$$\mathbf{a} = a_t\hat{\mathbf{u}}_t + a_n\hat{\mathbf{u}}_n$$

$$\hat{\mathbf{u}}_b = \hat{\mathbf{u}}_t \times \hat{\mathbf{u}}_n$$

Centro de curvatura respecto a P

$$\mathbf{r}_{C/P} = \varrho\hat{\mathbf{u}}_n$$

$$\mathbf{I} = \int_{t_1}^{t_2} \mathbf{F}\,dt \qquad \Delta\mathbf{v} = \frac{\mathbf{I}_{\text{net}}}{m} \qquad \mathbf{H}_O = \mathbf{r} \times m\mathbf{v}$$

$$\mathbf{M}_{O_{\text{net}}} = \mathbf{r} \times \mathbf{F}_{\text{net}} \qquad \int_{t_1}^{t_2} \mathbf{M}_{O_{\text{net}}}dt = \mathbf{H}_{O_2} - \mathbf{H}_{O_1}$$

$$\mathbf{M}_{O_{\text{net}}} = \frac{d\mathbf{H}_O}{dt}$$

Vector rotante

$$\frac{d\mathbf{A}}{dt} = \boldsymbol{\omega} \times \mathbf{A} \qquad \frac{d^2\mathbf{A}}{dt^2} = \boldsymbol{\alpha} \times \mathbf{A} + \boldsymbol{\omega} \times (\boldsymbol{\omega} \times \mathbf{A}) \qquad \frac{d^3\mathbf{A}}{dt^3} = \frac{d\boldsymbol{\alpha}}{dt} \times \mathbf{A} + 2\boldsymbol{\alpha} \times (\boldsymbol{\omega} \times \mathbf{A}) + \boldsymbol{\omega} \times [\boldsymbol{\alpha} \times \mathbf{A} + \boldsymbol{\omega} \times (\boldsymbol{\omega} \times \mathbf{A})]$$

$$\frac{d\hat{\mathbf{i}}}{dt} = \boldsymbol{\Omega} \times \hat{\mathbf{i}} \qquad \frac{d\hat{\mathbf{j}}}{dt} = \boldsymbol{\Omega} \times \hat{\mathbf{j}} \qquad \frac{d\hat{\mathbf{k}}}{dt} = \boldsymbol{\Omega} \times \hat{\mathbf{k}}$$

$$\frac{d\mathbf{Q}}{dt} = \left.\frac{d\mathbf{Q}}{dt}\right)_{\text{rel}} + \boldsymbol{\Omega} \times \mathbf{Q}$$

$$\frac{d\mathbf{Q}}{dt} = \frac{dQ_X}{dt}\hat{\mathbf{I}} + \frac{dQ_Y}{dt}\hat{\mathbf{J}} + \frac{dQ_Z}{dt}\hat{\mathbf{K}}$$

$$\left.\frac{d\mathbf{Q}}{dt}\right)_{\text{rel}} = \frac{dQ_x}{dt}\hat{\mathbf{i}} + \frac{dQ_y}{dt}\hat{\mathbf{j}} + \frac{dQ_z}{dt}\hat{\mathbf{k}}$$

Movimiento relativo

$$\mathbf{r} = \mathbf{r}_O + \mathbf{r}_{\text{rel}}$$

$$\mathbf{v} = \mathbf{v}_O + \boldsymbol{\Omega} \times \mathbf{r}_{\text{rel}} + \mathbf{v}_{\text{rel}}$$

$$\mathbf{a} = \mathbf{a}_O + \dot{\boldsymbol{\Omega}} \times \mathbf{r}_{\text{rel}} + \underbrace{\boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{r}_{\text{rel}})}_{\text{Centrípeta}} + \underbrace{2\boldsymbol{\Omega} \times \mathbf{v}_{\text{rel}}}_{\text{Coriolis}} + \mathbf{a}_{\text{rel}}$$

Movimiento en el centro de la tierra

$$\boldsymbol{\omega} = -\dot{\phi}\hat{\mathbf{i}} + \dot{\Lambda}\cos\phi\hat{\mathbf{j}} + \dot{\Lambda}\sin\phi\hat{\mathbf{k}}$$

$$\mathbf{v}_{\text{rel}} = \dot{x}\hat{\mathbf{i}} + \dot{y}\hat{\mathbf{j}} + \dot{z}\hat{\mathbf{k}}$$

$$\mathbf{a}_{\text{rel}} = \left[\ddot{x} + \frac{\dot{x}(\dot{z} - \dot{y}\tan\phi)}{R_E + z}\right]\hat{\mathbf{i}} + \left(\ddot{y} + \frac{\dot{y}\dot{z} + \dot{x}^2\tan\phi}{R_E + z}\right)\hat{\mathbf{j}} + \left(\ddot{z} - \frac{\dot{x}^2 + \dot{y}^2}{R_E + z}\right)\hat{\mathbf{k}}$$

$$\dot{x} = (R_E + z)\dot{\Lambda}\cos\phi \qquad \dot{y} = (R_E + z)\dot{\phi}$$

$$\left.\mathbf{a}_{\text{rel}}\right)_{\text{neglecting earth's curvature}} = \ddot{x}\hat{\mathbf{i}} + \ddot{y}\hat{\mathbf{j}} + \ddot{z}\hat{\mathbf{k}}$$

$$\dot{\phi} = \frac{\dot{y}}{R_E + z} \qquad \dot{\Lambda} = \frac{\dot{x}}{(R_E + z)\cos\phi}$$

$$\ddot{\phi} = \frac{(R_E + z)\ddot{y} - \dot{y}\dot{z}}{(R_E + z)^2} \qquad \ddot{\Lambda} = \frac{(R_E + z)\ddot{x}\cos\phi - (\dot{z}\cos\phi - \dot{y}\sin\phi)\dot{x}}{(R_E + z)^2\cos^2\phi}$$

$$\boldsymbol{\Omega} = \Omega\hat{\mathbf{K}} = \Omega\cos\phi\hat{\mathbf{j}} + \Omega\sin\phi\hat{\mathbf{k}}$$

$$\mathbf{v} = [\dot{x} + \Omega(R_E + z)\cos\phi]\hat{\mathbf{i}} + \dot{y}\hat{\mathbf{j}} + \dot{z}\hat{\mathbf{k}}$$

$$\begin{aligned}\mathbf{a} = &\left[\ddot{x} + \frac{\dot{x}(\dot{z} - \dot{y}\tan\phi)}{R_E + z} + 2\Omega(\dot{z}\cos\phi - \dot{y}\sin\phi)\right]\hat{\mathbf{i}} \\ &+ \left\{\ddot{y} + \frac{\dot{y}\dot{z} + \dot{x}^2\tan\phi}{R_E + z} + \Omega\sin\phi[\Omega(R_E + z)\cos\phi + 2\dot{x}]\right\}\hat{\mathbf{j}} \\ &+ \left\{\ddot{z} - \frac{\dot{x}^2 + \dot{y}^2}{R_E + z} - \Omega\cos\phi[\Omega(R_E + z)\cos\phi + 2\dot{x}]\right\}\hat{\mathbf{k}}\end{aligned}$$

Casos especiales

Straight and level, unaccelerated flight: $\dot{z} = \ddot{z} = \ddot{x} = \ddot{y} = 0$

$$\mathbf{v} = [\dot{x} + \Omega(R_E + z)\cos\phi]\hat{\mathbf{i}} + \dot{y}\hat{\mathbf{j}}$$

$$\begin{aligned}\mathbf{a} = &-\left[\frac{\dot{x}\dot{y}\tan\phi}{R_E + z} + 2\Omega\dot{y}\sin\phi\right]\hat{\mathbf{i}}\\ &+\left\{\frac{\dot{x}^2\tan\phi}{R_E + z} + \Omega\sin\phi[\Omega(R_E + z)\cos\phi + 2\dot{x}]\right\}\hat{\mathbf{j}}\\ &-\left\{\frac{\dot{x}^2 + \dot{y}^2}{R_E + z} + \Omega\cos\phi[\Omega(R_E + z)\cos\phi + 2\dot{x}]\right\}\hat{\mathbf{k}}\end{aligned}$$

Flight due north (y) at constant speed and altitude: $\dot{z} = \ddot{z} = \dot{x} = \ddot{x} = \ddot{y} = 0$

$$\mathbf{v} = \Omega(R_E + z)\cos\phi\hat{\mathbf{i}} + \dot{y}\hat{\mathbf{j}}$$

$$\begin{aligned}\mathbf{a} = &-2\Omega\dot{y}\sin\phi\hat{\mathbf{i}} + \Omega^2(R_E + z)\sin\phi\cos\phi\hat{\mathbf{j}}\\ &-\left[\frac{\dot{y}^2}{R_E + z} + \Omega^2(R_E + z)\cos^2\phi\right]\hat{\mathbf{k}}\end{aligned}$$

Flight due east (x) at constant speed and altitude: $\dot{z} = \ddot{z} = \ddot{x} = \dot{y} = \ddot{y} = 0$

$$\mathbf{v} = [\dot{x} + \Omega(R_E + z)\cos\phi]\hat{\mathbf{i}}$$

$$\begin{aligned}\mathbf{a} = &\left\{\frac{\dot{x}^2\tan\phi}{R_E + z} + \Omega\sin\phi\,[\Omega(R_E + z)\cos\phi + 2\dot{x}]\right\}\hat{\mathbf{j}}\\ &-\left\{\frac{\dot{x}^2}{R_E + z} + \Omega\cos\phi\,[\Omega(R_E + z)\cos\phi + 2\dot{x}]\right\}\hat{\mathbf{k}}\end{aligned}$$

Flight straight up (z): $\dot{x} = \ddot{x} = \dot{y} = \ddot{y} = 0$

$$\mathbf{v} = \Omega(R_E + z)\cos\phi\hat{\mathbf{i}} + \dot{z}\hat{\mathbf{k}}$$

$$\begin{aligned}\mathbf{a} = &\,2\Omega(\dot{z}\cos\phi)\hat{\mathbf{i}} + \Omega^2(R_E + z)\sin\phi\cos\phi\hat{\mathbf{j}}\\ &+\left[\ddot{z} - \Omega^2(R_E + z)\cos^2\phi\right]\hat{\mathbf{k}}\end{aligned}$$

Stationary: $\dot{x} = \ddot{x} = \dot{y} = \ddot{y} = \dot{z} = \ddot{z} = 0$

$$\mathbf{v} = \Omega(R_E + z)\cos\phi\hat{\mathbf{i}}$$

$$\mathbf{a} = \Omega^2(R_E + z)\sin\phi\cos\phi\hat{\mathbf{j}} - \Omega^2(R_E + z)\cos^2\phi\hat{\mathbf{k}}$$

$$\Omega = \frac{2\pi\,\text{rad}}{\text{sidereal day}} = \frac{2\pi\,\text{rad}}{23.93\,\text{hr}} = \frac{2\pi\,\text{rad}}{86\,160\,\text{s}} = 7.292 \times 10^{-5}\text{rad/s}$$

Lagrangiano

$$\mathcal{L} = T - U.$$

$$\frac{\partial\mathcal{L}}{\partial q_i} = \frac{d}{dt}\frac{\partial\mathcal{L}}{\partial\dot{q}_i}$$

(generalized force) = (rate of change of generalized momentum)