EOM =

$$D[\mathcal{X}, \{t, 2\}] == \left(\left(\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -\alpha \end{pmatrix} \left(1 - \frac{1}{A}\right)\right).\mathcal{V}_1 + \left(\kappa \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -\alpha \end{pmatrix} \left(1 - \frac{1}{B}\mathcal{L}\right)\right).\mathcal{V}_2 - \begin{pmatrix} 0 \\ \gamma \\ 0 \end{pmatrix}\right) \text{ // Flatten;}$$

$$\{x_1[t] = y_1[t] = y_2[t] = 0,\ x_2[t] = 2\,w_p,\ \theta_p[t] \to 0\} : \left\{x_p[t] \to w_p,\ y_p[t] \to \frac{1}{2}\left(-2 - \gamma - 2\,h_p\right)\right\}$$

perturbations :

In[385]:=

$$\text{EquilibiumPoinit} = \left\{\theta_{p0} \to 0,\ x_{p0} \to w_p,\ y_{p0} \to -\left(\frac{1}{2}\gamma + h_p + 1\right)\right\}$$

$$\text{GivenEquibPoints} = \{x_1[t] \to 0,\ y_1[t] \to 0,\ y_2[t] \to 0,\ x_2[t] \to 2\,w_p\}$$

```
perturb = {
   θp[t] → θp0 + δθ[t],
   xp[t] → xp0 + δx[t],
   yp[t] → yp0 + δy[t]
  }
perturbD2 = {
   D[θp[t], {t, 2}] → D[δθ[t], {t, 2}],
   D[xp[t], {t, 2}] → D[δx[t], {t, 2}],
   D[yp[t], {t, 2}] → D[δy[t], {t, 2}]
  }
```

Out[385]= $\left\{\theta_{p0} \to 0,\ x_{p0} \to w_p,\ y_{p0} \to -1 - \frac{\gamma}{2} - h_p\right\}$

Out[386]= $\{x_1[t] \to 0,\ y_1[t] \to 0,\ y_2[t] \to 0,\ x_2[t] \to 2\,w_p\}$

Out[387]= $\{\theta_p[t] \to \theta_{p0} + \delta\theta[t],\ x_p[t] \to x_{p0} + \delta x[t],\ y_p[t] \to y_{p0} + \delta y[t]\}$

Out[388]= $\{\theta_p''[t] \to \delta\theta''[t],\ x_p''[t] \to \delta x''[t],\ y_p''[t] \to \delta y''[t]\}$

In[445]:= **D[𝒳, {t, 2}] /. perturbD2**

Out[445]= $\{\{\delta x''[t]\},\ \{\delta y''[t]\},\ \{\delta\theta''[t]\}\}$

In[286]:= **Aw = A /. nameChange**

Out[286]=

$$\sqrt{\left((\mathrm{Sin}[\theta_p[t]]\,h_p + \mathrm{Cos}[\theta_p[t]]\,w_p + x_1[t] - x_p[t])^2 + (-\mathrm{Cos}[\theta_p[t]]\,h_p + \mathrm{Sin}[\theta_p[t]]\,w_p + y_1[t] - y_p[t])^2\right)}$$

In[320]:= **Bw = B /. nameChange**

Out[320]=

$$\sqrt{\left((\mathrm{Sin}[\theta_p[t]]\,h_p - \mathrm{Cos}[\theta_p[t]]\,w_p + x_2[t] - x_p[t])^2 + (-\mathrm{Cos}[\theta_p[t]]\,h_p - \mathrm{Sin}[\theta_p[t]]\,w_p + y_2[t] - y_p[t])^2\right)}$$

In[343]:= **smallAngleRule = {Cos[δθ[t]] → 1, Sin[δθ[t]] -> δθ[t]}**

Out[343]= $\{\mathrm{Cos}[\delta\theta[t]] \to 1,\ \mathrm{Sin}[\delta\theta[t]] \to \delta\theta[t]\}$

In[425]:=
```
(v1 = 𝒱₁ /. nameChange /. perturb /. EquilibiumPoinit /. smallAngleRule) //
  TraditionalForm
(v2 = 𝒱₂ /. nameChange /. perturb /. EquilibiumPoinit /. smallAngleRule) //
  TraditionalForm
```

Out[425]//TraditionalForm=

$$\begin{pmatrix} -\delta\mathrm{x}(t) + h_p\,\delta\theta(t) + x_1(t) \\ \frac{\gamma}{2} - \delta\mathrm{y}(t) + w_p\,\delta\theta(t) + y_1(t) + 1 \\ w_p\left(\frac{\gamma}{2} + h_p - \delta\mathrm{y}(t) - \delta\theta(t)\,(-w_p - \delta\mathrm{x}(t) + x_1(t)) + y_1(t) + 1\right) + h_p\left(-w_p - \delta\mathrm{x}(t) + x_1(t) + \delta\theta(t)\left(\frac{\gamma}{2} + h_p - \delta\mathrm{y}(t) + y_1(t) + 1\right)\right) \end{pmatrix}$$

Out[426]//TraditionalForm=

$$\begin{pmatrix} -2\,w_p - \delta\mathrm{x}(t) + h_p\,\delta\theta(t) + x_2(t) \\ \frac{\gamma}{2} - \delta\mathrm{y}(t) - w_p\,\delta\theta(t) + y_2(t) + 1 \\ w_p\left(-\frac{\gamma}{2} - h_p + \delta\mathrm{y}(t) + \delta\theta(t)\,(-w_p - \delta\mathrm{x}(t) + x_2(t)) - y_2(t) - 1\right) + h_p\left(-w_p - \delta\mathrm{x}(t) + x_2(t) + \delta\theta(t)\left(\frac{\gamma}{2} + h_p - \delta\mathrm{y}(t) + y_2(t) + 1\right)\right) \end{pmatrix}$$

In[427]:=
```
v1 /. GivenEquibPoints // Simplify
v2 /. GivenEquibPoints // Simplify
```

Out[427]=

$$\left\{\{-\delta x[t] + h_p\,\delta\theta[t]\},\ \left\{1 + \frac{\gamma}{2} - \delta y[t] + w_p\,\delta\theta[t]\right\},\ \left\{\frac{1}{2}\left(2\,w_p^2\,\delta\theta[t] + w_p\,(2 + \gamma - 2\,\delta y[t] + 2\,\delta x[t]\,\delta\theta[t]) + h_p\,(-2\,\delta x[t] + (2 + \gamma + 2\,h_p - 2\,\delta y[t])\,\delta\theta[t])\right)\right\}\right\}$$

Out[428]=

$$\left\{\{-\delta x[t] + h_p\,\delta\theta[t]\},\ \left\{\frac{1}{2}\,(2 + \gamma - 2\,\delta y[t] - 2\,w_p\,\delta\theta[t])\right\},\ \left\{w_p^2\,\delta\theta[t] - \frac{1}{2}\,w_p\,(2 + \gamma - 2\,\delta y[t] + 2\,\delta x[t]\,\delta\theta[t]) + \frac{1}{2}\,h_p\,(-2\,\delta x[t] + (2 + \gamma + 2\,h_p - 2\,\delta y[t])\,\delta\theta[t])\right\}\right\}$$

In[315]:=
```
(*D[Aw,xp[t]]
 D[Aw,yp[t]]
 D[Aw,θp[t]]*)
temp = {xp[t] -> xp0, yp[t] → yp0, θp[t] → θp0};
"derivatives of 'A' in the 0 point:"
D[Aw^2, xp[t]] /. temp /. EquilibiumPoinit
D[Aw^2, yp[t]] /. temp /. EquilibiumPoinit
D[Aw^2, θp[t]] /. temp /. EquilibiumPoinit
```

In[321]:=
```
"derivatives of 'B' in the 0 point:"
D[Bw^2, x_p[t]] /. temp /. EquilibiumPoinit
D[Bw^2, y_p[t]] /. temp /. EquilibiumPoinit
D[Bw^2, θ_p[t]] /. temp /. EquilibiumPoinit
```

Out[321]= derivatives of 'B' in the 0 point:

Out[322]= $-2\,(-2\,w_p + x_2[t])$

Out[323]= $-2\left(1 + \frac{\gamma}{2} + y_2[t]\right)$

Out[324]= $2\,h_p\,(-2\,w_p + x_2[t]) - 2\,w_p\left(1 + \frac{\gamma}{2} + y_2[t]\right)$

In[407]:= **n = 1; Ataylored = Series[Aw /. GivenEquibPoints, {x_p[t], x_{p0}, n}, {y_p[t], y_{p0}, n}, {θ_p[t], θ_{p0}, n}] /. EquilibiumPoinit**

Out[407]=
$$\left(\left(\sqrt{\left(-1-\frac{\Upsilon}{2}-h_p\right)^2+2\left(-1-\frac{\Upsilon}{2}-h_p\right)h_p+h_p^2}-\frac{\left(\left(-1-\frac{\Upsilon}{2}-h_p\right)w_p+h_p w_p\right)\theta_p[t]}{\sqrt{\left(-1-\frac{\Upsilon}{2}-h_p\right)^2+2\left(-1-\frac{\Upsilon}{2}-h_p\right)h_p+h_p^2}}+O[\theta_p[t]]^2\right)+\left(\frac{-1-\frac{\Upsilon}{2}}{\sqrt{\left(-1-\frac{\Upsilon}{2}-h_p\right)^2+2\left(-1-\frac{\Upsilon}{2}-h_p\right)h_p+h_p^2}}+\left(-\frac{w_p}{\sqrt{\left(-1-\frac{\Upsilon}{2}-h_p\right)^2+2\left(-1-\frac{\Upsilon}{2}-h_p\right)h_p+h_p^2}}+\frac{\left(-1-\frac{\Upsilon}{2}\right)\left(\left(-1-\frac{\Upsilon}{2}-h_p\right)w_p+h_p w_p\right)}{\left(\left(-1-\frac{\Upsilon}{2}-h_p\right)^2+2\left(-1-\frac{\Upsilon}{2}-h_p\right)h_p+h_p^2\right)^{3/2}}\right)\theta_p[t]+O[\theta_p[t]]^2\right)\left(y_p[t]+1+\frac{\Upsilon}{2}+h_p\right)+O\left[y_p[t]+1+\frac{\Upsilon}{2}+h_p\right]^2\right)+$$
$$\left(\left(-\frac{h_p\,\theta_p[t]}{\sqrt{\left(-1-\frac{\Upsilon}{2}-h_p\right)^2+2\left(-1-\frac{\Upsilon}{2}-h_p\right)h_p+h_p^2}}+O[\theta_p[t]]^2\right)+\left(\frac{\left(-1-\frac{\Upsilon}{2}\right)h_p\,\theta_p[t]}{\left(\left(-1-\frac{\Upsilon}{2}-h_p\right)^2+2\left(-1-\frac{\Upsilon}{2}-h_p\right)h_p+h_p^2\right)^{3/2}}+O[\theta_p[t]]^2\right)\left(y_p[t]+1+\frac{\Upsilon}{2}+h_p\right)+O\left[y_p[t]+1+\frac{\Upsilon}{2}+h_p\right]^2\right)(x_p[t]-w_p)+O[x_p[t]-w_p]^2$$

In[411]:= **perturb**

Out[411]= $\{\theta_p[t]\to\theta_{p0}+\delta\theta[t],\ x_p[t]\to x_{p0}+\delta x[t],\ y_p[t]\to y_{p0}+\delta y[t]\}$

In[326]:= **n = 1; Series[Bw, {x_p[t], x_{p0}, n}, {y_p[t], y_{p0}, n}, {θ_p[t], θ_{p0}, n}] /. EquilibiumPoinit**

In[367]:= `% // Simplify // TraditionalForm`

Out[367]//TraditionalForm=

$$\left(\left(\frac{1}{2}\sqrt{(\gamma+2)^2}+\frac{(\gamma+2)\,w_p\,\theta_p(t)}{\sqrt{(\gamma+2)^2}}+O\left(\theta_p(t)^2\right)\right)+\left(\frac{\gamma}{2}+h_p+y_p(t)+1\right)\left(\frac{-\gamma-2}{\sqrt{(\gamma+2)^2}}+O\left(\theta_p(t)^2\right)\right)+O\left(\left(\frac{\gamma}{2}+h_p+y_p(t)+1\right)^2\right)\right)+(x_p(t)-w_p)\left(\left(-\frac{2\,h_p\,\theta_p(t)}{\sqrt{(\gamma+2)^2}}+O\left(\theta_p(t)^2\right)\right)+\left(-\frac{4\,h_p\,\theta_p(t)}{(\gamma+2)\sqrt{(\gamma+2)^2}}+O\left(\theta_p(t)^2\right)\right)\left(\frac{\gamma}{2}+h_p+y_p(t)+1\right)+O\left(\left(\frac{\gamma}{2}+h_p+y_p(t)+1\right)^2\right)\right)+O\left((x_p(t)-w_p)^2\right)$$

In[429]:=

$$\text{Ataylored} = 1+\frac{\gamma}{2}-\delta y[t]+w\,\delta\theta[t]$$

$$\text{Btaylored} = 1+\frac{\gamma}{2}-\delta y[t]-w\,\delta\theta[t]$$

$$\mathcal{V}\text{taylored}_1 = \text{v1 /. GivenEquibPoints}$$

$$\mathcal{V}\text{taylored}_2 = \text{v2 /. GivenEquibPoints}$$

Out[429]= $1+\frac{\gamma}{2}-\delta y[t]+w\,\delta\theta[t]$

Out[430]= $1+\frac{\gamma}{2}-\delta y[t]-w\,\delta\theta[t]$

Out[431]=

$$\left\{\{-\delta x[t]+h_p\,\delta\theta[t]\},\left\{1+\frac{\gamma}{2}-\delta y[t]+w_p\,\delta\theta[t]\right\},\left\{w_p\left(1+\frac{\gamma}{2}+h_p-\delta y[t]-(-w_p-\delta x[t])\,\delta\theta[t]\right)+h_p\left(-w_p-\delta x[t]+\left(1+\frac{\gamma}{2}+h_p-\delta y[t]\right)\delta\theta[t]\right)\right\}\right\}$$

Out[432]=

$$\left\{\{-\delta x[t]+h_p\,\delta\theta[t]\},\left\{1+\frac{\gamma}{2}-\delta y[t]-w_p\,\delta\theta[t]\right\},\left\{w_p\left(-1-\frac{\gamma}{2}-h_p+\delta y[t]+(w_p-\delta x[t])\,\delta\theta[t]\right)+h_p\left(w_p-\delta x[t]+\left(1+\frac{\gamma}{2}+h_p-\delta y[t]\right)\delta\theta[t]\right)\right\}\right\}$$

In[390]:=
```
EOM(*=D[𝒳,{t,2}]==((1 0 0; 0 1 0; 0 0 -α) (1-1/A)).𝒱1+(κ(1 0 0; 0 1 0; 0 0 -α) (1-1/B ℒ)).𝒱2-(0; γ; 0)*)
  (*/.perturbD2*) // TraditionalForm
```

Out[390]//TraditionalForm=

$$\begin{pmatrix} x_p''(t) \\ y_p''(t) \\ \theta_p''(t) \end{pmatrix} = \begin{pmatrix} (\sin(\theta_p(t))\, h_p + \cos(\theta_p(t))\, l_p + x_1(t) - x_p(t)) \\ -\gamma + \left(1 - \frac{1}{\sqrt{(\sin(\theta_p(t))\, h_p + \cos(\theta_p(t))\, l_p + x_1(t) - x_p(t))^2 + (-\cos}} \right. \\ -\alpha\, (l_p\, (\cos(\theta_p(t))\, (y_1(t) - y_p(t)) - \sin(\theta_p(t))\, (x_1(t) - x_p(t))) + h_p\, (\cos(\theta_p(t))\, (x_1(t) - x_p(t)) + \sin(\theta_p(t))\, (y_1(t) - y_p(t))) \end{pmatrix}$$

```
(*(EOMrephrase=D[𝒳,{t,2}]==((1 0 0; 0 1 0; 0 0 -α) ((A-1)/A)).𝒱1+(κ(1 0 0; 0 1 0; 0 0 -α) ((B-ℒ)/B)).𝒱2-(0; γ; 0)
   (*//Flatten*))//Simplify//TraditionalForm*)
```

In[433]:=
```
(EOMrephrase = D[𝒳, {t, 2}] A B ==
    B ((1 0 0; 0 1 0; 0 0 -α) (A - 1)).𝒱1 + A (κ (1 0 0; 0 1 0; 0 0 -α) (B - ℒ)).𝒱2 - A B (0; γ; 0)) // TraditionalForm
```

Out[433]//TraditionalForm=

$$\begin{pmatrix} \sqrt{(\sin(\theta_p(t))\, h_p + \cos(\theta_p(t))\, l_p + x_1(t) - x_p(t))^2 + (-\cos(\theta_p(t))\, h_p + \sin(\theta_p(t))\, l_p + y_1(t) - y_p(t))^2}\ \sqrt{(\sin(\theta_p(t))\, h_p - \cos(\theta_p(t))\, l_p} \\ \sqrt{(\sin(\theta_p(t))\, h_p + \cos(\theta_p(t))\, l_p + x_1(t) - x_p(t))^2 + (-\cos(\theta_p(t))\, h_p + \sin(\theta_p(t))\, l_p + y_1(t) - y_p(t))^2}\ \sqrt{(\sin(\theta_p(t))\, h_p - \cos(\theta_p(t))\, l_p} \\ \sqrt{(\sin(\theta_p(t))\, h_p + \cos(\theta_p(t))\, l_p + x_1(t) - x_p(t))^2 + (-\cos(\theta_p(t))\, h_p + \sin(\theta_p(t))\, l_p + y_1(t) - y_p(t))^2}\ \sqrt{(\sin(\theta_p(t))\, h_p - \cos(\theta_p(t))\, l_p} \end{pmatrix}$$

In[447]:=
```
(EOMLinearized = (D[𝒳, {t, 2}] /. perturbD2) Ataylored Btaylored ==
    (Btaylored (1 0 0; 0 1 0; 0 0 -α) (Ataylored - 1)).𝒱taylored1 +
     (Ataylored κ (1 0 0; 0 1 0; 0 0 -α) (Btaylored - ℒ)).𝒱taylored2 -
    Ataylored Btaylored (0; γ; 0)) // TraditionalForm
```

Out[447]//TraditionalForm=

$$\begin{pmatrix} \left(\frac{\gamma}{2} - \delta y(t) - w\,\delta\theta(t) + 1\right)\left(\frac{\gamma}{2} - \delta y(t) + w\,\delta\theta(t) + 1\right)\delta x''(t) \\ \left(\frac{\gamma}{2} - \delta y(t) - w\,\delta\theta(t) + 1\right)\left(\frac{\gamma}{2} - \delta y(t) + w\,\delta\theta(t) + 1\right)\delta y''(t) \\ \left(\frac{\gamma}{2} - \delta y(t) - w\,\delta\theta(t) + 1\right)\left(\frac{\gamma}{2} - \delta y(t) + w\,\delta\theta(t) + 1\right)\delta\theta''(t) \end{pmatrix} = \begin{pmatrix} \\ -\gamma\left(\frac{\gamma}{2} - \delta y(t) - w\,\delta\theta(\right. \\ -\alpha\left(\frac{\gamma}{2} - \delta y(t) - w\,\delta\theta(t) + 1\right)\left(\frac{\gamma}{2} - \delta y(t) + w\,\delta\theta(t)\right)\left(w_p\left(\frac{\gamma}{2} + h_p - \right.\right. \end{pmatrix}$$

In[461]:=
```
EOMLinearized //. (1 + γ/2 → γ12) //. (-1 - γ/2 → -γ12) // TraditionalForm
```

Out[461]//TraditionalForm=

$$\begin{pmatrix} (\gamma 12 - \delta\mathrm{y}(t) - w\,\delta\theta(t))\,(\gamma 12 - \delta\mathrm{y}(t) + w\,\delta\theta(t))\,\delta\mathrm{x}''(t) \\ (\gamma 12 - \delta\mathrm{y}(t) - w\,\delta\theta(t))\,(\gamma 12 - \delta\mathrm{y}(t) + w\,\delta\theta(t))\,\delta\mathrm{y}''(t) \\ (\gamma 12 - \delta\mathrm{y}(t) - w\,\delta\theta(t))\,(\gamma 12 - \delta\mathrm{y}(t) + w\,\delta\theta(t))\,\delta\theta''(t) \end{pmatrix} = \begin{pmatrix} \\ -\gamma\,(\gamma 12 - \delta\mathrm{y}(t) - w\,\delta\theta(t) \\ -\alpha\,(\gamma 12 - \delta\mathrm{y}(t) - w\,\delta\theta(t))\left(\frac{\gamma}{2} - \delta\mathrm{y}(t) + w\,\delta\theta(t)\right)(w_p\,(\gamma 12 + h_p - \delta\mathrm{y} \end{pmatrix}$$

In[462]:=
```
EOMLinearized //. (1 + γ/2 → γ12) //. (-1 - γ/2 → -γ12)
```

Out[462]=

$$\{\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\,(\gamma 12 - \delta y[t] + w\,\delta\theta[t])\,\delta x''[t]\},$$
$$\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\,(\gamma 12 - \delta y[t] + w\,\delta\theta[t])\,\delta y''[t]\},$$
$$\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\,(\gamma 12 - \delta y[t] + w\,\delta\theta[t])\,\delta\theta''[t]\}\} ==$$
$$\Big\{\Big\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\left(\frac{\gamma}{2} - \delta y[t] + w\,\delta\theta[t]\right)(-\delta x[t] + h_p\,\delta\theta[t]) +$$
$$\kappa\,(-\mathcal{L} + \gamma 12 - \delta y[t] - w\,\delta\theta[t])\,(\gamma 12 - \delta y[t] + w\,\delta\theta[t])\,(-\delta x[t] + h_p\,\delta\theta[t])\Big\},$$
$$\Big\{-\gamma\,(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\,(\gamma 12 - \delta y[t] + w\,\delta\theta[t]) +$$
$$\kappa\,(-\mathcal{L} + \gamma 12 - \delta y[t] - w\,\delta\theta[t])\,(\gamma 12 - \delta y[t] + w\,\delta\theta[t])\,(\gamma 12 - \delta y[t] - w_p\,\delta\theta[t]) +$$
$$(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\left(\frac{\gamma}{2} - \delta y[t] + w\,\delta\theta[t]\right)(\gamma 12 - \delta y[t] + w_p\,\delta\theta[t])\Big\},$$
$$\Big\{-\alpha\,(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\left(\frac{\gamma}{2} - \delta y[t] + w\,\delta\theta[t]\right)$$
$$(w_p\,(\gamma 12 + h_p - \delta y[t] - (-w_p - \delta x[t])\,\delta\theta[t]) +$$
$$h_p\,(-w_p - \delta x[t] + (\gamma 12 + h_p - \delta y[t])\,\delta\theta[t])) - \alpha\,\kappa\,(-\mathcal{L} + \gamma 12 - \delta y[t] - w\,\delta\theta[t])$$
$$(\gamma 12 - \delta y[t] + w\,\delta\theta[t])\,(w_p\,(-\gamma 12 - h_p + \delta y[t] + (w_p - \delta x[t])\,\delta\theta[t]) +$$
$$h_p\,(w_p - \delta x[t] + (\gamma 12 + h_p - \delta y[t])\,\delta\theta[t]))\Big\}\Big\}$$

In[457]:= **EOMLinearized /. $\left(1 + \frac{\gamma}{2} \to \gamma 12\right)$**

Out[457]=
$$\{\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\ (\gamma 12 - \delta y[t] + w\,\delta\theta[t])\ \delta x''[t]\},$$
$$\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\ (\gamma 12 - \delta y[t] + w\,\delta\theta[t])\ \delta y''[t]\},$$
$$\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\ (\gamma 12 - \delta y[t] + w\,\delta\theta[t])\ \delta\theta''[t]\}\} ==$$
$$\Big\{\Big\{(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\ \left(\frac{\gamma}{2} - \delta y[t] + w\,\delta\theta[t]\right)\ (-\delta x[t] + h_p\,\delta\theta[t]) +$$
$$\kappa\ (-\mathcal{L} + \gamma 12 - \delta y[t] - w\,\delta\theta[t])\ (\gamma 12 - \delta y[t] + w\,\delta\theta[t])\ (-\delta x[t] + h_p\,\delta\theta[t])\Big\},$$
$$\Big\{-\gamma\ (\gamma 12 - \delta y[t] - w\,\delta\theta[t])\ (\gamma 12 - \delta y[t] + w\,\delta\theta[t]) +$$
$$\kappa\ (-\mathcal{L} + \gamma 12 - \delta y[t] - w\,\delta\theta[t])\ (\gamma 12 - \delta y[t] + w\,\delta\theta[t])\ (\gamma 12 - \delta y[t] - w_p\,\delta\theta[t]) +$$
$$(\gamma 12 - \delta y[t] - w\,\delta\theta[t])\ \left(\frac{\gamma}{2} - \delta y[t] + w\,\delta\theta[t]\right)\ (\gamma 12 - \delta y[t] + w_p\,\delta\theta[t])\Big\},$$
$$\Big\{-\alpha\ (\gamma 12 - \delta y[t] - w\,\delta\theta[t])\ \left(\frac{\gamma}{2} - \delta y[t] + w\,\delta\theta[t]\right)$$
$$(w_p\ (\gamma 12 + h_p - \delta y[t] - (-w_p - \delta x[t])\ \delta\theta[t]) +$$
$$h_p\ (-w_p - \delta x[t] + (\gamma 12 + h_p - \delta y[t])\ \delta\theta[t])) - \alpha\,\kappa\ (-\mathcal{L} + \gamma 12 - \delta y[t] - w\,\delta\theta[t])$$
$$(\gamma 12 - \delta y[t] + w\,\delta\theta[t])\ \left(w_p\ \left(-1 - \frac{\gamma}{2} - h_p + \delta y[t] + (w_p - \delta x[t])\ \delta\theta[t]\right) +\right.$$
$$\left. h_p\ (w_p - \delta x[t] + (\gamma 12 + h_p - \delta y[t])\ \delta\theta[t])\right)\Big\}\Big\}$$

Eliminate

In[448]:= **EOMLinearized // Expand // TraditionalForm**

Out[448]//TraditionalForm=
$$\begin{pmatrix} \frac{1}{4}\,\delta x''(t)\,\gamma^2 - \delta y(t)\,\delta x''(t)\,\gamma + \delta x''(t)\,\gamma + \delta y(t)^2\,\delta x''(t) - w^2\,\delta\theta(t)^2\,\delta x''(t) - 2\,\delta y(t)\,\delta x''(t) + \delta x''(t) \\ \frac{1}{4}\,\delta y''(t)\,\gamma^2 - \delta y(t)\,\delta y''(t)\,\gamma + \delta y''(t)\,\gamma + \delta y(t)^2\,\delta y''(t) - w^2\,\delta\theta(t)^2\,\delta y''(t) - 2\,\delta y(t)\,\delta y''(t) + \delta y''(t) \\ \frac{1}{4}\,\delta\theta''(t)\,\gamma^2 - \delta y(t)\,\delta\theta''(t)\,\gamma + \delta\theta''(t)\,\gamma + \delta y(t)^2\,\delta\theta''(t) - w^2\,\delta\theta(t)^2\,\delta\theta''(t) - 2\,\delta y(t)\,\delta\theta''(t) + \delta\theta''(t) \end{pmatrix} = \Bigg(\quad -\frac{1}{8}\,\alpha\,w_p\,\gamma^3 + \frac{1}{8}\,\alpha\,\kappa\,w_p$$

In[450]:= **temp2 = EOMLinearized // Expand**

In[454]:= **Collect[temp2, δx[t] δy[t], Simplify]**

Out[454]=
$$\left\{\left\{\frac{1}{4}\left((2+\gamma)^2-4(2+\gamma)\,\delta y[t]+4\,\delta y[t]^2-4\,w^2\,\delta\theta[t]^2\right)\delta x''[t]\right\},\right.$$
$$\left\{\frac{1}{4}\left((2+\gamma)^2-4(2+\gamma)\,\delta y[t]+4\,\delta y[t]^2-4\,w^2\,\delta\theta[t]^2\right)\delta y''[t]\right\},$$
$$\left.\left\{\frac{1}{4}\left((2+\gamma)^2-4(2+\gamma)\,\delta y[t]+4\,\delta y[t]^2-4\,w^2\,\delta\theta[t]^2\right)\delta\theta''[t]\right\}\right\} ==$$
$$\left\{\left\{(1+\gamma+2\kappa-\mathcal{L}\kappa+\gamma\kappa)\,\delta x[t]\,\delta y[t]+\right.\right.$$
$$\frac{1}{4}\left(-\delta x[t]\left((2+\gamma)(\gamma+2\kappa-2\mathcal{L}\kappa+\gamma\kappa)+4(1+\kappa)\,\delta y[t]^2-4\,w\,(-1+\mathcal{L}\kappa)\,\delta\theta[t]-4\,w^2\right.\right.$$
$$\left.(1+\kappa)\,\delta\theta[t]^2\right)+h_p\,\delta\theta[t]\left((2+\gamma)(\gamma+2\kappa-2\mathcal{L}\kappa+\gamma\kappa)-4(1+\gamma+2\kappa-\mathcal{L}\kappa+\gamma\kappa)\right.$$
$$\left.\left.\left.\delta y[t]+4(1+\kappa)\,\delta y[t]^2-4\,w\,(-1+\mathcal{L}\kappa)\,\delta\theta[t]-4\,w^2\,(1+\kappa)\,\delta\theta[t]^2\right)\right)\right\},$$
$$\left\{\frac{1}{8}\left((2+\gamma)^2\,(\gamma\,(-1+\kappa)-2\,(-1+\mathcal{L})\,\kappa)-8\,(1+\kappa)\,\delta y[t]^3-\right.\right.$$
$$2\,(2+\gamma)\,(2\,w\,(-1+\mathcal{L}\kappa)+(\gamma\,(-1+\kappa)-2\,(-1+\mathcal{L})\,\kappa)\,w_p)\,\delta\theta[t]+$$
$$4\,w\,(w\,(\gamma-\gamma\kappa-2\,(1+\kappa))+2\,(1+\mathcal{L}\kappa)\,w_p)\,\delta\theta[t]^2+8\,w^2\,(-1+\kappa)\,w_p\,\delta\theta[t]^3+$$
$$4\,\delta y[t]^2\,(4+\gamma+6\kappa-2\mathcal{L}\kappa+3\gamma\kappa-2\,(-1+\kappa)\,w_p\,\delta\theta[t])-$$
$$2\,\delta y[t]\left((2+\gamma)\,(2+(6-4\mathcal{L})\,\kappa+\gamma\,(-1+3\kappa))+\right.$$
$$\left.\left.\left.4\,(w-w\mathcal{L}\kappa+(1+\gamma+(-2+\mathcal{L})\,\kappa-\gamma\kappa)\,w_p)\,\delta\theta[t]-4\,w^2\,(1+\kappa)\,\delta\theta[t]^2\right)\right)\right\},$$
$$\left\{-\alpha\,\delta x[t]\,\delta y[t]\,((1+\gamma+2\kappa-\mathcal{L}\kappa+\gamma\kappa)\,h_p+(-1+\gamma\,(-1+\kappa)+2\kappa-\mathcal{L}\kappa)\,w_p\,\delta\theta[t])+\right.$$
$$\frac{1}{8}\,\alpha\left(-2\,w_p^2\,\delta\theta[t]\left((2+\gamma)\,(\gamma+2\kappa-2\mathcal{L}\kappa+\gamma\kappa)-4\,(1+\gamma+2\kappa-\mathcal{L}\kappa+\gamma\kappa)\,\delta y[t]+\right.\right.$$
$$\left.4\,(1+\kappa)\,\delta y[t]^2-4\,w\,(-1+\mathcal{L}\kappa)\,\delta\theta[t]-4\,w^2\,(1+\kappa)\,\delta\theta[t]^2\right)+$$
$$w_p\left(-8\,(-1+\kappa)\,\delta y[t]^3+4\,\delta y[t]^2\,(-4+3\gamma\,(-1+\kappa)+6\kappa-2\mathcal{L}\kappa+2\,(-1+\kappa)\right.$$
$$\delta x[t]\,\delta\theta[t])+(2+\gamma+2\,\delta x[t]\,\delta\theta[t])\left((2+\gamma)\,(\gamma\,(-1+\kappa)-2\,(-1+\mathcal{L})\,\kappa)-\right.$$
$$\left.4\,(w+w\mathcal{L}\kappa)\,\delta\theta[t]-4\,w^2\,(-1+\kappa)\,\delta\theta[t]^2\right)+2\,\delta y[t]\left(-(2+\gamma)\right.$$
$$\left.\left.(-2+3\gamma\,(-1+\kappa)+6\kappa-4\mathcal{L}\kappa)+4\,(w+w\mathcal{L}\kappa)\,\delta\theta[t]+4\,w^2\,(-1+\kappa)\,\delta\theta[t]^2\right)\right)+$$
$$h_p\left(2\,\delta x[t]\left((2+\gamma)\,(\gamma+2\kappa-2\mathcal{L}\kappa+\gamma\kappa)+4\,(1+\kappa)\,\delta y[t]^2-4\,w\,(-1+\mathcal{L}\kappa)\,\delta\theta[t]-\right.\right.$$
$$\left.4\,w^2\,(1+\kappa)\,\delta\theta[t]^2\right)-(2+\gamma+2\,h_p-2\,\delta y[t])\,\delta\theta[t]$$
$$\left((2+\gamma)\,(\gamma+2\kappa-2\mathcal{L}\kappa+\gamma\kappa)-4\,(1+\gamma+2\kappa-\mathcal{L}\kappa+\gamma\kappa)\,\delta y[t]+\right.$$
$$\left.\left.\left.\left.\left.4\,(1+\kappa)\,\delta y[t]^2-4\,w\,(-1+\mathcal{L}\kappa)\,\delta\theta[t]-4\,w^2\,(1+\kappa)\,\delta\theta[t]^2\right)\right)\right)\right\}\right\}$$

Out[450]=
$$\left\{\left\{\delta x''[t]+\gamma\,\delta x''[t]+\frac{1}{2}\gamma^2\,\delta x''[t]-\right.\right.$$
$$\left.2\,\delta y[t]\,\delta x''[t]-\gamma\,\delta y[t]\,\delta x''[t]+\delta y[t]^2\,\delta x''[t]-w^2\,\delta\theta[t]^2\,\delta x''[t]\right\},$$
$$\left\{\delta y''[t]+\gamma\,\delta y''[t]+\frac{1}{4}\gamma^2\,\delta y''[t]-2\,\delta y[t]\,\delta y''[t]-\gamma\,\delta y[t]\,\delta y''[t]+\right.$$
$$\left.\delta y[t]^2\,\delta y''[t]-w^2\,\delta\theta[t]^2\,\delta y''[t]\right\},\ \left\{\delta\theta''[t]+\gamma\,\delta\theta''[t]+\frac{1}{4}\gamma^2\,\delta\theta''[t]-\right.$$
$$\left.\left.2\,\delta y[t]\,\delta\theta''[t]-\gamma\,\delta y[t]\,\delta\theta''[t]+\delta y[t]^2\,\delta\theta''[t]-w^2\,\delta\theta[t]^2\,\delta\theta''[t]\right\}\right\} ==$$
$$\left\{\left\{-\frac{1}{2}\gamma\,\delta x[t]-\frac{1}{4}\gamma^2\,\delta x[t]-\kappa\,\delta x[t]+\mathcal{L}\kappa\,\delta x[t]-\gamma\kappa\,\delta x[t]+\frac{1}{2}\mathcal{L}\gamma\kappa\,\delta x[t]-\frac{1}{4}\gamma^2\kappa\,\delta x[t]+\right.\right.$$
$$\delta x[t]\,\delta y[t]+\gamma\,\delta x[t]\,\delta y[t]+2\kappa\,\delta x[t]\,\delta y[t]-\mathcal{L}\kappa\,\delta x[t]\,\delta y[t]+\gamma\kappa\,\delta x[t]\,\delta y[t]-$$
$$\delta x[t]\,\delta y[t]^2-\kappa\,\delta x[t]\,\delta y[t]^2+\frac{1}{2}\gamma\,h_p\,\delta\theta[t]+\frac{1}{4}\gamma^2\,h_p\,\delta\theta[t]+\kappa\,h_p\,\delta\theta[t]-$$

$$\mathcal{L}\,\kappa\,h_p\,\delta\theta[t]+\gamma\,\kappa\,h_p\,\delta\theta[t]-\frac{1}{2}\mathcal{L}\,\gamma\,\kappa\,h_p\,\delta\theta[t]+\frac{1}{4}\gamma^2\,\kappa\,h_p\,\delta\theta[t]-w\,\delta x[t]\,\delta\theta[t]+$$

$$w\,\mathcal{L}\,\kappa\,\delta x[t]\,\delta\theta[t]-h_p\,\delta y[t]\,\delta\theta[t]-\gamma\,h_p\,\delta y[t]\,\delta\theta[t]-2\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]+$$

$$\mathcal{L}\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]-\gamma\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]+h_p\,\delta y[t]^2\,\delta\theta[t]+\kappa\,h_p\,\delta y[t]^2\,\delta\theta[t]+w\,h_p\,\delta\theta[t]^2-$$

$$w\,\mathcal{L}\,\kappa\,h_p\,\delta\theta[t]^2+w^2\,\delta x[t]\,\delta\theta[t]^2+w^2\,\kappa\,\delta x[t]\,\delta\theta[t]^2-w^2\,h_p\,\delta\theta[t]^3-w^2\,\kappa\,h_p\,\delta\theta[t]^3\Big\},$$

$$\Big\{-\frac{\gamma}{2}-\frac{\gamma^2}{2}-\frac{\gamma^3}{8}+\kappa-\mathcal{L}\,\kappa+\frac{3\,\gamma\,\kappa}{2}-\mathcal{L}\,\gamma\,\kappa+\frac{3\,\gamma^2\,\kappa}{4}-\frac{1}{4}\mathcal{L}\,\gamma^2\,\kappa+\frac{\gamma^3\,\kappa}{8}-\delta y[t]+\frac{1}{4}\gamma^2\,\delta y[t]-$$

$$3\,\kappa\,\delta y[t]+2\,\mathcal{L}\,\kappa\,\delta y[t]-3\,\gamma\,\kappa\,\delta y[t]+\mathcal{L}\,\gamma\,\kappa\,\delta y[t]-\frac{3}{4}\gamma^2\,\kappa\,\delta y[t]+2\,\delta y[t]^2+$$

$$\frac{1}{2}\gamma\,\delta y[t]^2+3\,\kappa\,\delta y[t]^2-\mathcal{L}\,\kappa\,\delta y[t]^2+\frac{3}{2}\gamma\,\kappa\,\delta y[t]^2-\delta y[t]^3-\kappa\,\delta y[t]^3+w\,\delta\theta[t]+$$

$$\frac{1}{2}w\,\gamma\,\delta\theta[t]-w\,\mathcal{L}\,\kappa\,\delta\theta[t]-\frac{1}{2}w\,\mathcal{L}\,\gamma\,\kappa\,\delta\theta[t]+\frac{1}{2}\gamma\,w_p\,\delta\theta[t]+\frac{1}{4}\gamma^2\,w_p\,\delta\theta[t]-\kappa\,w_p\,\delta\theta[t]+$$

$$\mathcal{L}\,\kappa\,w_p\,\delta\theta[t]-\gamma\,\kappa\,w_p\,\delta\theta[t]+\frac{1}{2}\mathcal{L}\,\gamma\,\kappa\,w_p\,\delta\theta[t]-\frac{1}{4}\gamma^2\,\kappa\,w_p\,\delta\theta[t]-w\,\delta y[t]\,\delta\theta[t]+$$

$$w\,\mathcal{L}\,\kappa\,\delta y[t]\,\delta\theta[t]-w_p\,\delta y[t]\,\delta\theta[t]-\gamma\,w_p\,\delta y[t]\,\delta\theta[t]+2\,\kappa\,w_p\,\delta y[t]\,\delta\theta[t]-$$

$$\mathcal{L}\,\kappa\,w_p\,\delta y[t]\,\delta\theta[t]+\gamma\,\kappa\,w_p\,\delta y[t]\,\delta\theta[t]+w_p\,\delta y[t]^2\,\delta\theta[t]-\kappa\,w_p\,\delta y[t]^2\,\delta\theta[t]-$$

$$w^2\,\delta\theta[t]^2+\frac{1}{2}w^2\,\gamma\,\delta\theta[t]^2-w^2\,\kappa\,\delta\theta[t]^2-\frac{1}{2}w^2\,\gamma\,\kappa\,\delta\theta[t]^2+w\,w_p\,\delta\theta[t]^2+$$

$$w\,\mathcal{L}\,\kappa\,w_p\,\delta\theta[t]^2+w^2\,\delta y[t]\,\delta\theta[t]^2+w^2\,\kappa\,\delta y[t]\,\delta\theta[t]^2-w^2\,w_p\,\delta\theta[t]^3+w^2\,\kappa\,w_p\,\delta\theta[t]^3\Big\},$$

$$\Big\{-\frac{1}{2}\alpha\,\gamma\,w_p-\frac{1}{2}\alpha\,\gamma^2\,w_p-\frac{1}{8}\alpha\,\gamma^3\,w_p+\alpha\,\kappa\,w_p-\mathcal{L}\,\alpha\,\kappa\,w_p+\frac{3}{2}\alpha\,\gamma\,\kappa\,w_p-\mathcal{L}\,\alpha\,\gamma\,\kappa\,w_p+\frac{3}{4}\alpha\,\gamma^2\,\kappa\,w_p-$$

$$\frac{1}{4}\mathcal{L}\,\alpha\,\gamma^2\,\kappa\,w_p+\frac{1}{8}\alpha\,\gamma^3\,\kappa\,w_p+\frac{1}{2}\alpha\,\gamma\,h_p\,\delta x[t]+\frac{1}{4}\alpha\,\gamma^2\,h_p\,\delta x[t]+\alpha\,\kappa\,h_p\,\delta x[t]-$$

$$\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta x[t]+\alpha\,\gamma\,\kappa\,h_p\,\delta x[t]-\frac{1}{2}\mathcal{L}\,\alpha\,\gamma\,\kappa\,h_p\,\delta x[t]+\frac{1}{4}\alpha\,\gamma^2\,\kappa\,h_p\,\delta x[t]+\alpha\,w_p\,\delta y[t]+$$

$$2\,\alpha\,\gamma\,w_p\,\delta y[t]+\frac{3}{4}\alpha\,\gamma^2\,w_p\,\delta y[t]-3\,\alpha\,\kappa\,w_p\,\delta y[t]+2\,\mathcal{L}\,\alpha\,\kappa\,w_p\,\delta y[t]-3\,\alpha\,\gamma\,\kappa\,w_p\,\delta y[t]+$$

$$\mathcal{L}\,\alpha\,\gamma\,\kappa\,w_p\,\delta y[t]-\frac{3}{4}\alpha\,\gamma^2\,\kappa\,w_p\,\delta y[t]-\alpha\,h_p\,\delta x[t]\,\delta y[t]-\alpha\,\gamma\,h_p\,\delta x[t]\,\delta y[t]-$$

$$2\,\alpha\,\kappa\,h_p\,\delta x[t]\,\delta y[t]+\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta x[t]\,\delta y[t]-\alpha\,\gamma\,\kappa\,h_p\,\delta x[t]\,\delta y[t]-2\,\alpha\,w_p\,\delta y[t]^2-$$

$$\frac{3}{2}\alpha\,\gamma\,w_p\,\delta y[t]^2+3\,\alpha\,\kappa\,w_p\,\delta y[t]^2-\mathcal{L}\,\alpha\,\kappa\,w_p\,\delta y[t]^2+\frac{3}{2}\alpha\,\gamma\,\kappa\,w_p\,\delta y[t]^2+\alpha\,h_p\,\delta x[t]\,\delta y[t]^2+$$

$$\alpha\,\kappa\,h_p\,\delta x[t]\,\delta y[t]^2+\alpha\,w_p\,\delta y[t]^3-\alpha\,\kappa\,w_p\,\delta y[t]^3-\frac{1}{2}\alpha\,\gamma\,h_p\,\delta\theta[t]-\frac{1}{2}\alpha\,\gamma^2\,h_p\,\delta\theta[t]-$$

$$\frac{1}{8}\alpha\,\gamma^3\,h_p\,\delta\theta[t]-\alpha\,\kappa\,h_p\,\delta\theta[t]+\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta\theta[t]-\frac{3}{2}\alpha\,\gamma\,\kappa\,h_p\,\delta\theta[t]+\mathcal{L}\,\alpha\,\gamma\,\kappa\,h_p\,\delta\theta[t]-$$

$$\frac{3}{4}\alpha\,\gamma^2\,\kappa\,h_p\,\delta\theta[t]+\frac{1}{4}\mathcal{L}\,\alpha\,\gamma^2\,\kappa\,h_p\,\delta\theta[t]-\frac{1}{8}\alpha\,\gamma^3\,\kappa\,h_p\,\delta\theta[t]-\frac{1}{2}\alpha\,\gamma\,h_p^2\,\delta\theta[t]-$$

$$\frac{1}{4}\alpha\,\gamma^2\,h_p^2\,\delta\theta[t]-\alpha\,\kappa\,h_p^2\,\delta\theta[t]+\mathcal{L}\,\alpha\,\kappa\,h_p^2\,\delta\theta[t]-\alpha\,\gamma\,\kappa\,h_p^2\,\delta\theta[t]+\frac{1}{2}\mathcal{L}\,\alpha\,\gamma\,\kappa\,h_p^2\,\delta\theta[t]-$$

$$\frac{1}{4}\alpha\,\gamma^2\,\kappa\,h_p^2\,\delta\theta[t]-w\,\alpha\,w_p\,\delta\theta[t]-\frac{1}{2}w\,\alpha\,\gamma\,w_p\,\delta\theta[t]-w\,\mathcal{L}\,\alpha\,\kappa\,w_p\,\delta\theta[t]-\frac{1}{2}w\,\mathcal{L}\,\alpha\,\gamma\,\kappa\,w_p\,\delta\theta[t]-$$

$$\frac{1}{2}\alpha\,\gamma\,w_p^2\,\delta\theta[t]-\frac{1}{4}\alpha\,\gamma^2\,w_p^2\,\delta\theta[t]-\alpha\,\kappa\,w_p^2\,\delta\theta[t]+\mathcal{L}\,\alpha\,\kappa\,w_p^2\,\delta\theta[t]-\alpha\,\gamma\,\kappa\,w_p^2\,\delta\theta[t]+$$

$$\frac{1}{2}\mathcal{L}\,\alpha\,\gamma\,\kappa\,w_p^2\,\delta\theta[t]-\frac{1}{4}\alpha\,\gamma^2\,\kappa\,w_p^2\,\delta\theta[t]+w\,\alpha\,h_p\,\delta x[t]\,\delta\theta[t]-w\,\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta x[t]\,\delta\theta[t]-$$

$$\frac{1}{2}\alpha\,\gamma\,w_p\,\delta x[t]\,\delta\theta[t]-\frac{1}{4}\alpha\,\gamma^2\,w_p\,\delta x[t]\,\delta\theta[t]+\alpha\,\kappa\,w_p\,\delta x[t]\,\delta\theta[t]-\mathcal{L}\,\alpha\,\kappa\,w_p\,\delta x[t]\,\delta\theta[t]+$$

$$\alpha\,\gamma\,\kappa\,w_p\,\delta x[t]\,\delta\theta[t]-\frac{1}{2}\mathcal{L}\,\alpha\,\gamma\,\kappa\,w_p\,\delta x[t]\,\delta\theta[t]+\frac{1}{4}\alpha\,\gamma^2\,\kappa\,w_p\,\delta x[t]\,\delta\theta[t]+$$
$$\alpha\,h_p\,\delta y[t]\,\delta\theta[t]+2\,\alpha\,\gamma\,h_p\,\delta y[t]\,\delta\theta[t]+\frac{3}{4}\alpha\,\gamma^2\,h_p\,\delta y[t]\,\delta\theta[t]+3\,\alpha\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]-$$
$$2\,\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]+3\,\alpha\,\gamma\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]-\mathcal{L}\,\alpha\,\gamma\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]+$$
$$\frac{3}{4}\alpha\,\gamma^2\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]+\alpha\,h_p^2\,\delta y[t]\,\delta\theta[t]+\alpha\,\gamma\,h_p^2\,\delta y[t]\,\delta\theta[t]+2\,\alpha\,\kappa\,h_p^2\,\delta y[t]\,\delta\theta[t]-$$
$$\mathcal{L}\,\alpha\,\kappa\,h_p^2\,\delta y[t]\,\delta\theta[t]+\alpha\,\gamma\,\kappa\,h_p^2\,\delta y[t]\,\delta\theta[t]+w\,\alpha\,w_p\,\delta y[t]\,\delta\theta[t]+w\,\mathcal{L}\,\alpha\,\kappa\,w_p\,\delta y[t]\,\delta\theta[t]+$$
$$\alpha\,w_p^2\,\delta y[t]\,\delta\theta[t]+\alpha\,\gamma\,w_p^2\,\delta y[t]\,\delta\theta[t]+2\,\alpha\,\kappa\,w_p^2\,\delta y[t]\,\delta\theta[t]-\mathcal{L}\,\alpha\,\kappa\,w_p^2\,\delta y[t]\,\delta\theta[t]+$$
$$\alpha\,\gamma\,\kappa\,w_p^2\,\delta y[t]\,\delta\theta[t]+\alpha\,w_p\,\delta x[t]\,\delta y[t]\,\delta\theta[t]+\alpha\,\gamma\,w_p\,\delta x[t]\,\delta y[t]\,\delta\theta[t]-$$
$$2\,\alpha\,\kappa\,w_p\,\delta x[t]\,\delta y[t]\,\delta\theta[t]+\mathcal{L}\,\alpha\,\kappa\,w_p\,\delta x[t]\,\delta y[t]\,\delta\theta[t]-\alpha\,\gamma\,\kappa\,w_p\,\delta x[t]\,\delta y[t]\,\delta\theta[t]-$$
$$2\,\alpha\,h_p\,\delta y[t]^2\,\delta\theta[t]-\frac{3}{2}\alpha\,\gamma\,h_p\,\delta y[t]^2\,\delta\theta[t]-3\,\alpha\,\kappa\,h_p\,\delta y[t]^2\,\delta\theta[t]+\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta y[t]^2\,\delta\theta[t]-$$
$$\frac{3}{2}\alpha\,\gamma\,\kappa\,h_p\,\delta y[t]^2\,\delta\theta[t]-\alpha\,h_p^2\,\delta y[t]^2\,\delta\theta[t]-\alpha\,\kappa\,h_p^2\,\delta y[t]^2\,\delta\theta[t]-\alpha\,w_p^2\,\delta y[t]^2\,\delta\theta[t]-$$
$$\alpha\,\kappa\,w_p^2\,\delta y[t]^2\,\delta\theta[t]-\alpha\,w_p\,\delta x[t]\,\delta y[t]^2\,\delta\theta[t]+\alpha\,\kappa\,w_p\,\delta x[t]\,\delta y[t]^2\,\delta\theta[t]+$$
$$\alpha\,h_p\,\delta y[t]^3\,\delta\theta[t]+\alpha\,\kappa\,h_p\,\delta y[t]^3\,\delta\theta[t]-w\,\alpha\,h_p\,\delta\theta[t]^2-\frac{1}{2}w\,\alpha\,\gamma\,h_p\,\delta\theta[t]^2+$$
$$w\,\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta\theta[t]^2+\frac{1}{2}w\,\mathcal{L}\,\alpha\,\gamma\,\kappa\,h_p\,\delta\theta[t]^2-w\,\alpha\,h_p^2\,\delta\theta[t]^2+w\,\mathcal{L}\,\alpha\,\kappa\,h_p^2\,\delta\theta[t]^2+w^2\,\alpha\,w_p\,\delta\theta[t]^2+$$
$$\frac{1}{2}w^2\,\alpha\,\gamma\,w_p\,\delta\theta[t]^2-w^2\,\alpha\,\kappa\,w_p\,\delta\theta[t]^2-\frac{1}{2}w^2\,\alpha\,\gamma\,\kappa\,w_p\,\delta\theta[t]^2-w\,\alpha\,w_p^2\,\delta\theta[t]^2+w\,\mathcal{L}\,\alpha\,\kappa\,w_p^2\,\delta\theta[t]^2-$$
$$w^2\,\alpha\,h_p\,\delta x[t]\,\delta\theta[t]^2-w^2\,\alpha\,\kappa\,h_p\,\delta x[t]\,\delta\theta[t]^2-w\,\alpha\,w_p\,\delta x[t]\,\delta\theta[t]^2-w\,\mathcal{L}\,\alpha\,\kappa\,w_p\,\delta x[t]\,\delta\theta[t]^2+$$
$$w\,\alpha\,h_p\,\delta y[t]\,\delta\theta[t]^2-w\,\mathcal{L}\,\alpha\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]^2-w^2\,\alpha\,w_p\,\delta y[t]\,\delta\theta[t]^2+w^2\,\alpha\,\kappa\,w_p\,\delta y[t]\,\delta\theta[t]^2+$$
$$w^2\,\alpha\,h_p\,\delta\theta[t]^3+\frac{1}{2}w^2\,\alpha\,\gamma\,h_p\,\delta\theta[t]^3+w^2\,\alpha\,\kappa\,h_p\,\delta\theta[t]^3+\frac{1}{2}w^2\,\alpha\,\gamma\,\kappa\,h_p\,\delta\theta[t]^3+$$
$$w^2\,\alpha\,h_p^2\,\delta\theta[t]^3+w^2\,\alpha\,\kappa\,h_p^2\,\delta\theta[t]^3+w^2\,\alpha\,w_p^2\,\delta\theta[t]^3+w^2\,\alpha\,\kappa\,w_p^2\,\delta\theta[t]^3+w^2\,\alpha\,w_p\,\delta x[t]\,\delta\theta[t]^3-$$
$$w^2\,\alpha\,\kappa\,w_p\,\delta x[t]\,\delta\theta[t]^3-w^2\,\alpha\,h_p\,\delta y[t]\,\delta\theta[t]^3-w^2\,\alpha\,\kappa\,h_p\,\delta y[t]\,\delta\theta[t]^3\}\}$$

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(*EOMLinearized[[2]]-EOM[[2]]//Simplify//TraditionalForm*)

(*EOMrephrase[[2]]-EOM[[2]]//Simplify//TraditionalForm*)
```

Out[403]//TraditionalForm=

$$-\sqrt{(\sin(\theta_p(t))\,h_p+\cos(\theta_p(t))\,l_p+x_1(t)-x_p(t))^2+(\cos(\theta_p(t))\,h_p-\sin(\theta_p(t))\,l_p-y_1(t)+y}$$

$$\alpha\left((l_p\,(\cos(\theta_p(t))\,(y_1(t)-y_p(t))-\sin(\theta_p(t))\,(x_1(t)-x_p(t)))+h_p\,(\cos(\theta_p(t))\,(x_1(t)-x_p(t))+\sin(\theta_p(t))\,(y_1(t)-y_p(t))))\left(1-\frac{}{\sqrt{(\sin(\theta}}\right.\right.$$