Impulse Response

In[ ]:=
```
accelData = Import["C:\\Users\\ambik\\Desktop\\ImpulseInput.xls", {"Data", 1}]
```

Out[ ]=
```
{{Time (s), Linear Acceleration x (m/s^2), Linear Acceleration y (m/s^2),
  Linear Acceleration z (m/s^2), Absolute acceleration (m/s^2)},
 {0.0499597, -0.0319996, -0.00270207, 0.000562502, 0.0321184}, ··· 5527 ··· ,
 {55.1707, -0.0490635, 0.0554145, -0.0286753, 0.0793742}}
```

large output | show less | show more | show all | set size limit...

In[ ]:=
```
rawplotData = Transpose[{accelData[[All, 1]], accelData[[All, 4]]}]
```

Out[ ]=
```
{{Time (s), Linear Acceleration z (m/s^2)}, {0.0499597, 0.000562502},
 {0.0599307, -0.0280339}, {0.0699027, -0.00842759}, ··· 5522 ··· , {55.1408, 0.0321451},
 {55.1508, 0.00452224}, {55.1608, 0.000874159}, {55.1707, -0.0286753}}
```

large output | show less | show more | show all | set size limit...

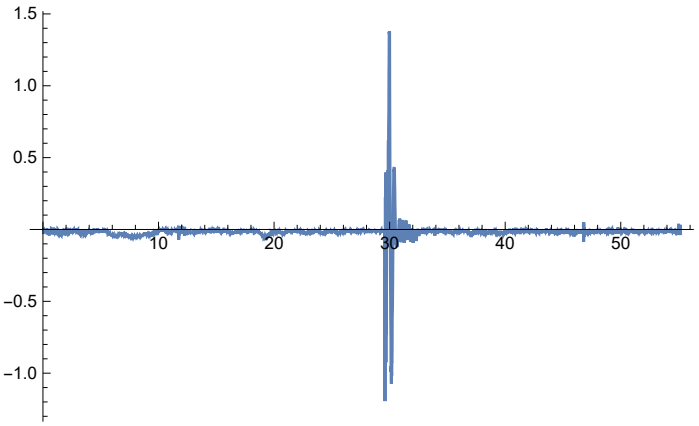
In[ ]:=
```
plotData = rawplotData[[2 ;;]]
```

Out[ ]=
```
{{0.0499597, 0.000562502}, {0.0599307, -0.0280339}, {0.0699027, -0.00842759},
 {0.0798737, -0.0150116}, ··· 5521 ··· , {55.1408, 0.0321451},
 {55.1508, 0.00452224}, {55.1608, 0.000874159}, {55.1707, -0.0286753}}
```

large output | show less | show more | show all | set size limit...

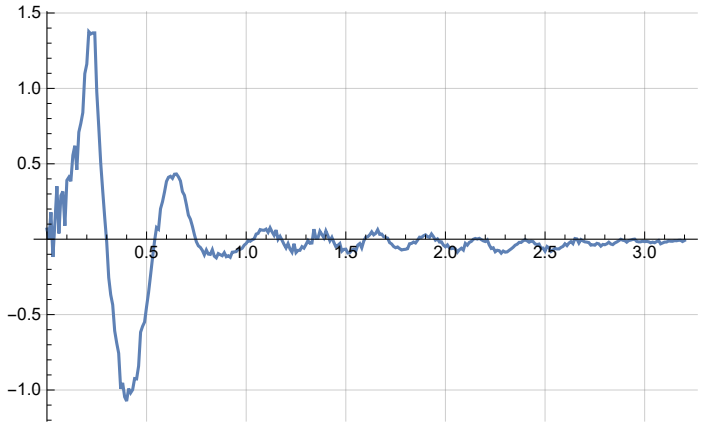
In[ ]:=
```
accelPlot = ListLinePlot[plotData, PlotRange → {All, All}]
```

Out[ ]=



```
In[•]:= usefulAccelData = Transpose[plotData[[2980 ;; 3300]]][[2]];

In[•]:= tf = (3300 - 2980) * 0.01
Out[•]= 3.2

In[•]:= time = Range[0, tf, 0.01];

In[•]:= usefulData = Transpose[{time, usefulAccelData}];

In[•]:= zddotPlotImpulse = ListLinePlot[usefulData, PlotRange → All, GridLines → Automatic]
```

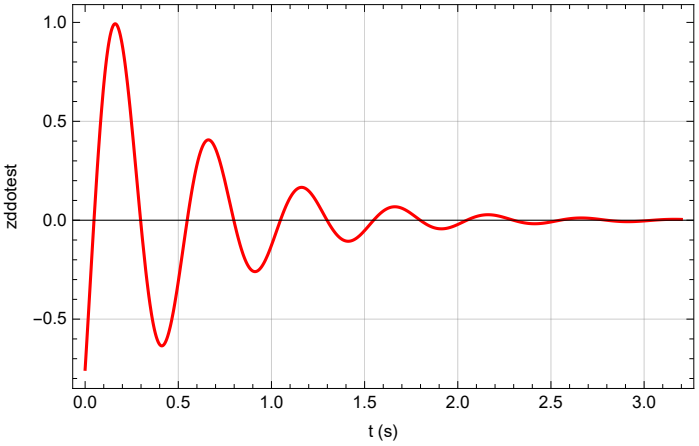
Out[•]=




```
In[•]:= SetAttributes[{A1, A2, b, c, ωn, ωd, ζ}, Constant]

In[•]:= x[t] = Exp[-ζ ωn t] (A1 Cos[ωd t] + A2 Sin[ωd t])
Out[•]= e^(-0.140841 t ωn) (A1 Cos[t ωd] + A2 Sin[t ωd])

In[•]:= Dt[Dt[x[t], t], t] // Simplify
Out[•]= e^(-0.140841 t ωn) ((-1. A1 ωd^2 - 0.281681 A2 ωd ωn + 0.0198361 A1 ωn^2) Cos[t ωd] +
        (-1. A2 ωd^2 + 0.281681 A1 ωd ωn + 0.0198361 A2 ωn^2) Sin[t ωd])

In[•]:= A1 =.; A2 =.; b =.; c =.;

In[•]:= ωn =.; ζ =.;

In[•]:= fitParam = FindFit[(usefulData), {Exp[-b t]
          ((Cos[c t]) (-A1 c^2 - 2 A2 b c + A1 b^2) + (Sin[c t]) (-A2 c^2 + 2 A1 b c + A2 b^2))},
        {A1, A2, b, c}, t, MaxIterations → 1000000] // Chop
Out[•]= {A1 → 0.00641119, A2 → -0.005293, b → 1.78688, c → 12.5608}
```

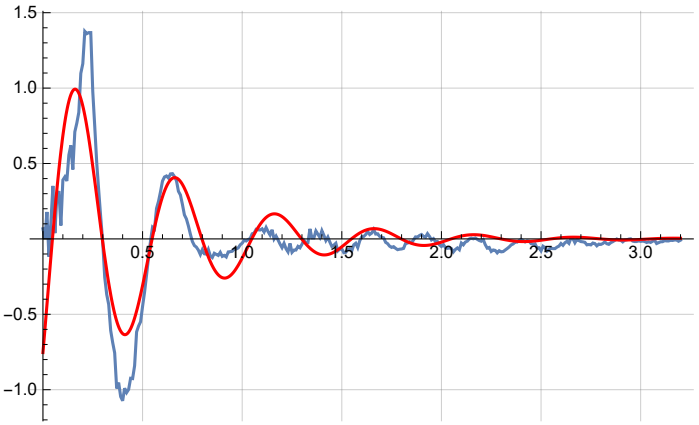
In[•]:=
```
fitPlotImpulse = Plot[Exp[-b t]
    ((Cos[c t]) (-A1 c^2 - 2 A2 b c + A1 b^2) + (Sin[c t]) (-A2 c^2 + 2 A1 b c + A2 b^2)) //.
   fitParam, {t, 0, tf}, PlotRange → All, PlotStyle → {Red}, Frame → True,
  GridLines → Automatic, FrameLabel → {"t (s)", "zddotest"}]
```

Out[•]=



In[•]:=
```
Show[zddotPlotImpulse, fitPlotImpulse]
```

Out[•]=



In[•]:=
```
Bcoeff = b /. fitParam
```

Out[•]= 1.78688

In[•]:=
```
Ccoeff = c /. fitParam
```

Out[•]= 12.5608

In[•]:=
```
eqn1 = Bcoeff == ζ ωn
eqn2 = Ccoeff == ωn Sqrt[1 - ζ^2]
```

Out[•]= $1.78688 == \zeta\, \omega n$

Out[•]= $12.5608 == \sqrt{1-\zeta^2}\ \omega n$

In[•]:=
```
solImpulse = Solve[{eqn1, eqn2}, {ζ, ωn}] // First
```

Out[•]= $\{\zeta \to 0.140841,\ \omega n \to 12.6873\}$

In[•]:= **eqn3 = ω n == Sqrt[k / m] /. solImpulse**

Out[•]= $12.6873 == \sqrt{\frac{k}{m}}$

In[•]:= **KsolImpulse = Solve[eqn3, k] /. {m → 1200} // First(*N/m*)**

Out[•]= {k → 193 160.}

Step Response Data

In[•]:= **accelData = Import["C:\\Users\\ambik\\Desktop\\StepInputNew.xls", {"Data", 1}]**

Out[•]=
```
{{Time (s), Linear Acceleration x (m/s^2), Linear Acceleration y (m/s^2),
  Linear Acceleration z (m/s^2), Absolute acceleration (m/s^2)},
 ··· 6581 ···, {65.6594, -0.139314, 0.147269, -0.0509082, 0.209017}}
```

large output | show less | show more | show all | set size limit...

In[•]:= **rawplotData = Transpose[{accelData[[All, 1]], accelData[[All, 4]]}]**

Out[•]=
```
{{Time (s), Linear Acceleration z (m/s^2)}, {0.0473149, -0.0203027},
 {0.0572849, -0.0135895}, {0.0672549, -0.00730785}, ··· 6575 ···, {65.6295, -0.0117319},
 {65.6394, -0.038063}, {65.6494, -0.0219885}, {65.6594, -0.0509082}}
```

large output | show less | show more | show all | set size limit...

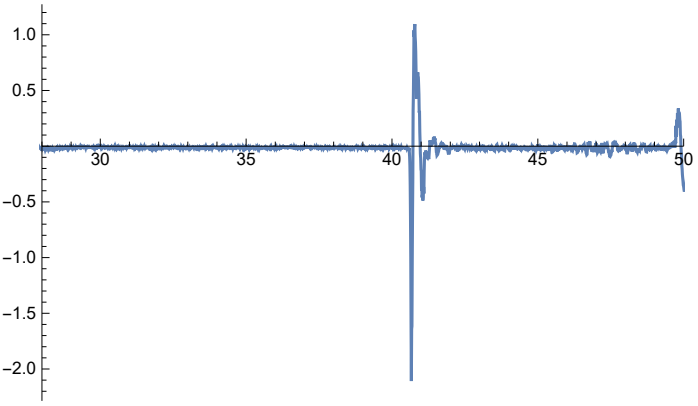
In[•]:= **plotData = rawplotData[[2 ;;]]**

Out[•]=
```
{{0.0473149, -0.0203027}, {0.0572849, -0.0135895}, {0.0672549, -0.00730785},
 {0.0772249, -0.0109916}, ··· 6574 ···, {65.6295, -0.0117319},
 {65.6394, -0.038063}, {65.6494, -0.0219885}, {65.6594, -0.0509082}}
```

large output | show less | show more | show all | set size limit...

In[•]:= `accelPlot = ListLinePlot[plotData, PlotRange → {{28, 50}, All}]`

Out[•]=



In[•]:= `usefulAccelData = Transpose[plotData[[4095 ;; 4300]]][[2]];`

In[•]:= `tf = (4300 - 4095) * 0.01`

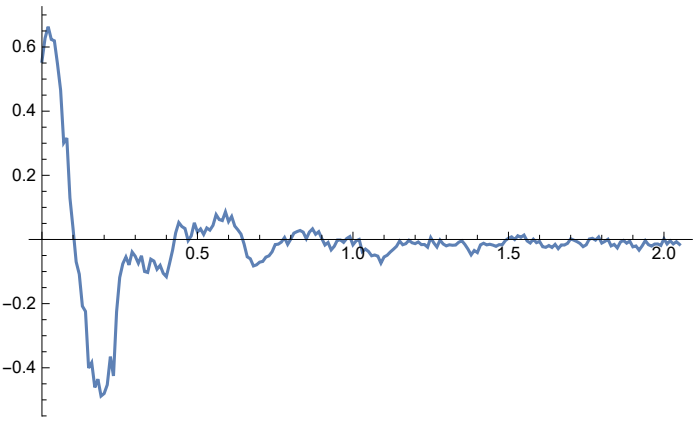
Out[•]= 2.05

In[•]:= `time = Range[0, tf, 0.01];`

In[•]:= `usefulData = Transpose[{time, usefulAccelData}];`

In[•]:= `zddotPlotUnit = ListLinePlot[usefulData, PlotRange → All]`

Out[•]=



Canonical 2nd order Transfer Function

Fitting Transfer function from Impulse Input data to the Unitstep response.

In[•]:= `kdc = 1 / (m s^2 + b s + K) /. {s → 0, K → k /. KsolImpulse}`

Out[•]= 5.17705×10^{-6}

In[•]:=
```
ζ = ζ /. solImpulse
ωn = ωn /. solImpulse
kdc = kdc
```

Out[•]= 0.140841

Out[•]= 12.6873

Out[•]= 5.17705×10^{-6}

In[•]:=
```
Gs = (kdc (ωn)^2 / (s^2 + 2 ζ ωn s + (ωn)^2))
```

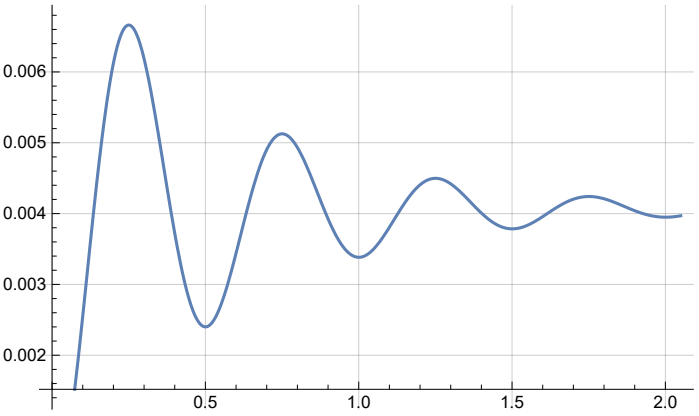
Out[•]=
$$\frac{0.000833333}{160.967 + 3.57377\, s + s^2}$$

In[•]:=
```
resUnit = OutputResponse[TransferFunctionModel[Gs, s], 80 * 9.81 UnitStep[t], t]
```

Out[•]=
$$\{(0. + 0.\,i) + 0.00406295\, e^{(-1.78688-12.5608\,i)\,t}\,(-1.\, e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t] + (8.89219 \times 10^{-17} + 2.22305 \times 10^{-17}\,i)\, e^{1.78688\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t] - (8.89219 \times 10^{-17} + 2.22305 \times 10^{-17}\,i)\, e^{(1.78688+25.1216\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t] + 1. \times 2.71828^{1.78688\,t}\, e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]^2\,\text{UnitStep}[t] - 0.142259\, e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t] + (3.63891 \times 10^{-17} + 0.510119\,i)\, e^{1.78688\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t] - (3.63891 \times 10^{-17} + 0.510119\,i)\, e^{(1.78688+25.1216\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t] - 0.0202375 \times 2.71828^{1.78688\,t}\, e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]^2\,\text{UnitStep}[t])\}$$

In[•]:=
```
Plot[resUnit, {t, 0, tf}, GridLines → Automatic]
```

Out[•]=

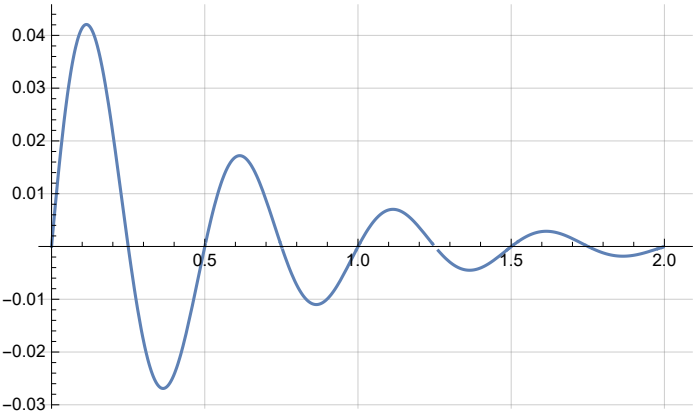


In[•]:= **velresUnit = Dt[resUnit, t]**

Out[•]=
$$\Big\{0.00406295\, e^{(-1.78688-12.5608\, i)\, t}\left(-1.\, e^{(0.+12.5608\, i)\, t}\cos[12.5608\, t]\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)+\right.$$
$$\left(8.89219\times 10^{-17}+2.22305\times 10^{-17}\, i\right) e^{1.78688\, t}\cos[12.5608\, t]\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)-$$
$$\left(8.89219\times 10^{-17}+2.22305\times 10^{-17}\, i\right) e^{(1.78688+25.1216\, i)\, t}$$
$$\cos[12.5608\, t]\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)+$$
$$1.\times 2.71828^{1.78688\, t}\, e^{(0.+12.5608\, i)\, t}\cos[12.5608\, t]^2\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)-$$
$$0.142259\, e^{(0.+12.5608\, i)\, t}\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)\sin[12.5608\, t]+$$
$$\left(3.63891\times 10^{-17}+0.510119\, i\right) e^{1.78688\, t}\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)\sin[12.5608\, t]-$$
$$\left(3.63891\times 10^{-17}+0.510119\, i\right) e^{(1.78688+25.1216\, i)\, t}\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)\sin[12.5608\, t]-$$
$$0.0202375\times 2.71828^{1.78688\, t}\, e^{(0.+12.5608\, i)\, t}\left(\begin{cases}\text{Indeterminate} & t == 0\\ 0 & \text{True}\end{cases}\right)\sin[12.5608\, t]^2-$$
$$(1.78688+12.5608\, i)\, e^{(0.+12.5608\, i)\, t}\cos[12.5608\, t]\,\text{UnitStep}[t]+$$
$$\left(6.1597\times 10^{-16}+6.4075\, i\right) e^{1.78688\, t}\cos[12.5608\, t]\,\text{UnitStep}[t]-$$
$$\left(5.75043\times 10^{-17}+6.4075\, i\right) e^{(1.78688+25.1216\, i)\, t}\cos[12.5608\, t]\,\text{UnitStep}[t]+$$
$$(1.78688+12.5608\, i)\, 2.71828^{1.78688\, t}\, e^{(0.+12.5608\, i)\, t}\cos[12.5608\, t]^2\,\text{UnitStep}[t]+$$
$$(12.5608-1.78688\, i)\, e^{(0.+12.5608\, i)\, t}\sin[12.5608\, t]\,\text{UnitStep}[t]-$$
$$\left(1.05191\times 10^{-15}-0.911523\, i\right) e^{1.78688\, t}\sin[12.5608\, t]\,\text{UnitStep}[t]+$$
$$(12.815-0.911523\, i)\, e^{(1.78688+25.1216\, i)\, t}\sin[12.5608\, t]\,\text{UnitStep}[t]-$$
$$25.63\times 2.71828^{1.78688\, t}\, e^{(0.+12.5608\, i)\, t}\cos[12.5608\, t]\sin[12.5608\, t]\,\text{UnitStep}[t]-$$
$$\left.(0.0361621+0.2542\, i)\, 2.71828^{1.78688\, t}\, e^{(0.+12.5608\, i)\, t}\sin[12.5608\, t]^2\,\text{UnitStep}[t]\right)-$$
$$(0.00726002+0.0510339\, i)\, e^{(-1.78688-12.5608\, i)\, t}\left(-1.\, e^{(0.+12.5608\, i)\, t}\cos[12.5608\, t]\,\text{UnitStep}[t]+\right.$$
$$\left(8.89219\times 10^{-17}+2.22305\times 10^{-17}\, i\right) e^{1.78688\, t}\cos[12.5608\, t]\,\text{UnitStep}[t]-$$
$$\left(8.89219\times 10^{-17}+2.22305\times 10^{-17}\, i\right) e^{(1.78688+25.1216\, i)\, t}\cos[12.5608\, t]\,\text{UnitStep}[t]+$$
$$1.\times 2.71828^{1.78688\, t}\, e^{(0.+12.5608\, i)\, t}\cos[12.5608\, t]^2\,\text{UnitStep}[t]-$$
$$0.142259\, e^{(0.+12.5608\, i)\, t}\sin[12.5608\, t]\,\text{UnitStep}[t]+$$
$$\left(3.63891\times 10^{-17}+0.510119\, i\right) e^{1.78688\, t}\sin[12.5608\, t]\,\text{UnitStep}[t]-$$
$$\left(3.63891\times 10^{-17}+0.510119\, i\right) e^{(1.78688+25.1216\, i)\, t}\sin[12.5608\, t]\,\text{UnitStep}[t]-$$
$$\left.0.0202375\times 2.71828^{1.78688\, t}\, e^{(0.+12.5608\, i)\, t}\sin[12.5608\, t]^2\,\text{UnitStep}[t]\right)\Big\}$$

In[•]:=
```
Plot[velresUnit, {t, 0, tf}, GridLines → Automatic]
```

Out[•]=



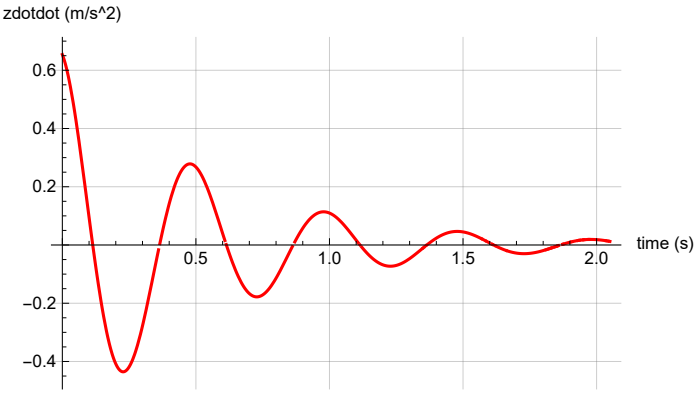
In[•]:=
```
acclresUnit = Dt[velresUnit, t]
```

Out[•]=
$$\Big\{(-0.01452-0.102068\,i)\,e^{(-1.78688-12.5608\,i)\,t}$$
$$\Big(-1.\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}+$$
$$\left(8.89219\times10^{-17}+2.22305\times10^{-17}\,i\right)e^{1.78688\,t}\,\text{Cos}[12.5608\,t]\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}-$$
$$\left(8.89219\times10^{-17}+2.22305\times10^{-17}\,i\right)e^{(1.78688+25.1216\,i)\,t}$$
$$\text{Cos}[12.5608\,t]\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}+$$
$$1.\times2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]^2\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}-$$
$$0.142259\,e^{(0.+12.5608\,i)\,t}\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}\text{Sin}[12.5608\,t]+$$
$$\left(3.63891\times10^{-17}+0.510119\,i\right)e^{1.78688\,t}\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}\text{Sin}[12.5608\,t]-$$
$$\left(3.63891\times10^{-17}+0.510119\,i\right)e^{(1.78688+25.1216\,i)\,t}\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}\text{Sin}[12.5608\,t]-$$
$$0.0202375\times2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\begin{pmatrix}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{pmatrix}\text{Sin}[12.5608\,t]^2-$$
$$(1.78688+12.5608\,i)\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$\left(6.1597\times10^{-16}+6.4075\,i\right)e^{1.78688\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$\left(5.75043\times10^{-17}+6.4075\,i\right)e^{(1.78688+25.1216\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$(1.78688+12.5608\,i)\,2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]^2\,\text{UnitStep}[t]+$$
$$(12.5608-1.78688\,i)\,e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$\left(1.05191\times10^{-15}-0.911523\,i\right)e^{1.78688\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$(12.815-0.911523\,i)\,e^{(1.78688+25.1216\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$25.63\times2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$(0.0361621+0.2542\,i)\,2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]^2\,\text{UnitStep}[t]\Big)-$$
$$(0.628054-0.182383\,i)\,e^{(-1.78688-12.5608\,i)\,t}\,\Big(-1.\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$\left(8.89219\times10^{-17}+2.22305\times10^{-17}\,i\right)e^{1.78688\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]-$$

$$\left(8.89219\times10^{-17}+2.22305\times10^{-17}\,i\right)e^{(1.78688+25.1216\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$1.\times2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]^2\,\text{UnitStep}[t]-$$
$$0.142259\,e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$\left(3.63891\times10^{-17}+0.510119\,i\right)e^{1.78688\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$\left(3.63891\times10^{-17}+0.510119\,i\right)e^{(1.78688+25.1216\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]-0.0202375\times$$
$$2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]^2\,\text{UnitStep}[t]\Big)+0.00406295\,e^{(-1.78688-12.5608\,i)\,t}$$
$$\Big((-4.57377-25.1216\,i)\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)+$$
$$\left(1.32086\times10^{-15}+12.815\,i\right)e^{1.78688\,t}\,\text{Cos}[12.5608\,t]\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)-$$
$$\left(2.03931\times10^{-16}+12.815\,i\right)e^{(1.78688+25.1216\,i)\,t}\,\text{Cos}[12.5608\,t]\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)+$$
$$(4.57377+25.1216\,i)\,2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}$$
$$\text{Cos}[12.5608\,t]^2\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)+$$
$$(24.9793-3.57377\,i)\,e^{(0.+12.5608\,i)\,t}\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)\text{Sin}[12.5608\,t]-$$
$$\left(2.06743\times10^{-15}-2.33316\,i\right)e^{1.78688\,t}\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)\text{Sin}[12.5608\,t]+$$
$$(25.63-2.33316\,i)\,e^{(1.78688+25.1216\,i)\,t}\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)\text{Sin}[12.5608\,t]-51.26\times$$
$$2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)\text{Sin}[12.5608\,t]-$$
$$(0.0925618+0.508399\,i)\,2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\left(\begin{cases}\text{Indeterminate} & t==0\\ 0 & \text{True}\end{cases}\right)$$
$$\text{Sin}[12.5608\,t]^2+(315.547-44.8894\,i)\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$\left(1.21121\times10^{-14}-22.8989\,i\right)e^{1.78688\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$(321.933-22.8989\,i)\,e^{(1.78688+25.1216\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$(476.514-44.8894\,i)\,2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]^2\,\text{UnitStep}[t]+$$
$$(44.8894+315.547\,i)\,e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]-$$
$$\left(9.61671\times10^{-15}+78.8546\,i\right)e^{1.78688\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$(45.7978+400.788\,i)\,e^{(1.78688+25.1216\,i)\,t}\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]-(91.5956+643.867\,i)$$
$$2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Cos}[12.5608\,t]\,\text{Sin}[12.5608\,t]\,\text{UnitStep}[t]+$$
$$(325.062-0.90845\,i)\,2.71828^{1.78688\,t}\,e^{(0.+12.5608\,i)\,t}\,\text{Sin}[12.5608\,t]^2\,\text{UnitStep}[t]\Big)\Big\}$$

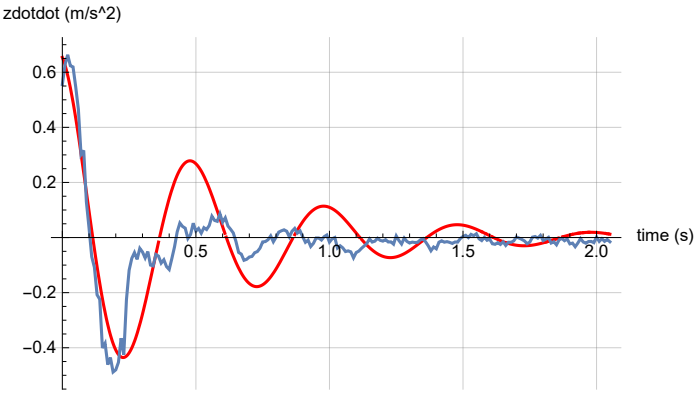
In[•]:=
```
acclResUnitPlot = Plot[acclresUnit, {t, 0, tf}, PlotRange → All,
  GridLines → Automatic, AxesLabel → {"time (s)", "zdotdot (m/s^2)" }, PlotStyle → Red]
```

Out[ ]=



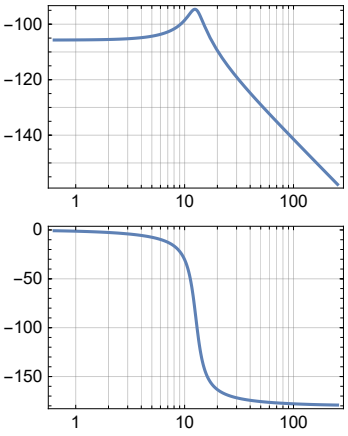
In[ ]:=
```
Show[acclResUnitPlot, zddotPlotUnit]
```

Out[ ]=



In[ ]:=
```
BodePlot[Gs, GridLines → Automatic, StabilityMarginsStyle → {Red, Green}]
```

Out[ ]=

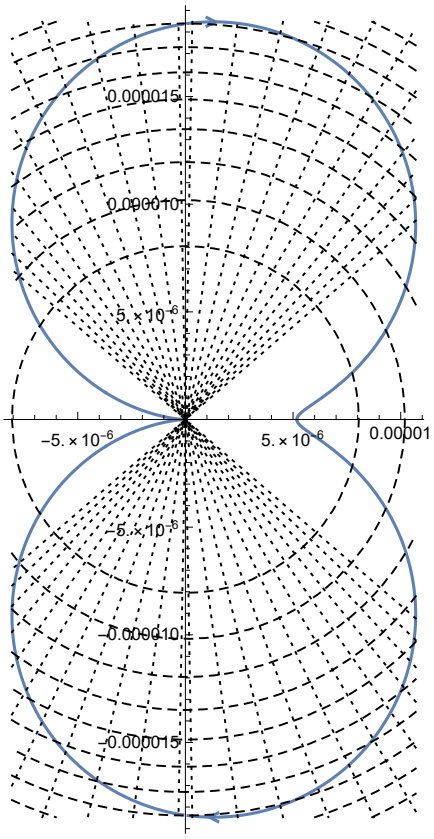


In[ ]:=
```
{gm, pm} = GainPhaseMargins[TransferFunctionModel[Gs, s]]
```

Out[ ]=
```
{{{None, ∞}}, {{None, ∞}}}
```

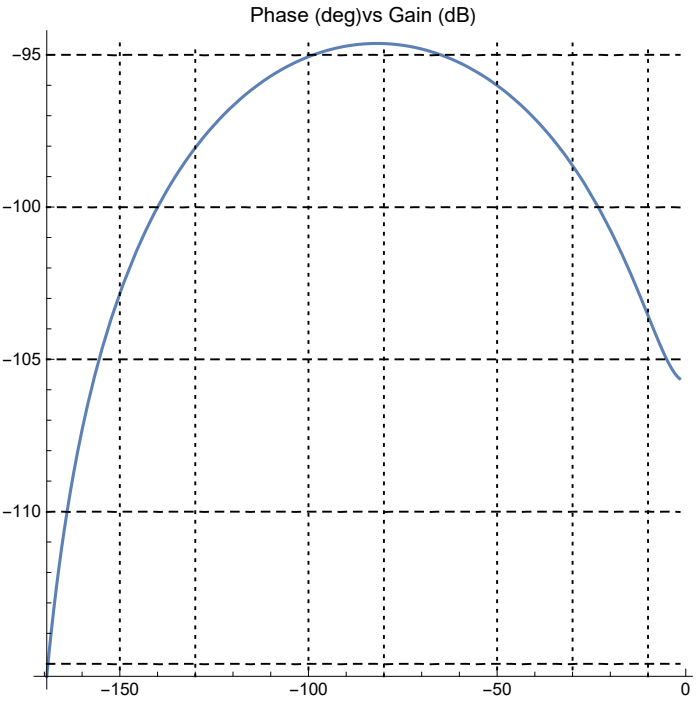
In[ ]:=
```
NyquistPlot[TransferFunctionModel[Gs, s], StabilityMargins → {gm, pm},
 StabilityMarginsStyle → {Directive[Red, Thick], Directive[Green, Thick]},
 PlotRange → All, NyquistGridLines → Automatic]
```

Out[ ]=



In[•]:=
```
NicholsPlot[TransferFunctionModel[Gs, s],
 PlotLabel → "Phase (deg)vs Gain (dB)", NicholsGridLines → Automatic, PlotRange → All]
```

Out[•]=

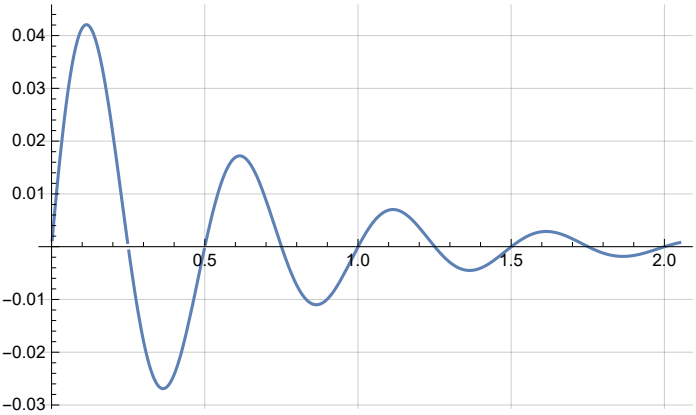


In[•]:=
```
resImpulse = OutputResponse[TransferFunctionModel[Gs, s], 80 * 9.81 DiracDelta[t], t]
```

Out[•]=
$$\left\{(0.+0.\,i)+0.000833333\,e^{-1.78688\,t}\left((0.+0.\,i)+\left(5.44564\times10^{-15}-2.17826\times10^{-14}\,i\right)\text{Cos}[12.5608\,t]\,\text{HeavisideTheta}[t]+\left(62.4801-6.00637\times10^{-15}\,i\right)\text{HeavisideTheta}[t]\,\text{Sin}[12.5608\,t]\right)\right\}$$

In[•]:=
```
Plot[resImpulse, {t, 0, tf}, GridLines → Automatic]
```

Out[•]=

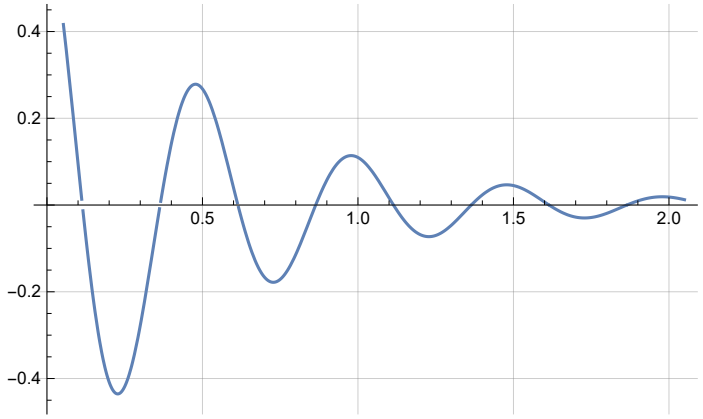


In[•]:=
```
velresImpulse = Dt[resImpulse, t]
```

Out[•]=
$$\{0.000833333\, e^{-1.78688\, t}\, \left(\left(5.44564\times 10^{-15}-2.17826\times 10^{-14}\, i\right) \text{Cos}[12.5608\, t]\, \text{DiracDelta}[t]+\left(784.8-7.54449\times 10^{-14}\, i\right) \text{Cos}[12.5608\, t]\, \text{HeavisideTheta}[t]+\left(62.4801-6.00637\times 10^{-15}\, i\right) \text{DiracDelta}[t]\, \text{Sin}[12.5608\, t]-\left(6.84017\times 10^{-14}-2.73607\times 10^{-13}\, i\right) \text{HeavisideTheta}[t]\, \text{Sin}[12.5608\, t]\right)-0.00148907\, e^{-1.78688\, t}\, \left((0.+0.\, i)+\left(5.44564\times 10^{-15}-2.17826\times 10^{-14}\, i\right) \text{Cos}[12.5608\, t]\, \text{HeavisideTheta}[t]+\left(62.4801-6.00637\times 10^{-15}\, i\right) \text{HeavisideTheta}[t]\, \text{Sin}[12.5608\, t]\right)\}$$

In[•]:=
```
Plot[velresImpulse, {t, 0, tf}, GridLines → Automatic]
```

Out[•]=



In[•]:=
```
acclresImpulse = Dt[velresImpulse, t]
```

Out[•]=
$$\{-0.00297814\, e^{-1.78688\, t}\, \left(\left(5.44564\times 10^{-15}-2.17826\times 10^{-14}\, i\right) \text{Cos}[12.5608\, t]\, \text{DiracDelta}[t]+\left(784.8-7.54449\times 10^{-14}\, i\right) \text{Cos}[12.5608\, t]\, \text{HeavisideTheta}[t]+\left(62.4801-6.00637\times 10^{-15}\, i\right) \text{DiracDelta}[t]\, \text{Sin}[12.5608\, t]-\left(6.84017\times 10^{-14}-2.73607\times 10^{-13}\, i\right) \text{HeavisideTheta}[t]\, \text{Sin}[12.5608\, t]\right)+0.00266079\, e^{-1.78688\, t}\, \left((0.+0.\, i)+\left(5.44564\times 10^{-15}-2.17826\times 10^{-14}\, i\right) \text{Cos}[12.5608\, t]\, \text{HeavisideTheta}[t]+\left(62.4801-6.00637\times 10^{-15}\, i\right) \text{HeavisideTheta}[t]\, \text{Sin}[12.5608\, t]\right)+0.000833333\, e^{-1.78688\, t}\, \left(\left(1569.6-1.5089\times 10^{-13}\, i\right) \text{Cos}[12.5608\, t]\, \text{DiracDelta}[t]-\left(8.5918\times 10^{-13}-3.43672\times 10^{-12}\, i\right) \text{Cos}[12.5608\, t]\, \text{HeavisideTheta}[t]-\left(1.36803\times 10^{-13}-5.47213\times 10^{-13}\, i\right) \text{DiracDelta}[t]\, \text{Sin}[12.5608\, t]-\left(9857.72-9.47648\times 10^{-13}\, i\right) \text{HeavisideTheta}[t]\, \text{Sin}[12.5608\, t]+\left(5.44564\times 10^{-15}-2.17826\times 10^{-14}\, i\right) \text{Cos}[12.5608\, t]\, \text{DiracDelta}'[t]+\left(62.4801-6.00637\times 10^{-15}\, i\right) \text{Sin}[12.5608\, t]\, \text{DiracDelta}'[t]\right)\}$$

In[•]:= **Plot[acclresImpulse, {t, 0, tf}, GridLines → Automatic]**

Out[•]=