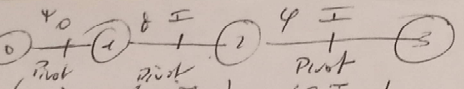
1. 

(1)

2. $\vec{v}(1/0) = R\dot{\psi}\vec{y}_{1(1)}$; $\vec{v}(2/1) = \vec{0}$; $\vec{v}(3/1) = \dot{\varphi}\vec{y}_{2(3)}$ (1)

3. $\vec{\Omega}(1/0) = \{\dot{\psi}\vec{z}_{0(1)}, \vec{0}\}_O$; $\vec{\Omega}(2/1) = \{\dot{\theta}\vec{x}_{1(1)}, \vec{0}\}_I$; $\vec{\Omega}(3/2) = \{\dot{\varphi}\vec{y}_{2(3)}, \vec{0}\}_I$ (1.5)

4. $\vec{\Omega}(3/0) = \{\dot{\psi}\vec{z}_1 + \dot{\theta}\vec{x}_{1(1)} + \dot{\varphi}\vec{y}_{2(3)}, R\dot{\psi}\vec{y}_{1(1)}\}_I$ (2)

$\|\vec{v}(I,3/0)\| = R|\dot{\psi}|$

5. $\vec{A}(I,3/0) = R\ddot{\psi}\vec{x}_1 + R\dot{\psi}^2\vec{y}_1$ $\|\vec{A}(I,3/0)\| = R\sqrt{\ddot{\psi}^2 + \dot{\psi}^4}$ (2)

6. (1)

7. $G = 10g$; $\ddot{\psi} = 0$; $\dot{\psi} = C^{te}$

$\|\vec{G}\| = 10g = \sqrt{g^2 + R^2\dot{\psi}^4} \Rightarrow 100g^2 = g^2 + R^2\dot{\psi}^4$

$\Rightarrow 99g^2 = R^2\dot{\psi}^4 \Rightarrow \dot{\psi}^2 = \sqrt{99}\frac{g}{R} \Rightarrow \dot{\psi} = \sqrt{\sqrt{99}\frac{g}{R}}$

$\dot{\psi} = \sqrt{\sqrt{99}\frac{9,81}{10}} = 3,124 rad/s \Rightarrow N_{10} \simeq 30\ t/min$ (3)

$\|\vec{v}(I,3/0)\| = R\dot{\psi} = 10 \times 3,124 = 31,2\ m/s = 112\ km/h$

$\tan\theta = \frac{R\dot{\psi}^2}{g} = \frac{10 \times 3,124^2}{9,81} \simeq 9,95 \Rightarrow \theta = 84°$

6. $\vec{G} = \vec{g} - \vec{A}(I,3/0) = g\vec{z}_1 - R\dot{\psi}^2\vec{x}_1 - R\ddot{\psi}\vec{y}_1$

$\vec{z}_1 = \cos\theta\vec{z}_2 + \sin\theta\vec{y}_2$; $\vec{x}_1 = \vec{x}_2$; $\vec{y}_1 = \cos\theta\vec{y}_2 - \sin\theta\vec{z}_2$

$\vec{x}_2 = \cos\varphi\vec{x}_3 + \sin\varphi\vec{z}_3$; $\vec{y}_2 = \vec{y}_3$; $\vec{z}_2 = \cos\varphi\vec{z}_3 - \sin\varphi\vec{x}_3$

$\vec{G}$ (3)

$G_x = -g\cos\theta\sin\varphi - R\ddot{\psi}\cos\varphi - R\dot{\psi}^2\sin\theta\sin\varphi$

$G_y = g\sin\theta - R\dot{\psi}^2\cos\theta$

$G_z = g\cos\theta\cos\varphi - R\ddot{\psi}\sin\varphi + R\dot{\psi}^2\sin\theta\cos\varphi$ (b)

$\|\vec{G}\| = \sqrt{g^2 + R^2(\ddot{\psi}^2 + \dot{\psi}^4)}$ (1)

• $G_y = 0 \Rightarrow \tan\theta = \frac{R\dot{\psi}^2}{g}$ (1)

$G_x = 0 \Rightarrow (R\dot{\psi}^2\sin\theta + g\cos\theta)\sin\varphi = -R\ddot{\psi}\cos\varphi$

$\Rightarrow \tan\varphi = \frac{-R\ddot{\psi}}{R\dot{\psi}^2\sin\theta + g\cos\theta}$ (1)

G_x et $G_y = 0$

$\tan\varphi = \frac{-R\ddot{\psi}}{R\dot{\psi}^2\tan\theta + g}\frac{1}{\cos\theta}$

$= \frac{-R\ddot{\psi}}{R\dot{\psi}^2\frac{R\dot{\psi}^2}{g} + g}\sqrt{1 + \frac{R^2\dot{\psi}^4}{g^2}}$

$= \frac{-R\ddot{\psi}\,g}{g^2 + R^2\dot{\psi}^4}\sqrt{\frac{g^2 + R^2\dot{\psi}^4}{g^2}} = \frac{-R\ddot{\psi}}{\sqrt{g^2 + R^2\dot{\psi}^4}} = \tan\varphi$ (2)

$\frac{1}{\cos\theta} = 1 + \tan^2\theta$

$\frac{1}{\cos\theta} = \sqrt{1 + \tan^2\theta}$