(\phi) + z(t)\sin(\theta)\cos(\phi)$

$PY := x(t)\cdot cosb + y(t)\cdot cose + z(t)\cdot cosH$ $\qquad PY := x(t)\cos(\theta)\sin(\phi) + y(t)\cos(\phi) + z(t)\sin(\theta)\sin(\phi)$

$PZ := x(t)\cdot cosc + y(t)\cdot cosf + z(t)\cdot cosi$ $\qquad PZ := -x(t)\sin(\theta) + z(t)\cos(\theta)$

ΕΠΑΛΗΘΕΥΣΗ : Έστωσαν (**zt, xt, yt**) οι συντεταγμένες σημείου L ως προς το σύστημα ($\boldsymbol{r}, \boldsymbol{\theta}, \boldsymbol{\phi}$).

$\mathbf{L\_ := zt\cdot\_r + xt\cdot\_\theta + yt\cdot\_\phi}$ $\qquad \vec{L} := yt\,\hat{\phi} + zt\,\hat{r} + xt\,\hat{\theta}$

ΩΣ ΠΡΟΣ ΤΟ ΩΧΥΖ ΓΙΝΟΝΤΑΙ :

ChangeBasis(*L_*, 1)

$$(zt\sin(\theta)\cos(\phi) + xt\cos(\theta)\cos(\phi) - yt\sin(\phi))\,\hat{i} + (zt\sin(\theta)\sin(\phi) + xt\cos(\theta)\sin(\phi) + yt\cos(\phi))\,\hat{j} + (-\sin(\theta)\,xt + \cos(\theta)\,zt)\,\hat{k}$$

$LX := Component(\mathbf{(18)}, 1)$ $\qquad LX := zt\sin(\theta)\cos(\phi) + xt\cos(\theta)\cos(\phi) - yt\sin(\phi)$

$LY := Component(\mathbf{(18)}, 2)$ $\qquad LY := zt\sin(\theta)\sin(\phi) + xt\cos(\theta)\sin(\phi) + yt\cos(\phi)$

$LZ := Component(\mathbf{(18)}, 3)$ $\qquad LZ := -\sin(\theta)\,xt + \cos(\theta)\,zt$

> *restart*

```
> with(Physics[Vectors]) :
> Setup(mathematicalnotation = true) :
> with(plots) :
> with(plottools) :
```

Δεδομένα :

> $R\_ := R\cdot\_r$

$$\vec{R} := R\,\hat{r} \tag{1}$$

> $S\_ := x(t)\cdot\_\theta + y(t)\cdot\_\phi + z(t)\cdot\_r$

$$\vec{S} := x(t)\,\hat{\theta} + y(t)\,\hat{\phi} + z(t)\,\hat{r} \tag{2}$$

> $P\_ := R\_ + S\_$

$$\vec{P} := \hat{r}\,(R + z(t)) + x(t)\,\hat{\theta} + y(t)\,\hat{\phi} \tag{3}$$

> $R1 := 6367442$

$$R1 := 6367442 \tag{4}$$

> $\Omega := 7.292\cdot 10^{-5}$

$$\Omega := 0.00007292000000 \tag{5}$$

> $H := 10000$

$$H := 10000 \tag{6}$$

> $\alpha := \frac{\text{Pi}}{4}$

$$\alpha := \frac{\pi}{4} \tag{7}$$

> $\beta := 0.25$

$$\beta := 0.25 \tag{8}$$

> $u[0] := 2000$

$$u_0 := 2000 \tag{9}$$

> $g := 9.80$

$$g := 9.80 \tag{10}$$

> $GP1 := 0.7072607424$

$$GP1 := 0.7072607424 \tag{11}$$

> $GM1 := 0.3875212718$

$$GM1 := 0.3875212718 \tag{12}$$

> $\omega\_ := \Omega\cdot\cos\left(\frac{\pi}{2} - \text{GP1}\right)\cdot\_r - \Omega\cdot\sin\left(\frac{\pi}{2} - GP1\right)\cdot\_\theta$

$$\vec{\omega} := 0.00004738006019\,\hat{r} - 0.00005542974199\,\hat{\theta} \tag{13}$$

> $u0\_ := -u[0]\cdot\cos(\alpha)\cos(\beta)\cdot\_\theta + u[0]\cdot\cos(\alpha)\sin(\beta)\cdot\_\phi + u[0]\cdot\sin(\alpha)\cdot\_r$

$$\vec{u0} := 247.4039593\,\sqrt{2}\,\hat{\phi} - 968.9124217\,\sqrt{2}\,\hat{\theta} + 1000.\,\sqrt{2}\,\hat{r} \tag{14}$$

> $F\_ := -m\cdot g\cdot\_r$

$$\vec{F} := -9.80\,m\,\hat{r} \tag{15}$$

> $evalf\left(\frac{\pi}{2} - \mathrm{GP1}\right)$

$$0.8635355846 \tag{16}$$

Ανάλυση :

> $u\_ := diff(P\_, t) + \omega\_ \times P\_$

$$\vec{u} := \hat{r}\,(\dot{z}(t) - 0.00005542974199\,y(t)) + \hat{\theta}\,(\dot{x}(t) - 0.00004738006019\,y(t)) + \hat{\phi}\,(\dot{y}(t) + 0.00004738006019\,x(t) + 0.00005542974199\,R + 0.00005542974199\,z(t)) \tag{17}$$

> $a\_ := diff(u\_, t) + \omega\_ \times u\_$

$$\vec{a} := \hat{r}\,(\ddot{z}(t) - 0.0001108594840\,\dot{y}(t) - 2.626264512\,10^{-9}\,x(t) - 3.072456297\,10^{-9}\,R - 3.072456297\,10^{-9}\,z(t)) + \hat{\theta}\,(\ddot{x}(t) - 0.00009476012038\,\dot{y}(t) - 2.244870104\,10^{-9}\,x(t) - 2.626264512\,10^{-9}\,R - 2.626264512\,10^{-9}\,z(t)) + \hat{\phi}\,(\ddot{y}(t) + 0.00009476012038\,\dot{x}(t) + 0.0001108594840\,\dot{z}(t) - 5.317326401\,10^{-9}\,y(t)) \tag{18}$$

> $FYGOKENTROS := \omega\_ \times (\omega\_ \times P\_)$

$$FYGOKENTROS := -5.317326401\,10^{-9}\,y(t)\,\hat{\phi} + (-2.626264512\,10^{-9}\,x(t) - 3.072456297\,10^{-9}\,R - 3.072456297\,10^{-9}\,z(t))\,\hat{r} + (-2.244870104\,10^{-9}\,x(t) - 2.626264512\,10^{-9}\,R - 2.626264512\,10^{-9}\,z(t))\,\hat{\theta} \tag{19}$$

> $CORIOLIS := 2\cdot\omega\_ \times (diff(P\_, t))$

$$CORIOLIS := -0.0001108594840\,\hat{r}\,\dot{y}(t) - 0.00009476012038\,\hat{\theta}\,\dot{y}(t) + (0.00009476012038\,\dot{x}(t) + 0.0001108594840\,\dot{z}(t))\,\hat{\phi} \tag{20}$$

Αν αγνοηθεί η φυγόκεντρος $\vec{\boldsymbol{\omega}} \times (\vec{\boldsymbol{\omega}} \times \vec{P})$ **:**

> $a\_ := \mathbf{(18)} - \mathbf{(19)}$

$$\vec{a} := \hat{r}\,(\ddot{z}(t) - 0.0001108594840\,\dot{y}(t)) + \hat{\theta}\,(\ddot{x}(t) - 0.00009476012038\,\dot{y}(t)) + \hat{\phi}\,(\ddot{y}(t) + 0.00009476012038\,\dot{x}(t) + 0.0001108594840\,\dot{z}(t)) \tag{21}$$

ΑΝ αγνοηθεί η Coriolis κατά : $\hat{\boldsymbol{\theta}}: -2\,\dot{y}(t)\,|\boldsymbol{\omega}|\cos(\boldsymbol{\theta})\,\hat{\boldsymbol{\theta}}, \quad \hat{r}: -2\,\dot{y}(t)\,|\boldsymbol{\omega}|\sin(\boldsymbol{\theta})\,\hat{r}$

θα έχουμε :

> $a\_ := \mathbf{(21)} - \left(-2\,\dot{y}(t)\,\Omega\cos\left(\frac{\pi}{2} - GP1\right)\hat{\theta}\right) - \left(-2\,\dot{y}(t)\,\Omega\sin\left(\frac{\pi}{2} - GP1\right)\hat{r}\right)$

$$\vec{a} := \hat{r}\,\ddot{z}(t) + \hat{\theta}\,\ddot{x}(t) + \hat{\phi}\,(\ddot{y}(t) + 0.00009476012038\,\dot{x}(t) + 0.0001108594840\,\dot{z}(t)) \tag{22}$$

ΤΕΛΙΚΗ ΕΚΦΡΑΣΗ ΤΗΣ ΕΠΙΤΑΧΥΝΣΕΩΣ ΤΟΥ ΒΛΗΜΑΤΟΣ P ΩΣ ΠΡΟΣ ΤΟ ΑΔΡΑΝΕΙΑΚΟ ΣΥΣΤΗΜΑ :

$$\vec{a} := 2\,\dot{z}(t)\,\Omega\sin(\theta)\,\hat{\phi} + 2\,\dot{x}(t)\,\Omega\cos(\theta)\,\hat{\phi} + \ddot{z}(t)\,\hat{r} + \ddot{x}(t)\,\hat{\theta} + \ddot{y}(t)\,\hat{\phi}$$

Μπορούμε να γράψουμε :

> $-g\cdot\_r = \mathbf{(22)}$

$$-9.80\,\hat{r} = \hat{r}\,\ddot{z}(t) + \hat{\theta}\,\ddot{x}(t) + \hat{\phi}\,(\ddot{y}(t) + 0.00009476012038\,\dot{x}(t) + 0.0001108594840\,\dot{z}(t)) \tag{23}$$

> $lhs(\mathbf{(23)}) - rhs(\mathbf{(23)}) = 0$

$$(-\ddot{y}(t) - 0.00009476012038\,\dot{x}(t) - 0.0001108594840\,\dot{z}(t))\,\widehat{\phi} + (-9.80 - \ddot{z}(t))\,\widehat{r} - \widehat{\theta}\,\ddot{x}(t) = 0 \quad (24)$$

> $Component(lhs((\mathbf{24})), 1) = 0$

$$-9.80 - \ddot{z}(t) = 0 \quad (25)$$

> $Component(lhs((\mathbf{24})), 2) = 0$

$$-\ddot{x}(t) = 0 \quad (26)$$

> $Component(lhs((\mathbf{24})), 3) = 0$

$$-\ddot{y}(t) - 0.00009476012038\,\dot{x}(t) - 0.0001108594840\,\dot{z}(t) = 0 \quad (27)$$

> $Eq1 := (\mathbf{26})\cdot(-1)$

$$Eq1 := \ddot{x}(t) = 0 \quad (28)$$

> $Eq2 := (\mathbf{27})\cdot(-1)$

$$Eq2 := \ddot{y}(t) + 0.00009476012038\,\dot{x}(t) + 0.0001108594840\,\dot{z}(t) = 0 \quad (29)$$

> $Eq3 := (\mathbf{25})\cdot(-1)$

$$Eq3 := 9.80 + \ddot{z}(t) = 0 \quad (30)$$

> $ics1 := x(0) = 0, D(x)(0) = -u[0]\cdot\cos(\alpha)\cdot\cos(\beta)$

$$ics1 := x(0) = 0, D(x)(0) = -968.9124217\sqrt{2} \quad (31)$$

> $ics3 := z(0) = \mathbf{H}, D(z)(0) = u[0]\cdot\sin(\alpha)$

$$ics3 := z(0) = 10000, D(z)(0) = 1000\sqrt{2} \quad (32)$$

> $ics2 := y(0) = 0, D(y)(0) = u[0]\cdot\cos(\alpha)\cdot\sin(\beta)$

$$ics2 := y(0) = 0, D(y)(0) = 247.4039593\sqrt{2} \quad (33)$$

> $sol1 := dsolve(\{Eq1, ics1\})$

$$sol1 := x(t) = -\frac{9689124217\sqrt{2}\,t}{10000000} \quad (34)$$

> $sol3 := dsolve(\{Eq3, ics3\})$

$$sol3 := z(t) = -\frac{49\,t^2}{10} + 1000\sqrt{2}\,t + 10000 \quad (35)$$

> $\dot{x}(t) = diff(rhs((\mathbf{34})), t)$

$$\dot{x}(t) = -\frac{9689124217\sqrt{2}}{10000000} \quad (36)$$

> $\dot{z}(t) = diff(rhs((\mathbf{35})), t)$

$$\dot{z}(t) = -\frac{49\,t}{5} + 1000\sqrt{2} \quad (37)$$

> $subs(\{(\mathbf{36}), (\mathbf{37})\}, Eq2)$

$$\ddot{y}(t) + 0.01904522628\sqrt{2} - 0.001086422943\,t = 0 \quad (38)$$

> $sol2 := dsolve(\{(\mathbf{38}), ics2\})$

$$sol2 := y(t) = \frac{362140981\,t^3}{2000000000000} - \frac{476130657\sqrt{2}\,t^2}{50000000000} + \frac{2474039593\sqrt{2}\,t}{10000000000} \quad (39)$$

Χρόνος απαιτούμενος *toriz* για άφιξη του Βλήματος στο ΟΡΙΖΟΝΤΙΟ επίπεδο Οθφρ .

> $toriz := fsolve(subs(z(t)=0, (35)), t=0.1..\infty)$

$$toriz := 295.5208414 \quad (40)$$

> $xt := evalf(subs(t=toriz, rhs((34))))$

$$xt := -404937.1632 \quad (41)$$

> $yt := evalf(subs(t=toriz, rhs((39))))$

$$yt := 106894.4996 \quad (42)$$

> $zt := evalf(subs(t=toriz, rhs((35))))$

$$zt := 0.0001 \quad (43)$$

ΑΡΧΙΚΗ ΤΑΧΥΤΗΤΑ ΕΚΤΟΞΕΥΣΗΣ $u_0 := ???$

ΓΩΝΙΑ ΕΚΤΟΞΕΥΣΗΣ ΩΣ ΠΡΟΣ ΤΟ ΟΡΙΖΟΝΤΙΟ ΕΠΙΠΕΔΟ : $\alpha := ???$

ΓΩΝΙΑ ΕΚΤΟΞΕΥΣΗΣ ΩΣ ΠΡΟΣ ΤΟ ΚΑΤΑΚΟΡΥΦΟ ΕΠΙΠΕΔΟ : $\beta := ???$

ΕΠΙΤΑΧΥΝΣΗ ΒΑΡΥΤΗΤΑΣ ΣΤΑΘΕΡΗ : $g = 9.80 \frac{[[m]]}{[[s]]^2}$

ΓΩΝΙΑΚΗ ΤΑΧΥΤΗΤΗΤΑ ΠΕΡΙΣΤΡΟΦΗΣ ΤΗΣ ΓΗΣ : $\Omega = 7.292 \cdot 10^{-5} \frac{[[rad]]}{[[s]]}$

ΝΕΕΣ ΘΕΣΕΙΣ ΜΕΤΑ ΤΗΝ ΣΤΡΟΦΗ $D\phi = \Omega \cdot Tpr[[rad]]$

> $xBn := R1 \cdot \sin\left(\frac{\pi}{2} - \mathrm{GP1}\right) \cdot \cos(\mathrm{GM1} + \mathrm{D}\phi)$

$$xBn := 4.840176456\ 10^6 \cos(0.3875212718 + D\phi) \quad (44)$$

> $yBn := R1 \cdot \sin\left(\frac{\pi}{2} - \mathrm{GP1}\right) \cdot \sin(\mathrm{GM1} + \mathrm{D}\phi)$

$$yBn := 4.840176456\ 10^6 \sin(0.3875212718 + D\phi) \quad (45)$$

> $zBn := R1 \cdot \cos\left(\frac{\pi}{2} - \mathrm{GP1}\right)$

$$zBn := 4.137270779\ 10^6 \quad (46)$$

> $xMOn := R1 \cdot \sin\left(\frac{\pi}{2} - GPMO\right) \cdot \cos(\mathrm{GMMO} + \mathrm{D}\phi)$

$$xMOn := 6367442 \cos(GPMO) \cos(GMMO + D\phi) \quad (47)$$

> $yMOn := R1 \cdot \sin\left(\frac{\pi}{2} - GPMO\right) \cdot \sin(\mathrm{GMMO} + \mathrm{D}\phi)$

$$yMOn := 6367442 \cos(GPMO) \sin(GMMO + D\phi) \quad (48)$$

> $zMOn := R1 \cdot \cos\left(\frac{\pi}{2} - GPMO\right)$

$$zMOn := 6367442 \sin(GPMO) \quad (49)$$

> $DistanceBMOn := \mathrm{sqrt}\left((xBn - xMOn)^2 + (yBn - yMOn)^2 + (zBn - zMOn)^2\right)$:

ΣΥΝΤΕΤΑΓΜΕΝΕΣ ΘΕΣΗΣ ΕΚΤΟΞΕΥΣΗΣ ΩΣ ΠΡΟΣ ΤΟ

ΑΔΡΑΝΕΙΑΚΟ ΣΥΣΤΗΜΑ ΩΧΥΖ :

> $XTE := R1 \cdot \sin\left(\frac{\pi}{2} - \mathrm{GP1}\right) \cdot \cos(\mathrm{GM1} + \Omega \cdot \mathrm{t})$

$$XTE := 4.840176456\ 10^6 \cos(0.00007292000000\ t + 0.3875212718) \quad \textbf{(50)}$$

> $YTE := R1 \cdot \sin\left(\frac{\pi}{2} - \mathrm{GP1}\right) \cdot \sin(\mathrm{GM1} + \Omega \cdot \mathrm{t})$

$$YTE := 4.840176456\ 10^6 \sin(0.00007292000000\ t + 0.3875212718) \quad \textbf{(51)}$$

> $ZTE := R1 \cdot \cos\left(\frac{\pi}{2} - \mathrm{GP1}\right)$

$$ZTE := 4.137270779\ 10^6 \quad \textbf{(52)}$$

> $evalf(subs(t = 0, \textbf{(50)}))$

$$4.481270602\ 10^6 \quad \textbf{(53)}$$

> $evalf(subs(t = 0, \textbf{(51)}))$

$$1.829076794\ 10^6 \quad \textbf{(54)}$$

ΣΥΝΤΕΤΑΓΜΕΝΕΣ ΒΛΗΜΑΤΟΣ ΩΣ ΠΡΟΣ ΤΟ ΑΔΡΑΝΕΙΑΚΟ ΣΥΣΤΗΜΑ ΩΧΥΖ : (ΠΡΟΣΟΧΗ ΣΤΙΣ ΑΝΤΙΣΤΟΙΧΙΕΣ)

$PX := x(t) \cdot cosa + y(t) \cdot cosd + z(t) \cdot cosg$ $\quad PX := x(t)\cos(\theta)\cos(\phi) - y(t)\sin(\phi) + z(t)\sin(\theta)\cos(\phi)$

$PY := x(t) \cdot cosb + y(t) \cdot cose + z(t) \cdot cosH$ $\quad PY := x(t)\cos(\theta)\sin(\phi) + y(t)\cos(\phi) + z(t)\sin(\theta)\sin(\phi)$

$PZ := x(t) \cdot cosc + y(t) \cdot cosf + z(t) \cdot cosi$ $\quad PZ := -x(t)\sin(\theta) + z(t)\cos(\theta)$

ΕΠΑΛΗΘΕΥΣΗ : Έστωσαν (zt, xt, yt) οι συντεταγμένες σημείου L ως προς το σύστημα $(\boldsymbol{r}, \boldsymbol{\theta}, \boldsymbol{\phi})$.

$\mathbf{L\_ := zt \cdot \_r + xt \cdot \_\theta + yt \cdot \_\phi}$ $\quad \vec{L} := yt\,\hat{\phi} + zt\,\hat{r} + xt\,\hat{\theta}$

ΩΣ ΠΡΟΣ ΤΟ ΩΧΥΖ ΓΙΝΟΝΤΑΙ :

$ChangeBasis(L\_, 1)$

$$(zt\sin(\theta)\cos(\phi) + xt\cos(\theta)\cos(\phi) - yt\sin(\phi))\,\hat{i} + (zt\sin(\theta)\sin(\phi) + xt\cos(\theta)\sin(\phi) + yt\cos(\phi))\,\hat{j} + (-\sin(\theta)\,xt + \cos(\theta)\,zt)\,\hat{k}$$

$LX := Component(\textbf{(18)}, 1)$ $\quad LX := zt\sin(\theta)\cos(\phi) + xt\cos(\theta)\cos(\phi) - yt\sin(\phi)$

$LY := Component(\textbf{(18)}, 2)$ $\quad LY := zt\sin(\theta)\sin(\phi) + xt\cos(\theta)\sin(\phi) + yt\cos(\phi)$

$LZ := Component(\textbf{(18)}, 3)$ $\quad LZ := -\sin(\theta)\,xt + \cos(\theta)\,zt$

> $LX := \sin\left(\frac{\mathrm{Pi}}{2} - \mathrm{GP1}\right) \cdot \cos(\mathrm{GM1} + \Omega \cdot \mathrm{t}) \cdot rhs(\mathrm{sol3}) + \cos\left(\frac{\mathrm{Pi}}{2} - \mathrm{GP1}\right) \cdot \cos(\mathrm{GM1} + \Omega \cdot \mathrm{t}) \cdot rhs(sol1) - \sin(\mathrm{GM1} + \Omega \cdot \mathrm{t}) \cdot rhs(sol2) :$

> $LY := \sin\left(\frac{\mathrm{Pi}}{2} - \mathrm{GP1}\right) \cdot \sin(\mathrm{GM1} + \Omega \cdot \mathrm{t}) \cdot rhs(\mathrm{sol3}) + \cos\left(\frac{\mathrm{Pi}}{2} - \mathrm{GP1}\right) \cdot \sin(\mathrm{GM1} + \Omega \cdot \mathrm{t}) \cdot rhs(\mathrm{sol1}) + \cos(\mathrm{GM1} + \Omega \cdot \mathrm{t}) \cdot rhs(\mathrm{sol2}) :$

> $LZ := -\sin\left(\frac{\text{Pi}}{2} - \text{GP1}\right) \cdot rhs(\text{sol1}) + \cos\left(\frac{\text{Pi}}{2} - \text{GP1}\right) \cdot rhs(\text{sol3}) :$

> $XBL := LX + R1 \cdot \sin\left(\frac{\pi}{2} - \text{GP1}\right) \cdot \cos(\text{GM1} + \Omega \cdot \text{t})$

$$XBL := 0.7601445692 \cos(0.00007292000000\, t + 0.3875212718) \left(-\frac{49\, t^2}{10} + 1000\sqrt{2}\, t + 10000\right) - 629.5547019 \cos(0.00007292000000\, t + 0.3875212718) \sqrt{2}\, t - \sin(0.00007292000000\, t + 0.3875212718) \left(\frac{362140981\, t^3}{2000000000000} - \frac{476130657\sqrt{2}\, t^2}{50000000000} + \frac{2474039593\sqrt{2}\, t}{10000000}\right) + 4.840176456\ 10^6 \cos(0.00007292000000\, t + 0.3875212718) \quad \textbf{(55)}$$

> $YBL := LY + R1 \cdot \sin\left(\frac{\pi}{2} - \text{GP1}\right) \cdot \sin(\text{GM1} + \Omega \cdot \text{t})$

$$YBL := 0.7601445692 \sin(0.00007292000000\, t + 0.3875212718) \left(-\frac{49\, t^2}{10} + 1000\sqrt{2}\, t + 10000\right) - 629.5547019 \sin(0.00007292000000\, t + 0.3875212718) \sqrt{2}\, t + \cos(0.00007292000000\, t + 0.3875212718) \left(\frac{362140981\, t^3}{2000000000000} - \frac{476130657\sqrt{2}\, t^2}{50000000000} + \frac{2474039593\sqrt{2}\, t}{10000000}\right) + 4.840176456\ 10^6 \sin(0.00007292000000\, t + 0.3875212718) \quad \textbf{(56)}$$

> $ZBL := LZ + R1 \cdot \cos\left(\frac{\pi}{2} - \text{GP1}\right)$

$$ZBL := 1386.267495\sqrt{2}\, t - 3.183794500\, t^2 + 4.143768319\ 10^6 \quad \textbf{(57)}$$

ΣΥΝΤΕΤΑΓΜΕΝΕΣ ΣΤΟΧΟΥ ΩΣ ΠΡΟΣ ΤΟ ΑΔΡΑΝΕΙΑΚΟ ΣΥΣΤΗΜΑ ΩΧΥΖ :

> $XST := R1 \cdot \sin\left(\frac{\pi}{2} - GPMO\right) \cdot \cos(\text{GMMO} + \Omega \cdot \text{t}) :$

> $YST := R1 \cdot \sin\left(\frac{\pi}{2} - GPMO\right) \cdot \sin(\text{GMMO} + \Omega \cdot \text{t}) :$

> $ZST := R1 \cdot \cos\left(\frac{\pi}{2} - GPMO\right) :$

ΠΡΟΣΔΙΟΡΙΣΜΟΣ ΤΩΝ ΣΥΝΤΕΤΑΓΜΕΝΩΝ θ,φ, ΤΟΥ ΣΗΜΕΙΟΥ ΠΡΟΣΚΡΟΥΣΗΣ :

ΩΣ ΠΡΟΣ ΤΟ ΑΔΡΑΝΕΙΑΚΟ ΣΥΣΤΗΜΑ ΩΧΥΖ

> $XPROSKR := R1 \cdot \sin(\theta) \cdot \cos(\phi)$

$$XPROSKR := 6367442 \sin(\theta) \cos(\phi) \quad (58)$$

> $YPROSKR := R1 \cdot \sin(\theta) \cdot \sin(\phi)$

$$YPROSKR := 6367442 \sin(\theta) \sin(\phi) \quad (59)$$

> $ZPROSKR := R1 \cdot \cos(\theta)$

$$ZPROSKR := 6367442 \cos(\theta) \quad (60)$$

> $sys := simplify(\{XBL - XPROSKR = 0, YBL - YPROSKR = 0, ZBL - ZPROSKR = 0\}, symbolic) :$

> $sys[1] :$

> $sys[2] :$

> $sys[3] :$

> $fsolve(sys, \{t = 0.1 ..1000, \theta = 0.1 ..0.88, \phi = 0.387 ..0.5\})$

$$\{\phi = 0.4340475217, t = 305.1388970, \theta = 0.7979609382\} \quad (61)$$

> **(61)**[1]

$$\phi = 0.4340475217 \quad (62)$$

> **(61)**[2]

$$t = 305.1388970 \quad (63)$$

> **(61)**[3]

$$\theta = 0.7979609382 \quad (64)$$

>

ΔΙΑΡΚΕΙΑ ΠΤΗΣΗΣ : *Tpr* .

> $\boldsymbol{Tpr := rhs((61)[2])}$

$$Tpr := 305.1388970 \quad (65)$$

ΚΑΡΤΕΣΙΑΝΕΣ ΣΥΝΤΕΤΑΓΜΕΝΕΣ X,Y,Z, ΤΟΥ ΣΗΜΕΙΟΥ ΠΡΟΣΚΡΟΥΣΗΣ

ΩΣ ΠΡΟΣ ΤΟ ΑΔΡΑΝΕΙΑΚΟ ΣΥΣΤΗΜΑ ΩΧΥΖ

> $X := evalf(subs(\{(61)[1], (61)[2], (61)[3]\}, (58)))$

$$X := 4.135947386\ 10^{6} \quad (66)$$

> $Y := evalf(subs(\{(61)[1], (61)[2], (61)[3]\}, (59)))$

$$Y := 1.917131601\ 10^{6} \quad (67)$$

> $Z := evalf(subs(\{(61)[1], (61)[2], (61)[3]\}, (60)))$

$$Z := 4.445544204\ 10^{6} \quad (68)$$

ΣΥΝΤΕΤΑΓΜΕΝΕΣ ΘΕΣΗΣ ΕΚΤΟΞΕΥΣΗΣ
ΩΣ ΠΡΟΣ ΤΟ ΑΔΡΑΝΕΙΑΚΟ ΣΥΣΤΗΜΑ ΩXYZ

$XTE := 4.481270602\ 10^6$

$YTE := 1.829076794\ 10^6$

$ZTE := 4.137270779\ 10^6$

> $D\phi := \Omega \cdot Tpr$

$$D\phi := 0.02225072837 \quad (69)$$

ΕΦΑΡΜΟΓΗ

ΒΕΡΟΙΑ : (0.7072607424 ⟦rad⟧ N , 0.3875212718 ⟦rad⟧ E)
ΣΚΟΠΙΑ : (0.7329911619⟦rad⟧ N , 0.3739891520⟦rad⟧ E)
ΜΟΣΧΑ : (0.9731222871⟦rad⟧ N, 0.6565457408⟦rad⟧ E)
GREENWICH :GMT: (0.8984470177 ⟦rad⟧N, 0⟦rad⟧)

> $GMTP := evalf\left(convert\left(51 + \frac{28}{60} + \frac{38}{60 \cdot 60}, units, deg, rad\right)\right)[\![rad]\!]$

$$GMTP := 0.8984470177\ [\![rad]\!] \quad (70)$$

> $GMTM := 0[\![rad]\!]$

$$GMTM := 0 \quad (71)$$

> $GMTP1 := 0.8984470177$

$$GMTP1 := 0.8984470177 \quad (72)$$

> $GMTM1 := 0$

$$GMTM1 := 0 \quad (73)$$

> $Ra := 6367442[\![m]\!]$

$$Ra := 6367442\ [\![m]\!] \quad (74)$$

> $GP := evalf\left(convert\left(40 + \frac{31}{60} + \frac{23}{60 \cdot 60}, units, deg, rad\right)\right) [\![rad]\!]$

$$GP := 0.7072607424\ [\![rad]\!] \quad (75)$$

> $GP1 := 0.7072607424$

$$GP1 := 0.7072607424 \quad (76)$$

> $GM := evalf\left(convert\left(22 + \frac{12}{60} + \frac{12}{60 \cdot 60}, units, deg, rad\right)\right) [\![rad]\!]$

$$GM := 0.3875212718\ [\![rad]\!] \quad (77)$$

> $GM1 := 0.3875212718$

$$GM1 := 0.3875212718 \quad (78)$$

> $GPsk := convert(41.9973, units, deg, rad)$

$$GPsk := 0.7329911619 \quad (79)$$

> $GMsk := convert(21.4280, units, deg, rad)$

$$GMsk := 0.3739891520 \quad (80)$$

> $GPMO := convert(55.7558, units, deg, rad)$

$$GPMO := 0.9731222871 \quad (81)$$

> $\mathrm{GMMO} := convert(37.6173, units, deg, rad)$

$$GMMO := 0.6565457408 \quad (82)$$

> $GP1 := 0.7072607424$

$$GP1 := 0.7072607424 \quad (83)$$

> $GM1 := 0.3875212718$

$$GM1 := 0.3875212718 \quad (84)$$

> $xB := R1 \cdot \sin\left(\frac{\pi}{2} - \mathrm{GP1}\right) \cdot \cos(\mathrm{GM1})$

$$xB := 4.481270602\ 10^{6} \quad (85)$$

> $yB := R1 \cdot \sin\left(\frac{\pi}{2} - \mathrm{GP1}\right) \cdot \sin(\mathrm{GM1})$

$$yB := 1.829076794\ 10^{6} \quad (86)$$

> $zB := R1 \cdot \cos\left(\frac{\pi}{2} - \mathrm{GP1}\right)$

$$zB := 4.137270779\ 10^{6} \quad (87)$$

> $xSK := R1 \cdot \sin\left(\frac{\pi}{2} - GPsk\right) \cdot \cos(GMsk) :$

> $ySK := R1 \cdot \sin\left(\frac{\pi}{2} - GPsk\right) \cdot \sin(GMsk) :$

> $zSK := R1 \cdot \cos\left(\frac{\pi}{2} - GPsk\right) :$

> $DistanceBSK := \mathrm{sqrt}\left((xB - xSK)^2 + (yB - ySK)^2 + (zB - zSK)^2\right)$

$$DistanceBSK := 176168.1254 \quad (88)$$

> $xMO := R1 \cdot \sin\left(\frac{\pi}{2} - GPMO\right) \cdot \cos(\mathrm{GMMO})$

$$xMO := 2.838188760\ 10^{6} \quad (89)$$

> $yMO := R1 \cdot \sin\left(\frac{\pi}{2} - GPMO\right) \cdot \sin(\text{GMMO})$

$$yMO := 2.187065106\ 10^{6} \tag{90}$$

> $zMO := R1 \cdot \cos\left(\frac{\pi}{2} - GPMO\right)$

$$zMO := 5.263625026\ 10^{6} \tag{91}$$

> $DistanceBMO := \text{sqrt}\left((xB - xMO)^2 + (yB - yMO)^2 + (zB - zMO)^2 \right)$

$$DistanceBMO := 2.023992950\ 10^{6} \tag{92}$$

> $evalf\left(\frac{45 \cdot \text{Pi}}{180}\right)$

$$0.7853981635 \tag{93}$$

> $PLATOS := spacecurve\left(\left[R1 \cdot \sin\left(\frac{\pi}{2} - \text{GP1}\right) \cdot \cos(\phi), R1 \cdot \sin\left(\frac{\pi}{2} - \text{GP1}\right) \cdot \sin(\phi), R1 \cdot \cos\left(\frac{\pi}{2} - \text{GP1}\right)\right], \phi = 0 ..2 \cdot \text{Pi}, color = red, thickness = 2\right) :$

> $MHKOS := spacecurve([R1 \cdot \sin(\theta) \cdot \cos(\text{GM1}), R1 \cdot \sin(\theta) \cdot \sin(\text{GM1}), R1 \cdot \cos(\theta)], \theta = 0 ..\text{Pi}, \text{color} = \text{blue}, thickness = 2) :$

> $GRIN := spacecurve([R1 \cdot \sin(\theta) \cdot \cos(0), R1 \cdot \sin(\theta) \cdot \sin(0), R1 \cdot \cos(\theta)], \theta = 0 ..\text{Pi}, \text{color} = \text{black}, \text{thickness} = 5, \text{linestyle} = 1) :$

> $GMT := pointplot3d\left(\left[R1 \cdot \sin\left(\frac{\pi}{2} - \text{GMTP1}\right) \cdot \cos(\text{GMTM1}), R1 \cdot \sin\left(\frac{\pi}{2} - \text{GMTP1}\right) \cdot \sin(\text{GMTM1}), R1 \cdot \cos\left(\frac{\pi}{2} - \text{GMTP1}\right)\right], symbol = solidcircle, symbolsize = 20, color = red\right) :$

> $GMT1 := textplot3d\left(\left[1.1 \cdot R1 \cdot \sin\left(\frac{\pi}{2} - (\text{GMTP1} + 0.1)\right) \cdot \cos(\text{GMTM1} - 0.2), 1.1 \cdot R1 \cdot \sin\left(\frac{\pi}{2} - (\text{GMTP1} + 0.1)\right) \cdot \sin(\text{GMTM1} - 0.2), R1 \cdot \cos\left(\frac{\pi}{2} - (\text{GMTP1} + 0.1)\right), \text{"G"}\right], font = [arial, bold, 15]\right) :$

> $ISHMER := spacecurve\left(\left[R1 \cdot \sin\left(\frac{\pi}{2}\right) \cdot \cos(\phi), R1 \cdot \sin\left(\frac{\pi}{2}\right) \cdot \sin(\phi), R1 \cdot \cos\left(\frac{\pi}{2}\right)\right], \phi = 0 ..2 \cdot \text{Pi}, color = \text{yellow}, \text{thickness} = 2\right) :$

> $GH := plot3d([R1 \cdot \sin(\theta) \cdot \cos(\phi), R1 \cdot \sin(\theta) \cdot \sin(\phi), R1 \cdot \cos(\theta)], \theta = 0 ..\text{Pi}, \phi = 0 ..2 \cdot \text{Pi}) :$

> $B := pointplot3d\left(\left[R1 \cdot \sin\left(\frac{\pi}{2} - \text{GP1}\right) \cdot \cos(\text{GM1}), R1 \cdot \sin\left(\frac{\pi}{2} - \text{GP1}\right) \cdot \sin(\text{GM1}), R1 \cdot \cos\left(\frac{\pi}{2} - \text{GP1}\right)\right], symbol = solidcircle, symbolsize = 20, color = green\right) :$

> $MOSXA := pointplot3d\left(\left[R1 \cdot \sin\left(\frac{\pi}{2} - \text{GPMO}\right) \cdot \cos(\text{GMMO}), R1 \cdot \sin\left(\frac{\pi}{2} - \text{GPMO}\right)\right.\right.$

$\cdot\sin(\mathrm{GMMO}), R1\cdot\cos\left(\frac{\pi}{2} - \mathrm{GPMO}\right)\Big]$, *symbol* = *solidcircle*, *symbolsize* = 20, *color* = *yellow*) :

> *MOSXA1* := *textplot3d*$\left(\left[1.1\cdot R1\cdot\sin\left(\frac{\pi}{2} - (\mathrm{GPMO} - 0.1)\right)\cdot\cos(\mathrm{GMMO} + 0.2), 1.1\cdot R1\cdot\sin\left(\frac{\pi}{2} - (\mathrm{GPMO} - 0.1)\right)\cdot\sin(\mathrm{GMMO} + 0.2), 1.1\cdot R1\cdot\cos\left(\frac{\pi}{2} - (\mathrm{GPMO} - 0.1)\right), \text{"M"}\right], font = [arial, bold, 15]\right)$:

> *AKSON* := *spacecurve*([0, 0, *R1*·1.2 − *m*·(*R1*·2·1.2)], *m* = 0 ..1, *color* = *black*, *thickness* = 5) :

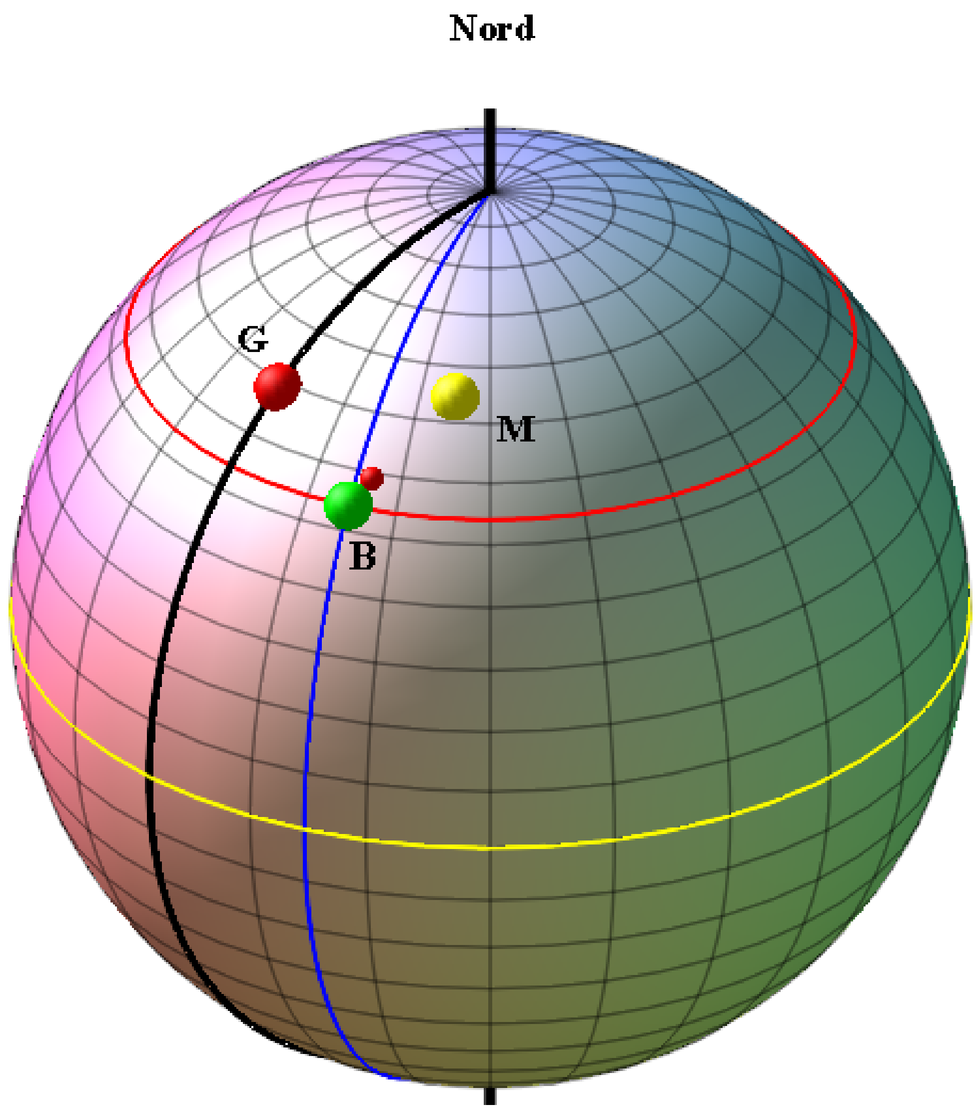
> *BORRAS* := *textplot3d*([0, 0, 1.4 *R1*, "Nord"], *font* = [*arial*, *bold*, 14]) :

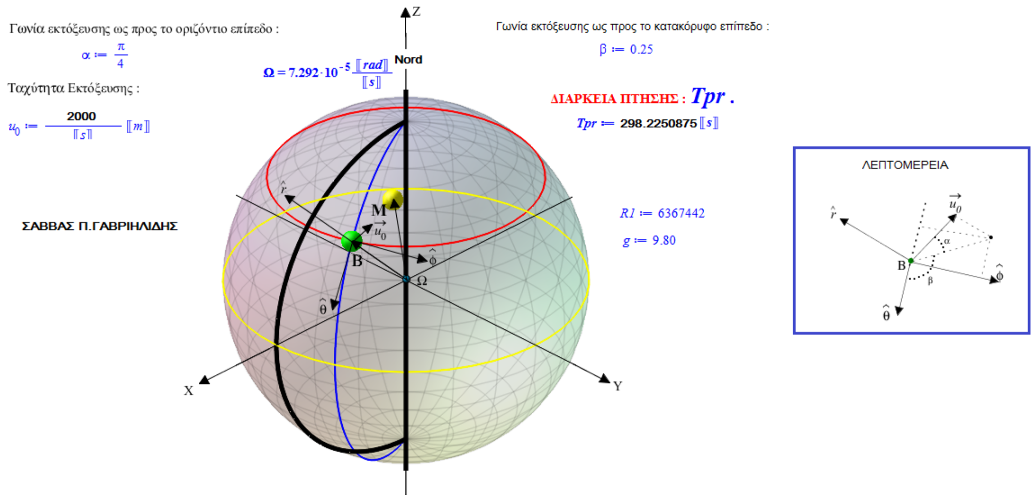
> *BEROIA* := *textplot3d*$\left(\left[1.1\cdot R1\cdot\sin\left(\frac{\pi}{2} - (GP1 - 0.1)\right)\cdot\cos(\mathrm{GM1} + 0.1), 1.1\cdot R1\cdot\sin\left(\frac{\pi}{2} - (\mathrm{GP1} - 0.1)\right)\cdot\sin(\mathrm{GM1} + 0.1), 1.1\cdot R1\cdot\cos\left(\frac{\pi}{2} - (\mathrm{GP1} - 0.1)\right), \text{"B"}\right], font = [arial, bold, 15]\right)$:

> *BLHMA* := *pointplot3d*([*X*, *Y*, *Z*], *symbol* = *solidcircle*, *symbolsize* = 10, *color* = *red*) :

> *SYNOLO* := *display*(*GMT*, *GMT1*, *PLATOS*, *MHKOS*, *GRIN*, *ISHMER*, *GH*, *B*, *MOSXA*, *AKSON*, *BORRAS*, *BEROIA*, *MOSXA1*, *BLHMA*, *orientation* = [45, 60, 0], *axes* = *none*) :

> *display*(*SYNOLO*, *scaling* = *constrained*)

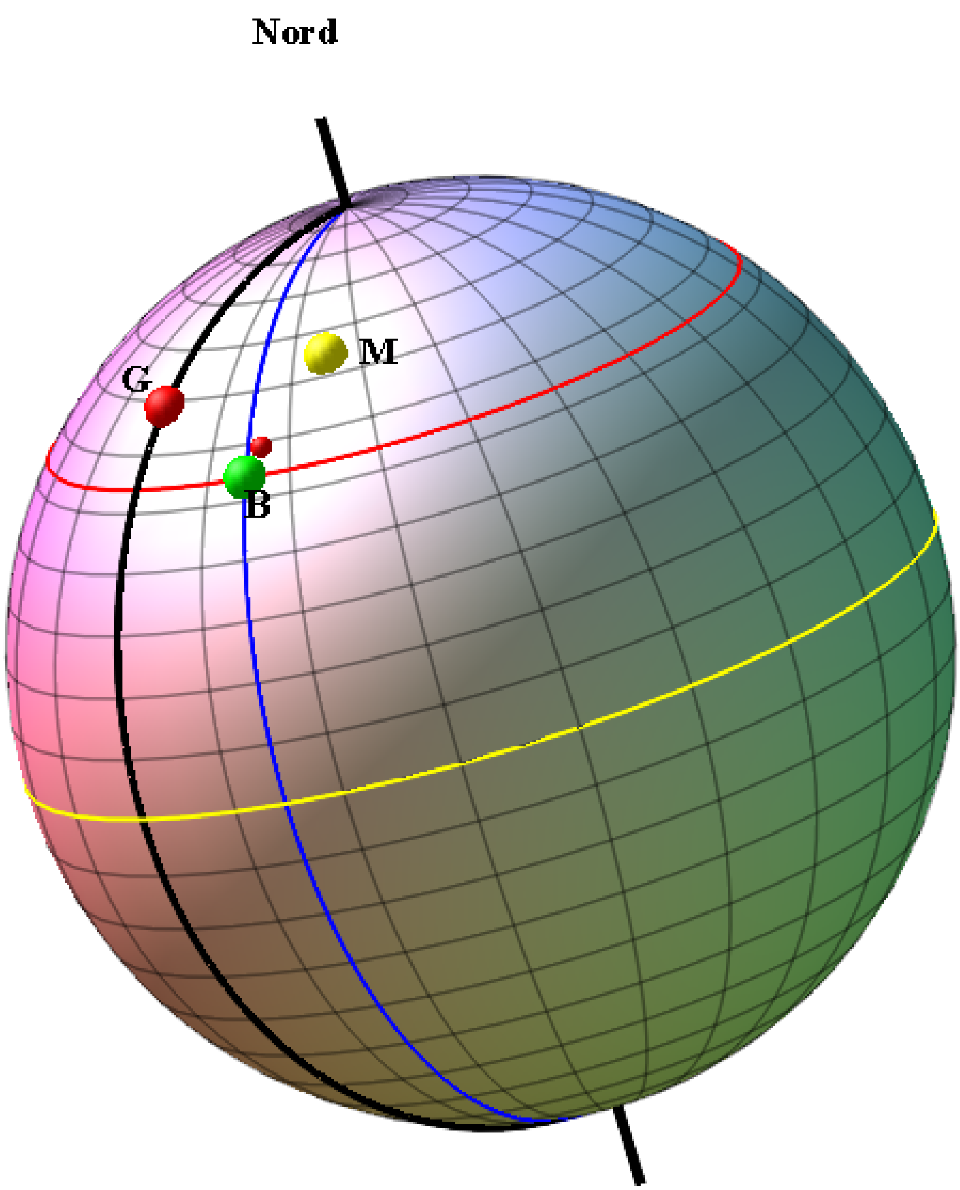

Nord
G
M
B



> $ROT := rotate\left(SYNOLO, \frac{23.439247}{180} \cdot \text{Pi}, [[0, 0, 0], [1, 0, 0]]\right):$

> $display(ROT, scaling = constrained, title$
$= $"ΘΕΣΕΙΣ GREENWICH−ΒΕΡΟΙΑΣ−ΣΤΟΧΟΥ -ΜΟΣΧΑΣ\nΣΑΒΒΑΣ Π. ΓΑΒΡΙΗΛΙΔΗΣ", $titlefont = [arial, bold, 12])$

ΘΕΣΕΙΣ GREENWICH-ΒΕΡΟΙΑΣ-ΣΤΟΧΟΥ -ΜΟΣΧΑΣ
ΣΑΒΒΑΣ Π. ΓΑΒΡΙΗΛΙΔΗΣ

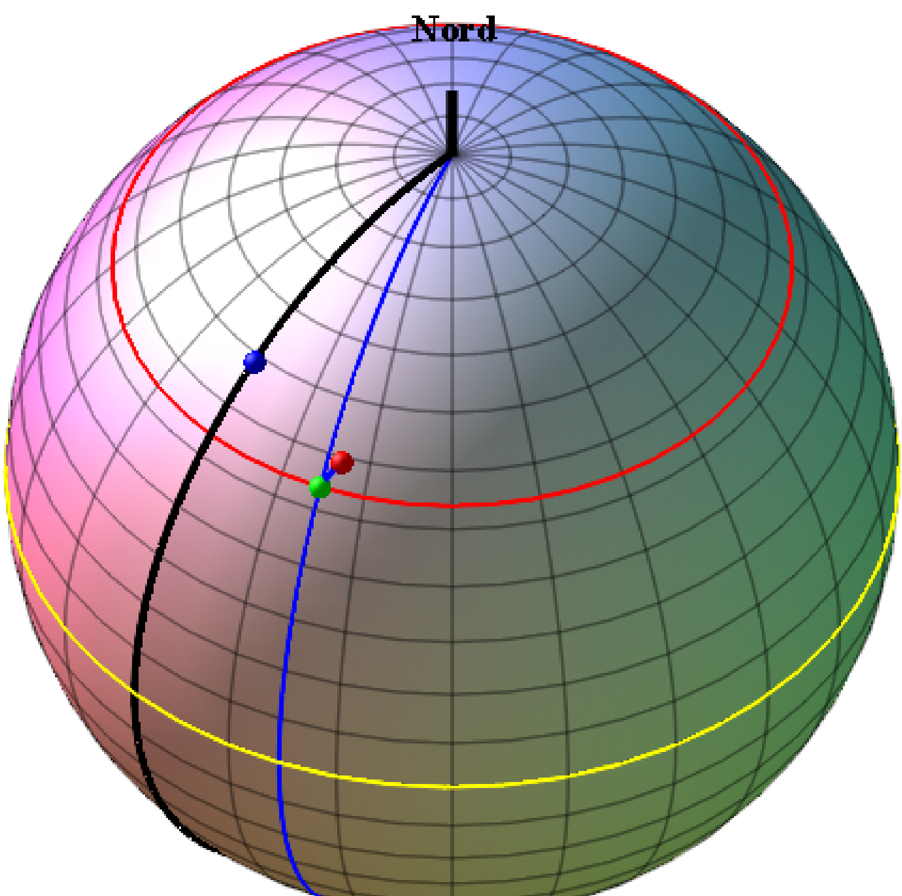


ANIMATION

```
> AGH := animate(plot3d, [[R1·sin(θ)·cos(ϕ + Ω·t), R1·sin(θ)·sin(ϕ + Ω·t), R1·cos(θ)], θ
    = 0..Pi, ϕ = 0..2·Pi], t = 0..86165, frames = 20) :
> AGRIN1 := animate(pointplot3d, [[R1·sin(π/2 − GMTP1)·cos(GMTM1 + Ω·t), R1·sin(π/2
    − GMTP1)·sin(GMTM1 + Ω·t), R1·cos(π/2 − GMTP1)], symbol = solidcircle,
    symbolsize = 10, color = blue], t = 0..86165, frames = 20) :
> ABER := animate(pointplot3d, [[R1·sin(π/2 − GP1)·cos(GM1 + Ω·t), R1·sin(π/2 − GP1)
    ·sin(GM1 + Ω·t), R1·cos(π/2 − GP1)], symbol = solidcircle, symbolsize = 10, color
    = green], t = 0..86165, frames = 20) :
> APLATOS := animate(spacecurve, [[R1·sin(π/2 − GP1)·cos(ϕ + Ω·t), R1·sin(π/2 − GP1)
    ·sin(ϕ + Ω·t), R1·cos(π/2 − GP1)], ϕ = 0..2·Pi, color = red, thickness = 2], t = 0..86165,
    frames = 20) :
> AMHKOS := animate(spacecurve, [[R1·sin(θ)·cos(GM1 + Ω·t), R1·sin(θ)·sin(GM1 + Ω
    ·t), R1·cos(θ)], θ = 0..Pi, color = blue, thickness = 2], t = 0..86165, frames = 20) :
> AGRIN := animate(spacecurve, [[R1·sin(θ)·cos(0 + Ω·t), R1·sin(θ)·sin(0 + Ω·t), R1
    ·cos(θ)], θ = 0..Pi, color = black, thickness = 5, linestyle = 1], t = 0..86165, frames = 20) :
> AISHMER := animate(spacecurve, [[R1·sin(π/2)·cos(ϕ + Ω·t), R1·sin(π/2)·sin(ϕ + Ω·t),
    R1·cos(π/2)], ϕ = 0..2·Pi, color = yellow, thickness = 2], t = 0..86165, frames = 20) :
> TROXIA := spacecurve([XBL, YBL, ZBL], t = 0..Tpr, color = blue, thickness = 3) :
> BLHMA := pointplot3d([X, Y, Z], symbol = solidcircle, symbolsize = 10, color = red) :
> BLHMA1 := animate(pointplot3d, [[R1·sin(rhs((64)))·cos(rhs((62)) + Ω·t), R1·sin(rhs(
    (64)))·sin(rhs((62)) + Ω·t), R1·cos(rhs((64)))], symbol = solidcircle, symbolsize = 10,
    color = red], t = 0..86165, frames = 20) :
> B := pointplot3d([R1·sin(π/2 − GP1)·cos(GM1), R1·sin(π/2 − GP1)·sin(GM1), R1
    ·cos(π/2 − GP1)], symbol = solidcircle, symbolsize = 10, color = green) :
> AKSON := spacecurve([0, 0, R1·1.2 − m·(R1·2·1.2)], m = 0..1, color = black, thickness = 5) :
> display(AGH, AGRIN1, AKSON, ABER, APLATOS, AMHKOS, AGRIN, AISHMER, TROXIA,
    BLHMA, B, BORRAS, BLHMA1, scaling = constrained, axes = none, orientation = [45, 45,
```

0], *title*
= "ΘΕΣΕΙΣ GREENWICH-ΒΕΡΟΙΑΣ-ΣΤΟΧΟΥ ΓΙΑ ΑΔΡΑΝΕΙΑΚΟ ΠΑΡΑΤΗΡΗΤΗ ΣΤΗ ΘΕΣΗ ΕΚΤΟΞΕΥΣΗΣ\nΣΑΒΒΑΣ Π. ΓΑΒΡΙΗΛΙΔΗΣ-ANIMATION", *titlefont* = [*arial*, *bold*, 12])

ΘΕΣΕΙΣ GREENWICH-ΒΕΡΟΙΑΣ-ΣΤΟΧΟΥ ΓΙΑ ΑΔΡΑΝΕΙΑΚΟ ΠΑΡΑΤΗΡΗΤΗ ΣΤΗ ΘΕΣΗ ΕΚΤΟΞΕΥΣΗΣ
ΣΑΒΒΑΣ Π. ΓΑΒΡΙΗΛΙΔΗΣ-ANIMATION



ΤΡΟΧΙΑ ΤΟΥ ΒΛΗΜΑΤΟΣ ΟΠΩΣ ΤΗΝ ΒΛΕΠΕΙ ΠΑΡΑΤΗΡΗΤΗΣ (ΠΕΡΙΣΤΡΕΦΟΜΕΝΟΣ) ΑΠΟ ΤΗΝ ΘΕΣΗ ΕΚΤΟΞΕΥΣΗΣ .

> *rhs*(*sol1*)

$$-\frac{9689124217\sqrt{2}\,t}{10000000} \tag{94}$$

> *rhs*(*sol2*)

$$\frac{362140981\,t^3}{2000000000000}-\frac{476130657\sqrt{2}\,t^2}{50000000000}+\frac{2474039593\sqrt{2}\,t}{10000000} \tag{95}$$

> *rhs*(*sol3*)

$$-\frac{49\,t^2}{10}+1000\sqrt{2}\,t+10000 \tag{96}$$

```
> TBL := spacecurve([(94), (95), (96)], t = 0 ..Tpr, thickness = 2, linestyle = 3, color = blue) :
> BL := animate(pointplot3d, [[(94), (95), (96)], symbol = solidcircle, symbolsize = 25, color
      = red, ], t = 0 ..Tpr, frames = 80) :
> BL1 := pointplot3d([subs(t = 0, (94)), subs(t = 0, (95)), subs(t = 0, (96))], symbol = solidcircle,
      symbolsize = 25, color = red) :
> PAR := pointplot3d([0, 0, 0], symbol = solidbox, symbolsize = 25, color = green) :
> PAR1 := textplot3d([0, 0, -12000, "ΒΕΡΟΙΑ"], font = [arial, bold, 12]) :
> AFIKSI := pointplot3d([subs(t = Tpr, (94)), subs(t = Tpr, (95)), subs(t = Tpr, (96))], symbol
      = solidcircle, symbolsize = 30, color = yellow) :
> TEX := textplot3d([subs(t = Tpr, (94)), subs(t = Tpr, (95)), subs(t = Tpr, (96)) − 12000,
      "ΣΤΟΧΟΣ"], font = [arial, 12, bold]) :
> display(TBL, BL, BL1, PAR, PAR1, AFIKSI, TEX, orientation = [95, 75, 0], scaling
      = unconstrained, labels = [x, y, z], labelfont = [arial, bold, 14], title
      = "ΤΡΟΧΙΑ ΒΛΗΜΑΤΟΣ ΓΙΑ ΠΑΡΑΤΗΡΗΤΗ ΣΤΗ ΘΕΣΗ ΕΚΤΟΞΕΥΣΗΣ\nΣΑΒΒΑΣ Π.
      ΓΑΒΡΙΗΛΙΔΗΣ-ANIMATION", titlefont = [arial, 12, bold], axes = boxed)
```

ΤΡΟΧΙΑ ΒΛΗΜΑΤΟΣ ΓΙΑ ΠΑΡΑΤΗΡΗΤΗ ΣΤΗ ΘΕΣΗ ΕΚΤΟΞΕΥΣΗΣ
ΣΑΒΒΑΣ Π. ΓΑΒΡΙΗΛΙΔΗΣ-ANIMATION