```
> restart
> Sistema := diff(Vc(t), t) = -10·Vc(t) - 10·II(t) + 120·cos(120·Pi·t), diff(II(t), t) = 1/10
      ·Vc(t) - 3/10·II(t) : Sistema[1]; Sistema[2]
```

$$\frac{d}{dt} Vc(t) = -10\, Vc(t) - 10\, II(t) + 120 \cos(120\, \pi\, t)$$

$$\frac{d}{dt} II(t) = \frac{1}{10} Vc(t) - \frac{3}{10} II(t) \tag{1}$$

```
> AA := array([[-10, -10], [1/10, -3/10]])
```

$$AA := \begin{bmatrix} -10 & -10 \\ \frac{1}{10} & -\frac{3}{10} \end{bmatrix} \tag{2}$$

```
> Xcero := array([0, 0])
```

$$Xcero := \begin{bmatrix} 0 & 0 \end{bmatrix} \tag{3}$$

```
> BB := array([120·cos(120·Pi·t), 0])
```

$$BB := \begin{bmatrix} 120 \cos(120\, \pi\, t) & 0 \end{bmatrix} \tag{4}$$

```
> with(linalg) :
> MatExp := exponential(AA, t) : evalf(%, 2)
```

$$\begin{bmatrix} 1.0\, e^{-10.\, t} - 0.01\, e^{-0.20\, t} & 1.1\, e^{-10.\, t} - 1.1\, e^{-0.20\, t} \\ -0.011\, e^{-10.\, t} + 0.011\, e^{-0.20\, t} & -0.01\, e^{-10.\, t} + 1.0\, e^{-0.20\, t} \end{bmatrix} \tag{5}$$

```
> SolHom := evalm(MatExp &* Xcero)
```

$$SolHom := \begin{bmatrix} 0 & 0 \end{bmatrix} \tag{6}$$

```
> MatExpTau := map(rcurry(eval, t = t - tau), MatExp) : evalf(%, 2)
```

$$\begin{bmatrix} 1.0\, e^{-10.\, t + 10.\, \tau} - 0.01\, e^{-0.20\, t + 0.20\, \tau} & 1.1\, e^{-10.\, t + 10.\, \tau} - 1.1\, e^{-0.20\, t + 0.20\, \tau} \\ -0.011\, e^{-10.\, t + 10.\, \tau} + 0.011\, e^{-0.20\, t + 0.20\, \tau} & -0.01\, e^{-10.\, t + 10.\, \tau} + 1.0\, e^{-0.20\, t + 0.20\, \tau} \end{bmatrix} \tag{7}$$

```
> BBtau := map(rcurry(eval, t = tau), BB)
```

$$BBtau := \begin{bmatrix} 120 \cos(120\, \pi\, \tau) & 0 \end{bmatrix} \tag{8}$$

```
> ProdTau := evalm(MatExpTau &* BBtau) : evalf(%, 2)
```

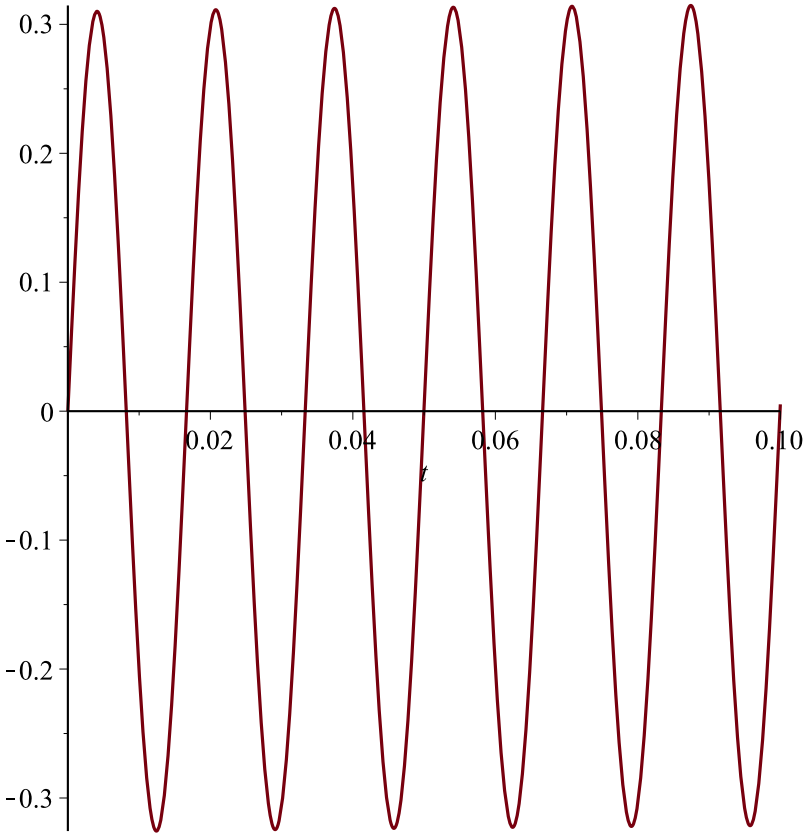
$$\left[120.\, \left(1.0\, e^{-10.\, t + 10.\, \tau} - 0.01\, e^{-0.20\, t + 0.20\, \tau}\right) \cos(370.\, \tau),\ 120.\, \left(-0.011\, e^{-10.\, t + 10.\, \tau} + 0.011\, e^{-0.20\, t + 0.20\, \tau}\right) \cos(370.\, \tau)\right] \tag{9}$$

```
> SolNoHom := map(int, ProdTau, tau = 0..t) : Vc(t) = evalf(SolNoHom[1], 2); II(t)
      = evalf(SolNoHom[2], 2)
```

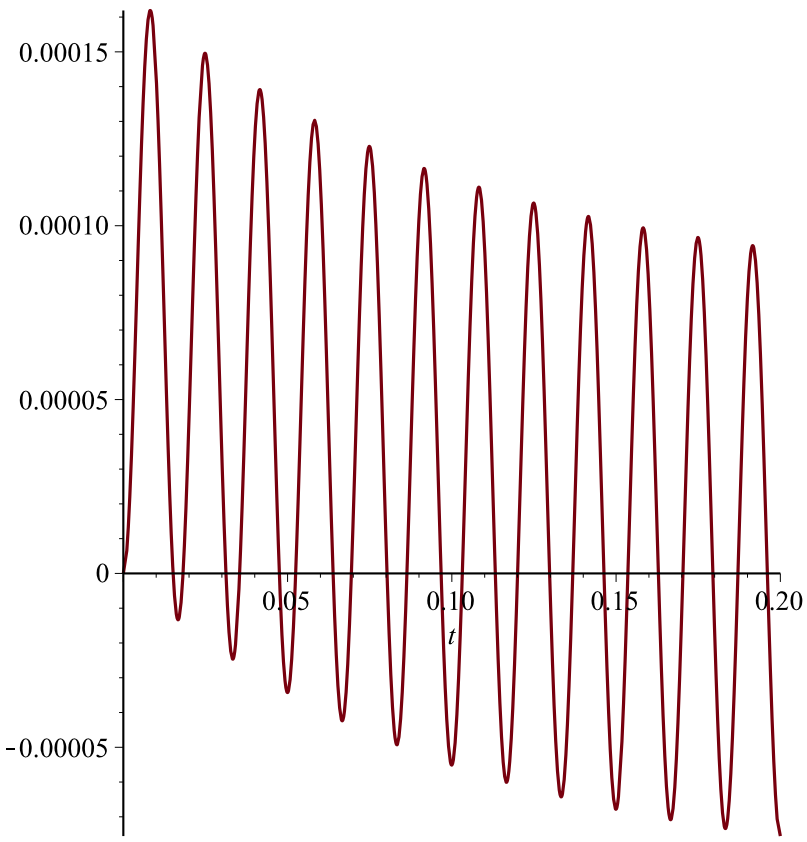
$$Vc(t) = -0.0090\, e^{-10.\, t} + 0.32 \sin(370.\, t) + 0.0085 \cos(370.\, t)$$

$$II(t) = 0.000090\, e^{-10.\, t} - 0.000085 \cos(370.\, t) + 0.0000024 \sin(370.\, t) \tag{10}$$

```
> plot(SolNoHom[1], t = 0..0.1)
```



> $plot(SolNoHom[2], t = 0..0.2)$



> *restart*

> $Sist := diff(x[1](t), t) = v[1](t), diff(x[2](t), t) = v[2](t), diff(v[1](t), t) = \frac{(-k[1]-k[2])}{M[1]} \cdot x[1](t) + \frac{k[2]}{M[1]} \cdot x[2](t), diff(v[2](t), t) = \frac{k[2]}{M[2]} \cdot x[1](t) - \frac{k[2]}{M[2]} \cdot x[2](t) : Sist[1]; Sist[2]; Sist[3]; Sist[4]$

$$\frac{d}{dt} x_1(t) = v_1(t)$$

$$\frac{d}{dt} x_2(t) = v_2(t)$$

$$\frac{d}{dt} v_1(t) = \frac{(-k_1 - k_2)\, x_1(t)}{M_1} + \frac{k_2\, x_2(t)}{M_1}$$

$$\frac{d}{dt} v_2(t) = \frac{k_2\, x_1(t)}{M_2} - \frac{k_2\, x_2(t)}{M_2} \quad \textbf{(11)}$$

> $Xcero := array\left(\left[\frac{1}{10}, \frac{1}{10}, 0, 0\right]\right)$

(12)

$$Xcero := \begin{bmatrix} \frac{1}{10} & \frac{1}{10} & 0 & 0 \end{bmatrix} \quad (12)$$

> $k[1] := 4; k[2] := 2; M[1] := 1; M[2] := 1;$

$$k_1 := 4$$
$$k_2 := 2$$
$$M_1 := 1$$
$$M_2 := 1 \quad (13)$$

> $with(linalg)$:

> $AA := array\left(\left[[0, 0, 1, 0], [0, 0, 0, 1], \left[\frac{(-k[1]-k[2])}{M[1]}, \frac{k[2]}{M[1]}, 0, 0\right], \left[\frac{k[2]}{M[2]}, -\frac{k[2]}{M[2]}, 0, 0\right]\right]\right)$

$$AA := \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -6 & 2 & 0 & 0 \\ 2 & -2 & 0 & 0 \end{bmatrix} \quad (14)$$

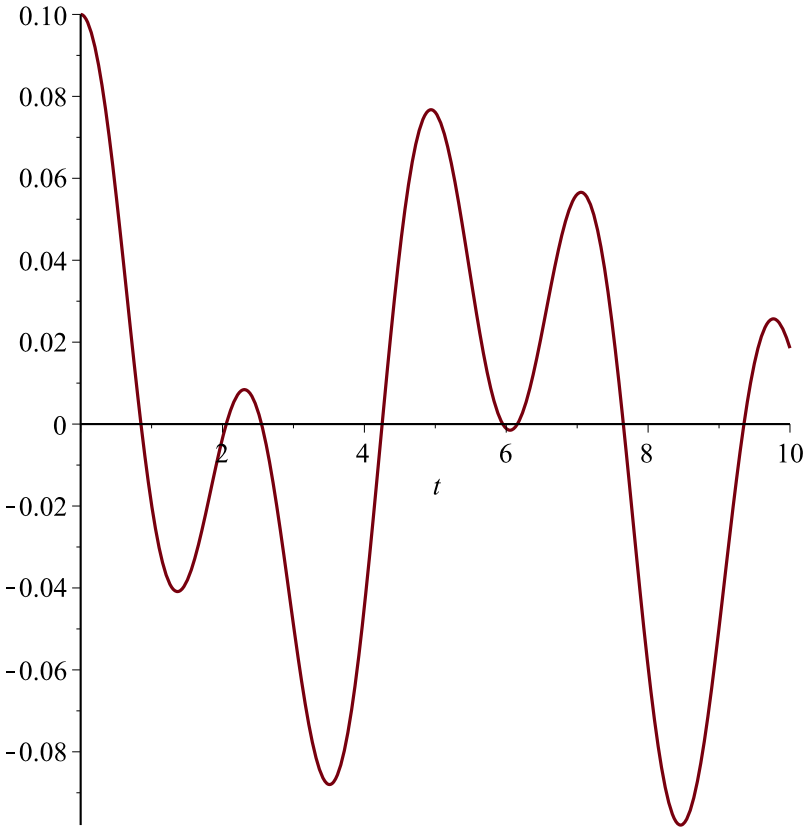
> $MatExp := exponential(AA, t) : evalf(MatExp[1, 1], 2)$

$$0.15\cos(1.1\,t) + 0.88\cos(2.6\,t) + 0.017\,I\sin(1.1\,t) \quad (15)$$

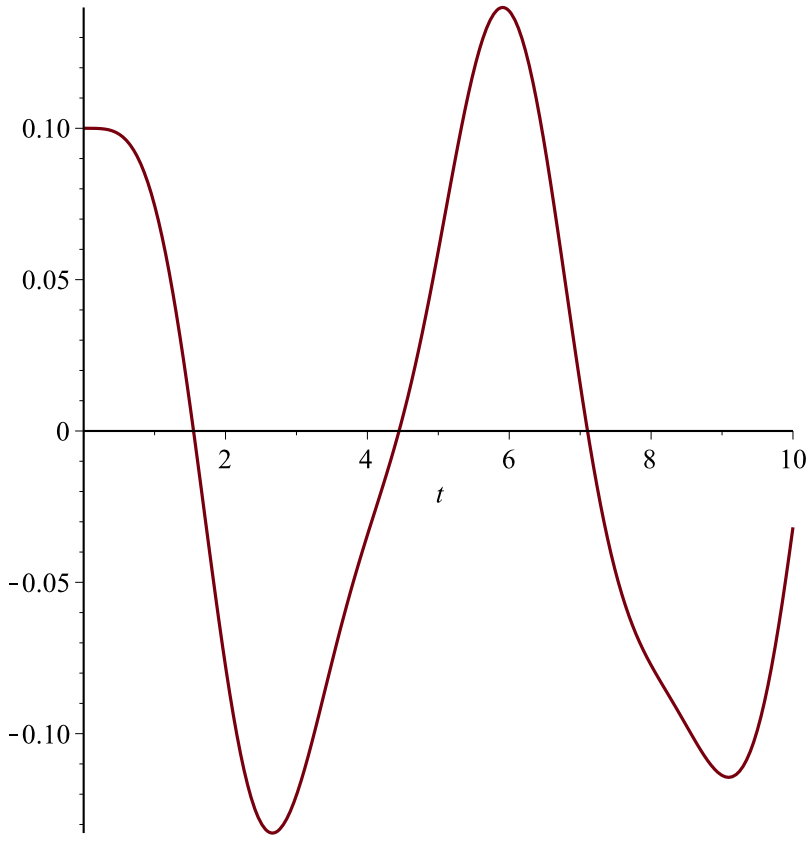
> $SolPart := evalm(MatExp \&* Xcero) : x[1](t) = evalf(SolPart[1], 2); x[2](t) = evalf(SolPart[2], 2)$

$$x_1(t) = 0.051\cos(1.1\,t) + 0.052\cos(2.6\,t) + 0.0017\,I\sin(1.1\,t)$$
$$x_2(t) = 0.13\cos(1.1\,t) - 0.022\cos(2.6\,t) + 0.0017\,I\sin(1.1\,t) \quad (16)$$

> $plot(SolPart[1], t = 0..10)$



> $plot(SolPart[2], t = 0..10)$



> *restart*

> $Sist := diff(x[1](t), t) = v[1](t), diff(x[2](t), t) = v[2](t), diff(v[1](t), t) = \frac{(-k[1]-k[2])}{M[1]} \cdot x[1](t) + \frac{k[2]}{M[1]} \cdot x[2](t), diff(v[2](t), t) = \frac{k[2]}{M[2]} \cdot x[1](t) - \frac{k[2]}{M[2]} \cdot x[2](t) : Sist[1]; Sist[2]; Sist[3]; Sist[4]$

$$\frac{d}{dt} x_1(t) = v_1(t)$$

$$\frac{d}{dt} x_2(t) = v_2(t)$$

$$\frac{d}{dt} v_1(t) = \frac{(-k_1 - k_2)\, x_1(t)}{M_1} + \frac{k_2\, x_2(t)}{M_1}$$

$$\frac{d}{dt} v_2(t) = \frac{k_2\, x_1(t)}{M_2} - \frac{k_2\, x_2(t)}{M_2} \quad \textbf{(17)}$$

> $Xcero := array\left(\left[\frac{1}{10}, \frac{1}{10}, 0, 0\right]\right)$

(18)

$$Xcero := \begin{bmatrix} \frac{1}{10} & \frac{1}{10} & 0 & 0 \end{bmatrix} \quad (18)$$

> $k[1] := 2; k[2] := 4; M[1] := 1; M[2] := 1;$

$$k_1 := 2$$
$$k_2 := 4$$
$$M_1 := 1$$
$$M_2 := 1 \quad (19)$$

> $with(linalg) :$

> $AA := array\left(\left[[0, 0, 1, 0], [0, 0, 0, 1], \left[\frac{(-k[1]-k[2])}{M[1]}, \frac{k[2]}{M[1]}, 0, 0\right], \left[\frac{k[2]}{M[2]}, -\frac{k[2]}{M[2]}, 0, 0\right]\right]\right)$

$$AA := \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -6 & 4 & 0 & 0 \\ 4 & -4 & 0 & 0 \end{bmatrix} \quad (20)$$

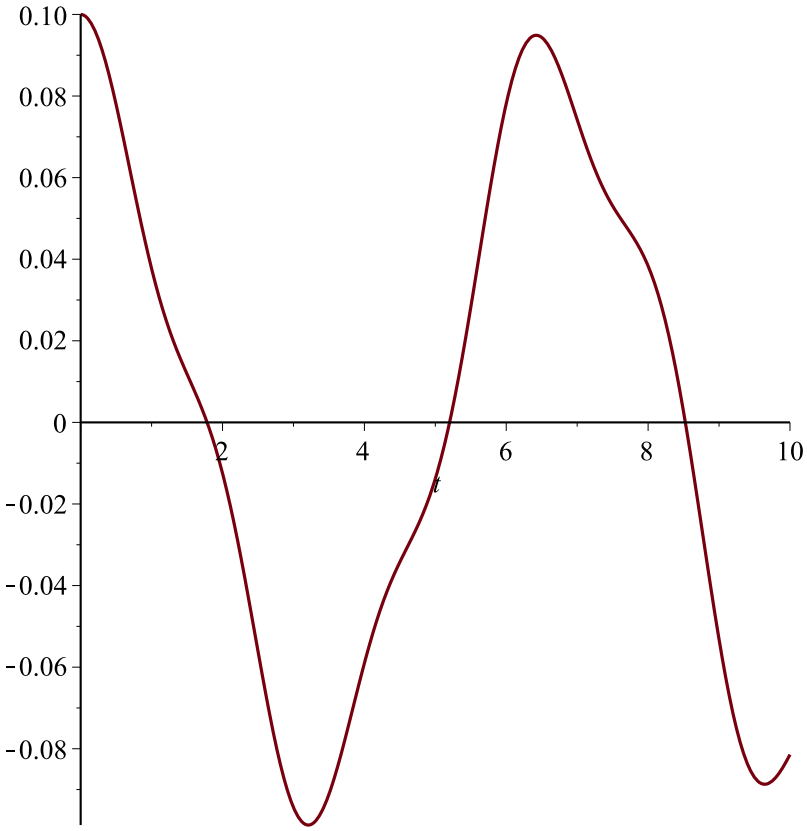
> $MatExp := exponential(AA, t) : evalf(MatExp[1, 1], 2)$

$$0.41\cos(0.95\,t) + 0.61\cos(3.0\,t) \quad (21)$$

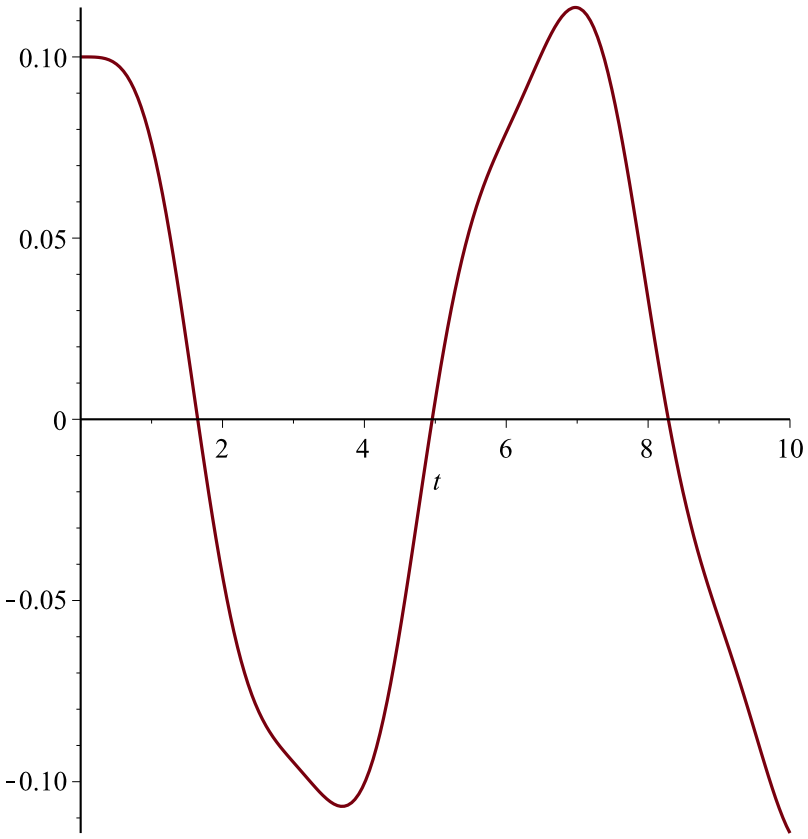
> $SolPart := evalm(MatExp \&* Xcero) : x[1](t) = evalf(SolPart[1], 2); x[2](t) = evalf(SolPart[2], 2)$

$$x_1(t) = 0.089\cos(0.95\,t) + 0.013\cos(3.0\,t)$$
$$x_2(t) = 0.11\cos(0.95\,t) - 0.011\cos(3.0\,t) \quad (22)$$

> $plot(SolPart[1], t = 0..10)$



> $plot(SolPart[2], t = 0..10)$



> *restart*

> $Sist := diff(x[1](t), t) = v[1](t), diff(x[2](t), t) = v[2](t), diff(v[1](t), t) = \frac{(-k[1]-k[2])}{M[1]} \cdot x[1](t) + \frac{k[2]}{M[1]} \cdot x[2](t), diff(v[2](t), t) = \frac{k[2]}{M[2]} \cdot x[1](t) - \frac{k[2]}{M[2]} \cdot x[2](t) : Sist[1]; Sist[2]; Sist[3]; Sist[4]$

$$\frac{d}{dt} x_1(t) = v_1(t)$$

$$\frac{d}{dt} x_2(t) = v_2(t)$$

$$\frac{d}{dt} v_1(t) = \frac{(-k_1 - k_2)\, x_1(t)}{M_1} + \frac{k_2\, x_2(t)}{M_1}$$

$$\frac{d}{dt} v_2(t) = \frac{k_2\, x_1(t)}{M_2} - \frac{k_2\, x_2(t)}{M_2} \quad \textbf{(23)}$$

> $Xcero := array\left(\left[\frac{1}{10}, \frac{1}{10}, 0, 0\right]\right)$

(24)

$$Xcero := \begin{bmatrix} \frac{1}{10} & \frac{1}{10} & 0 & 0 \end{bmatrix} \quad (24)$$

> $k[1] := 4; k[2] := 2; M[1] := 1; M[2] := 2;$

$$k_1 := 4$$
$$k_2 := 2$$
$$M_1 := 1$$
$$M_2 := 2 \quad (25)$$

> $with(linalg) :$

> $AA := array\left(\left[[0, 0, 1, 0], [0, 0, 0, 1], \left[\frac{(-k[1]-k[2])}{M[1]}, \frac{k[2]}{M[1]}, 0, 0\right], \left[\frac{k[2]}{M[2]}, -\frac{k[2]}{M[2]}, 0, 0\right]\right]\right)$

$$AA := \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -6 & 2 & 0 & 0 \\ 1 & -1 & 0 & 0 \end{bmatrix} \quad (26)$$

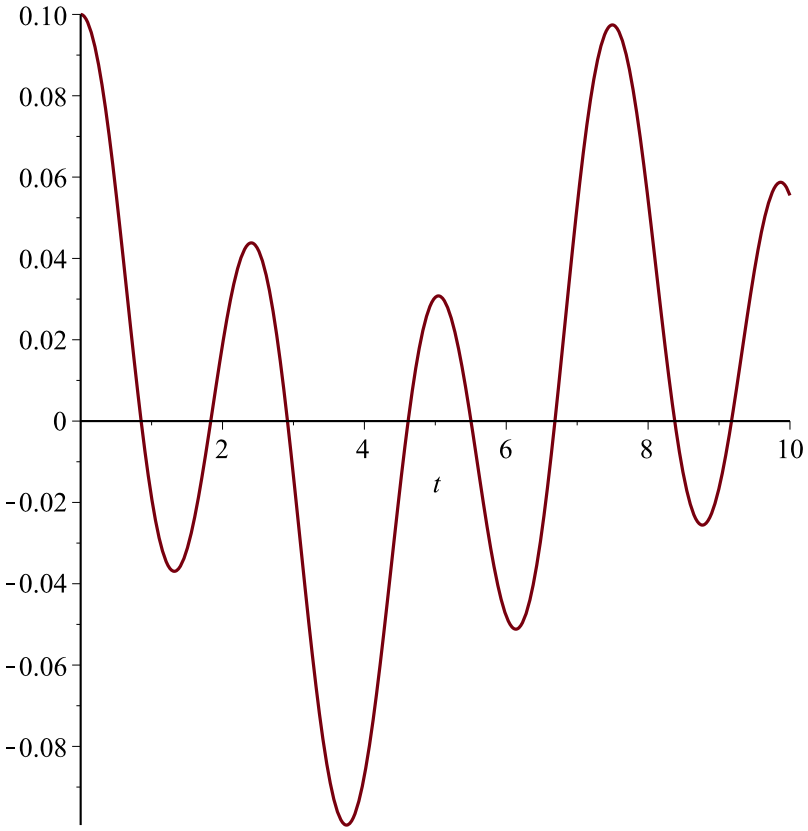
> $MatExp := exponential(AA, t) : evalf(MatExp[1, 1], 2)$

$$0.072 \cos(-0.75\, t) + 0.89 \cos(2.4\, t) \quad (27)$$

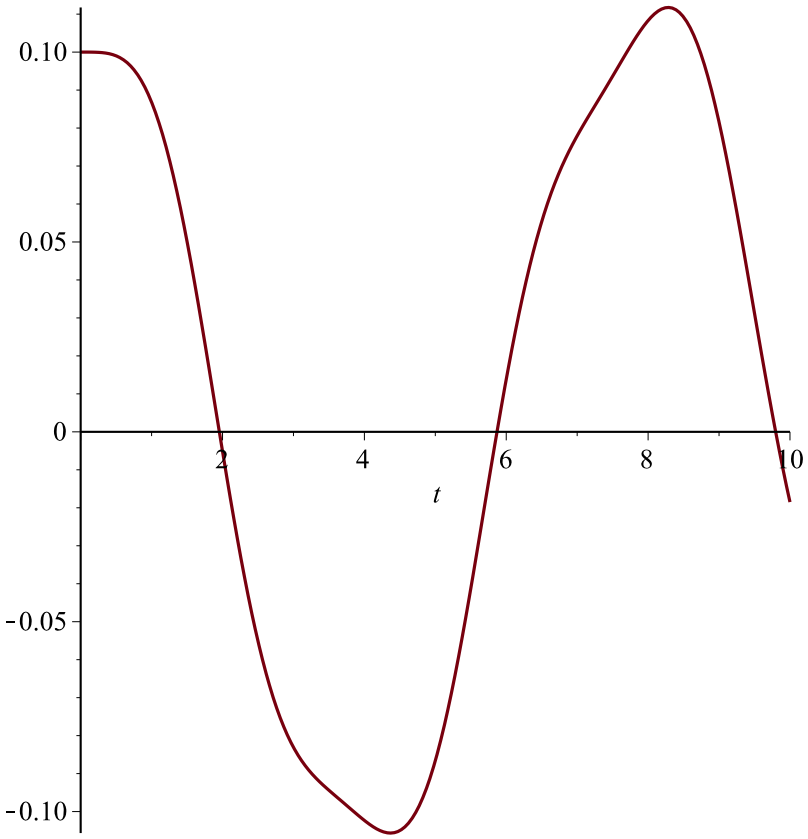
> $SolPart := evalm(MatExp \,\&*\, Xcero) : x[1](t) = evalf(SolPart[1], 2); x[2](t) = evalf(SolPart[2], 2)$

$$x_1(t) = 0.041 \cos(-0.75\, t) + 0.055 \cos(2.4\, t)$$
$$x_2(t) = 0.11 \cos(-0.75\, t) - 0.0098 \cos(2.4\, t) \quad (28)$$

> $plot(SolPart[1], t = 0..10)$



> $plot(SolPart[2], t = 0..10)$



> *restart*

> $Sist := diff(x[1](t), t) = v[1](t), diff(x[2](t), t) = v[2](t), diff(v[1](t), t) = \frac{(-k[1]-k[2])}{M[1]} \cdot x[1](t) + \frac{k[2]}{M[1]} \cdot x[2](t), diff(v[2](t), t) = \frac{k[2]}{M[2]} \cdot x[1](t) - \frac{k[2]}{M[2]} \cdot x[2](t) : Sist[1]; Sist[2]; Sist[3]; Sist[4]$

$$\frac{d}{dt} x_1(t) = v_1(t)$$

$$\frac{d}{dt} x_2(t) = v_2(t)$$

$$\frac{d}{dt} v_1(t) = \frac{(-k_1 - k_2)\, x_1(t)}{M_1} + \frac{k_2\, x_2(t)}{M_1}$$

$$\frac{d}{dt} v_2(t) = \frac{k_2\, x_1(t)}{M_2} - \frac{k_2\, x_2(t)}{M_2} \quad \textbf{(29)}$$

> $Xcero := array\left(\left[\frac{1}{10}, \frac{1}{10}, 0, 0\right]\right)$

(30)

$$Xcero := \begin{bmatrix} \frac{1}{10} & \frac{1}{10} & 0 & 0 \end{bmatrix} \quad (30)$$

> $k[1] := 4; k[2] := 2; M[1] := 2; M[2] := 1;$

$$k_1 := 4$$
$$k_2 := 2$$
$$M_1 := 2$$
$$M_2 := 1 \quad (31)$$

> $with(linalg) :$

> $AA := array\left(\left[[0, 0, 1, 0], [0, 0, 0, 1], \left[\frac{(-k[1]-k[2])}{M[1]}, \frac{k[2]}{M[1]}, 0, 0\right], \left[\frac{k[2]}{M[2]}, -\frac{k[2]}{M[2]}, 0, 0\right]\right]\right)$

$$AA := \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -3 & 1 & 0 & 0 \\ 2 & -2 & 0 & 0 \end{bmatrix} \quad (32)$$

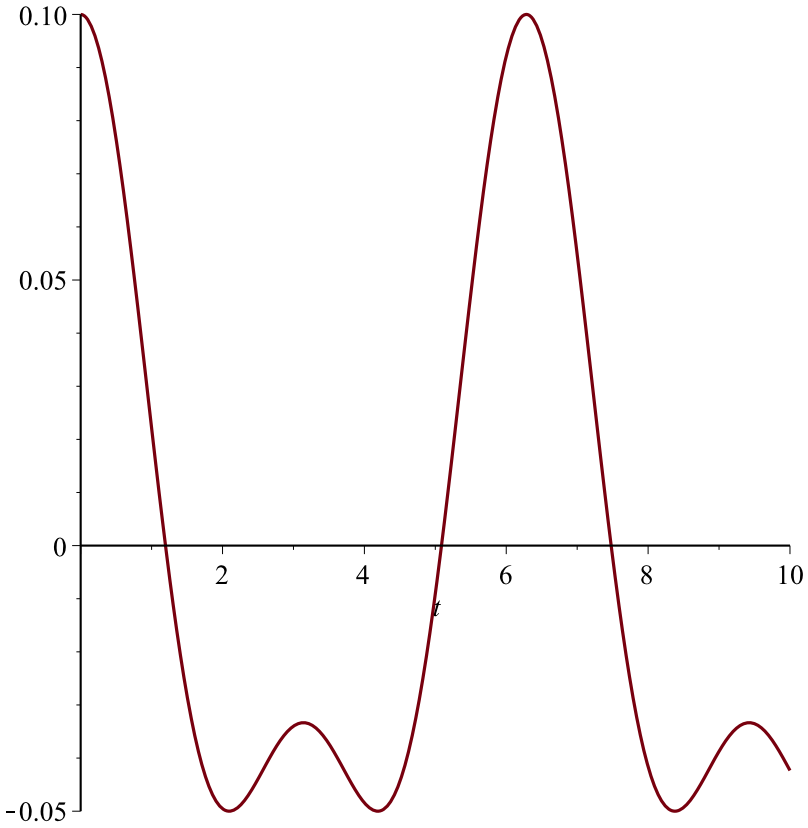
> $MatExp := exponential(AA, t) : evalf(MatExp[1, 1], 2)$

$$0.33\cos(t) + 0.67\cos(2.\,t) \quad (33)$$

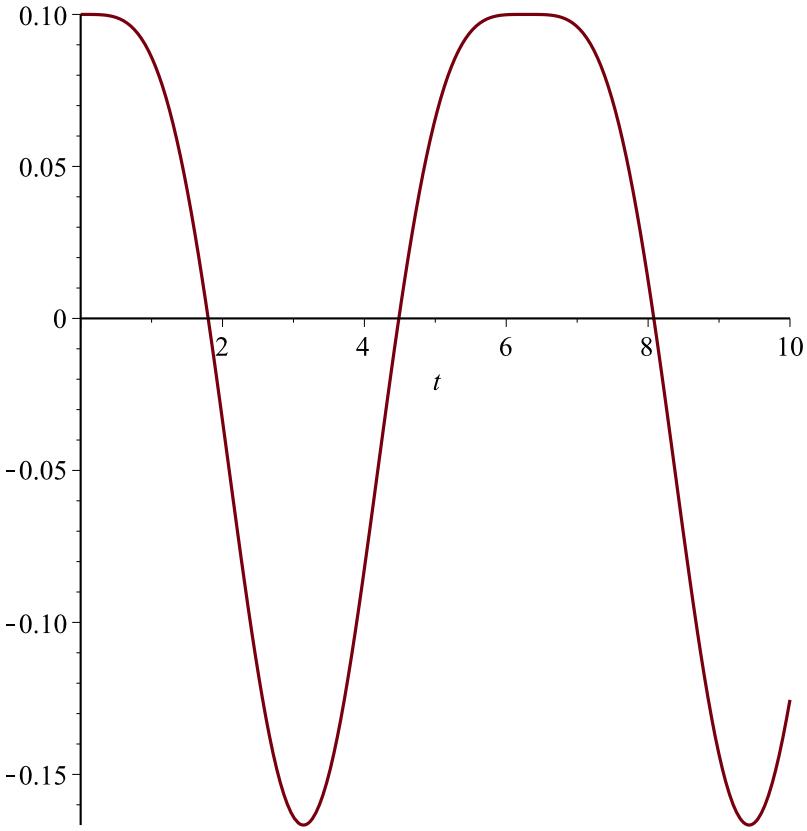
> $SolPart := evalm(MatExp \&* Xcero) : x[1](t) = evalf(SolPart[1], 2); x[2](t) = evalf(SolPart[2], 2)$

$$x_1(t) = 0.067\cos(t) + 0.033\cos(2.\,t)$$
$$x_2(t) = 0.13\cos(t) - 0.033\cos(2.\,t) \quad (34)$$

> $plot(SolPart[1], t = 0..10)$



> $plot(SolPart[2], t = 0..10)$




```
> restart
> Sist := diff(x[1](t), t) = v[1](t), diff(x[2](t), t) = v[2](t), diff(v[1](t), t)
      = (-k[1] - k[2])/M[1] ·x[1](t) + k[2]/M[1] ·x[2](t), diff(v[2](t), t) = k[2]/M[2] ·x[1](t)
      - k[2]/M[2] ·x[2](t) : Sist[1]; Sist[2]; Sist[3]; Sist[4]
```

$$\frac{d}{dt}\,x_1(t) = v_1(t)$$

$$\frac{d}{dt}\,x_2(t) = v_2(t)$$

$$\frac{d}{dt}\,v_1(t) = \frac{\left(-k_1 - k_2\right)x_1(t)}{M_1} + \frac{k_2\,x_2(t)}{M_1}$$

$$\frac{d}{dt}\,v_2(t) = \frac{k_2\,x_1(t)}{M_2} - \frac{k_2\,x_2(t)}{M_2} \qquad \textbf{(35)}$$

```
> Xcero := array([1/10, 1/10, 0, 0])
```

(36)

$$Xcero := \begin{bmatrix} \frac{1}{10} & \frac{1}{10} & 0 & 0 \end{bmatrix} \quad (36)$$

> $k[1] := 4; k[2] := 2; M[1] := 1; M[2] := 1;$

$$k_1 := 4$$
$$k_2 := 2$$
$$M_1 := 1$$
$$M_2 := 1 \quad (37)$$

> $with(linalg) :$

> $AA := array\left(\left[[0, 0, 1, 0], [0, 0, 0, 1], \left[\frac{(-k[1]-k[2])}{M[1]}, \frac{k[2]}{M[1]}, 0, 0\right], \left[\frac{k[2]}{M[2]}, -\frac{k[2]}{M[2]}, 0, 0\right]\right]\right)$

$$AA := \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -6 & 2 & 0 & 0 \\ 2 & -2 & 0 & 0 \end{bmatrix} \quad (38)$$

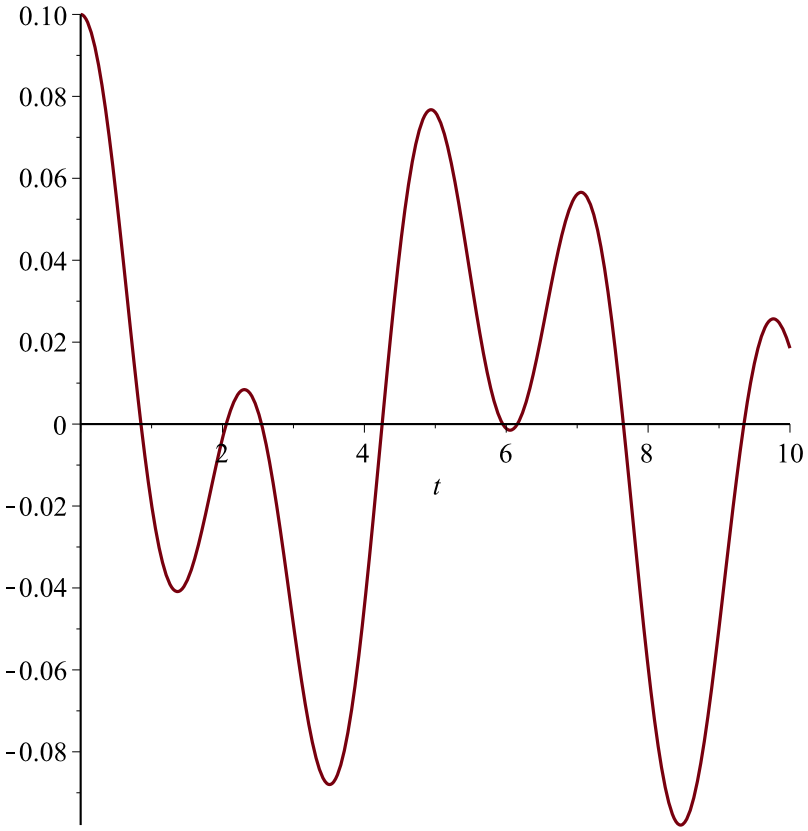
> $MatExp := exponential(AA, t) : evalf(MatExp[1, 1], 2)$

$$0.15 \cos(1.1\, t) + 0.88 \cos(2.6\, t) + 0.017\, I \sin(1.1\, t) \quad (39)$$

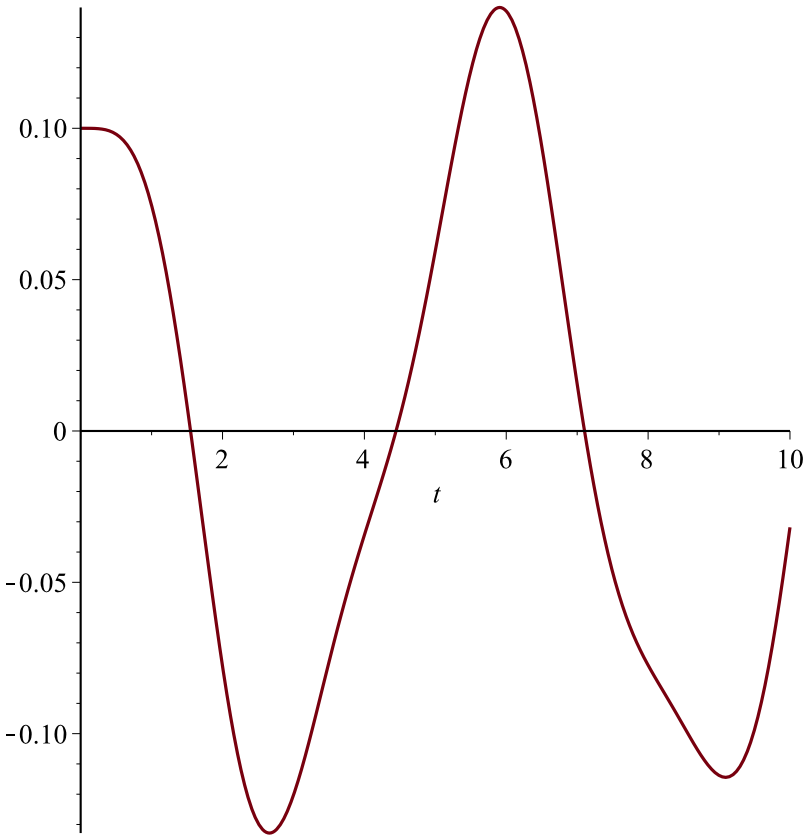
> $SolPart := evalm(MatExp \&* Xcero) : x[1](t) = evalf(SolPart[1], 2); x[2](t) = evalf(SolPart[2], 2)$

$$x_1(t) = 0.051 \cos(1.1\, t) + 0.052 \cos(2.6\, t) + 0.0017\, I \sin(1.1\, t)$$
$$x_2(t) = 0.13 \cos(1.1\, t) - 0.022 \cos(2.6\, t) + 0.0017\, I \sin(1.1\, t) \quad (40)$$

> $plot(SolPart[1], t = 0..10)$



> $plot(SolPart[2], t = 0..10)$


0.10
0.05
0
-0.05
-0.10
2
4
6
8
10
t