In[1]:=

```
(* Report And Work Data Generation GLOBALS *)
repFile = "/Users/gediz/Desktop/Report.pdf";
datFile = "/Users/gediz/Desktop/Data.dat";
LogOut = ConstantArray[0, 100];
outCnt = 1;
TraditionallyFormattedOutput[x_, str_] :=
  (LogOut[[outCnt]] = Text[TraditionalForm[{str, x // MatrixForm} // MatrixForm]];
   outCnt++; LogOut[[outCnt - 1]]);
TFO = TraditionallyFormattedOutput;

TFO[
 "Mathematica Built-in Function Test using a problem which has a known solution
   - Meireovitch // Fundementals of Vibration
   //Two Degree Of Freedom Systems//Example 5.2//Page 221", "CONTENT"]
```

TFO[

Example 5.2. Consider the simplified model of an automobile shown in Fig. 5.5, let the parameters have the values $m = 1,500$ kg, $I_C = 2,000$ kg m^2, $k_1 = 36,000$ kg/m, $k_2 = 40,000$ kg/m, $a = 1.3$ m and $b = 1.7$ m, calculate the natural modes of the system and write an expression for the response.

, "Question"]

TFO[

$$\begin{bmatrix} 1,500 & 0 \\ 0 & 2,000 \end{bmatrix} \begin{bmatrix} \ddot{x} \\ \ddot{\theta} \end{bmatrix} + \begin{bmatrix} 76,000 & 21,200 \\ 21,200 & 176,440 \end{bmatrix} \begin{bmatrix} x \\ \theta \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \qquad \text{(a)}$$

But, free vibration is harmonic, so that by analogy with Eqs. (5.23) and (5.31) we can write

$$x(t) = X\cos(\omega t - \phi),\ \theta(t) = \Theta\cos(\omega t - \phi) \qquad \text{(b)}$$

,

 "Equations Of Motion in Matrix Form"]

TFO[

$$\mathbf{x}(t) = C_1 \cos(6.857811t - \phi_1)\begin{bmatrix} 1 \\ -0.257341 \end{bmatrix}$$

$$+ C_2 \cos(9.584211t - \phi_2)\begin{bmatrix} 1 \\ 2.914417 \end{bmatrix} \qquad \text{(l)}$$

where the amplitudes C_1, C_2 and the phase angles ϕ_1, ϕ_2 must be determined from the initial displacements $x(0)$, $\theta(0)$ and the initial velocities $\dot{x}(0)$, $\dot{\theta}(0)$, as will be shown in Sec. 5.4.

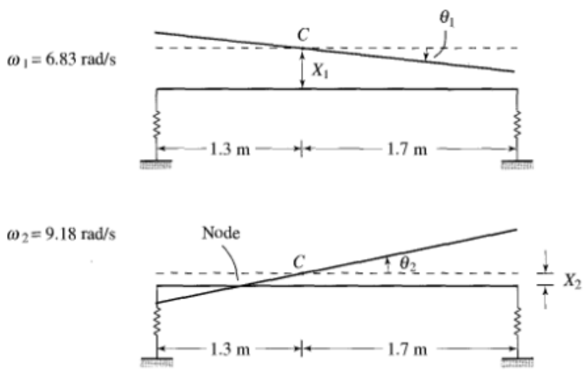

FIGURE 5.8
Natural modes for the automobile model of Fig. 5.5

, "Results"]

```
M = N[{{1500, 0}, {0, 2000}}];
K = N[{{76 000, 21 200}, {21 200, 176 440}}];

TFO[M, "Mass Matrix"]
TFO[K, "Stifness Matrix"]

eigsys = Eigensystem[{K, M}];
"EigSys Transpose ve Reverse veriyor yani dogal frekanslari sirali vermiyor ve
  ozvektorleri de transpose sekilde veriyor !"
eigs = Reverse[eigsys[[1]]];
eigvecs = Transpose[Reverse[eigsys[[2]]]];
Ωm = Table[ωi = Sqrt[eigs[[i]]], {i, 1, 2}];
Um = eigvecs;

TFO[Ωm, "EigenFrequencies"]
TFO[Um, "EigenVectors"]
```

Out[7]=

CONTENT

Mathematica Built−in Function Test using a problem which has a known solution
− Meireovitch // Fundementals of Vibration //Two Degree Of Freedom Systems//Example 5.2//Page 221

Out[8]=

Question

Example 5.2. Consider the simplified model of an automobile shown in Fig. 5.5, let the parameters have the values $m = 1,500$ kg, $I_C = 2,000$ kg m^2, $k_1 = 36,000$ kg/m, $k_2 = 40,000$ kg/m, $a = 1.3$ m and $b = 1.7$ m, calculate the natural modes of the system and write an expression for the response.

Out[9]=

Equations Of Motion in Matrix Form

$$\begin{bmatrix} 1,500 & 0 \\ 0 & 2,000 \end{bmatrix} \begin{bmatrix} \ddot{x} \\ \ddot{\theta} \end{bmatrix} + \begin{bmatrix} 76,000 & 21,200 \\ 21,200 & 176,440 \end{bmatrix} \begin{bmatrix} x \\ \theta \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \qquad \text{(a)}$$

But, free vibration is harmonic, so that by analogy with Eqs. (5.23) and (5.31) we can write

$$x(t) = X\cos(\omega t - \phi), \; \theta(t) = \Theta\cos(\omega t - \phi) \qquad \text{(b)}$$

Out[10]=

Results

$$\mathbf{x}(t) = C_1\cos(6.857811t - \phi_1)\begin{bmatrix} 1 \\ -0.257341 \end{bmatrix}$$

$$+ C_2\cos(9.584211t - \phi_2)\begin{bmatrix} 1 \\ 2.914417 \end{bmatrix} \qquad \text{(l)}$$

where the amplitudes C_1, C_2 and the phase angles ϕ_1, ϕ_2 must be determined from the initial displacements $x(0)$, $\theta(0)$ and the initial velocities $\dot{x}(0)$, $\dot{\theta}(0)$, as will be shown in Sec. 5.4.

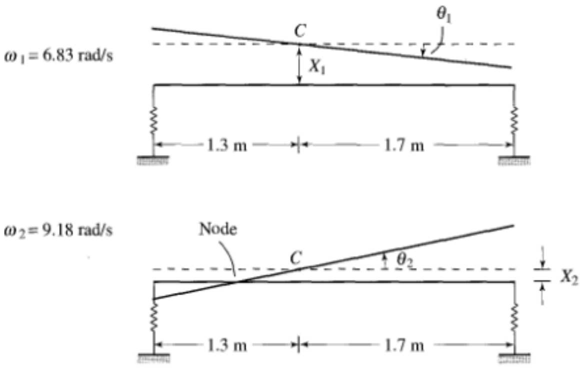

FIGURE 5.8
Natural modes for the automobile model of Fig. 5.5

Out[13]=

Mass Matrix

$$\begin{pmatrix} 1500. & 0. \\ 0. & 2000. \end{pmatrix}$$

Out[14]=

Stifness Matrix

$$\begin{pmatrix} 76\,000. & 21\,200. \\ 21\,200. & 176\,440. \end{pmatrix}$$

Out[16]=

```
EigSys Transpose ve Reverse veriyor yani dogal frekanslari
  sirali vermiyor ve ozvektorleri de transpose sekilde veriyor !
```

Out[21]=

EigenFrequencies

$$\begin{pmatrix} 6.85781 \\ 9.58421 \end{pmatrix}$$

Out[22]=

EigenVectors

$$\begin{pmatrix} -0.968447 & 0.324548 \\ 0.249221 & 0.945869 \end{pmatrix}$$

In[23]:=

```
(* Ortogonalite Degerlendirmesi *)
Ur = Um[[1 ;; 2, 1]];
Us = Um[[1 ;; 2, 2]];
Ur.K.Us;
TFO[Ur.K.Us, "Checking Orthogonality"]
```

Out[26]=

$$\begin{pmatrix} \text{Checking Orthogonality} \\ 3.63798\times10^{-12} \end{pmatrix}$$

In[27]:=

```
(* Kutle Normalizasyon *)
Ur2 = Ur / Sqrt[Ur.M.Ur];
Ur2.M.Ur2;
Us2 = Us / Sqrt[Us.M.Us];
Us2.M.Us2;
Um2 = Transpose[{Ur2, Us2} ];
TFO[Um2, "Mass Normalized EigenVectors"]
```

Out[32]=

$$\begin{pmatrix} \text{Mass Normalized EigenVectors} \\ \begin{pmatrix} -0.0247503 & 0.0073546 \\ 0.00636927 & 0.0214344 \end{pmatrix} \end{pmatrix}$$

In[33]:=

```
(* Birim Normalizasyon *)
Ur3 = Ur / Ur[[1]];
Us3 = Us / Us[[1]];
Um3 = Transpose[{Ur3, Us3}];
TFO[Um3, "Unit Normalized EigenVectors"]
```

Out[36]=

$$\begin{pmatrix} \text{Unit Normalized EigenVectors} \\ \begin{pmatrix} 1. & 1. \\ -0.257341 & 2.91442 \end{pmatrix} \end{pmatrix}$$

In[43]:=

```
Table[LogOut[[i]], {i, 1, outCnt}] // MatrixForm
Export[repFile, % // MatrixForm];
```

Out[43]//MatrixForm=

CONTENT

Mathematica Built−in Function Test using a problem which has a known solution

− Meireovitch // Fundementals of Vibration //Two Degree Of Freedom Systems//Example 5.2//Page 221

Question

Question

Example 5.2. Consider the simplified model of an automobile shown in Fig. 5.5, let the parameters have the values $m = 1,500$ kg, $I_C = 2,000$ kg m^2, $k_1 = 36,000$ kg/m, $k_2 = 40,000$ kg/m, $a = 1.3$ m and $b = 1.7$ m, calculate the natural modes of the system and write an expression for the response.

Equations Of Motion in Matrix Form

$$\begin{bmatrix} 1,500 & 0 \\ 0 & 2,000 \end{bmatrix} \begin{bmatrix} \ddot{x} \\ \ddot{\theta} \end{bmatrix} + \begin{bmatrix} 76,000 & 21,200 \\ 21,200 & 176,440 \end{bmatrix} \begin{bmatrix} x \\ \theta \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \qquad \text{(a)}$$

But, free vibration is harmonic, so that by analogy with Eqs. (5.23) and (5.31) we can write

$$x(t) = X\cos(\omega t - \phi), \ \theta(t) = \Theta\cos(\omega t - \phi) \qquad \text{(b)}$$

Results

$$\mathbf{x}(t) = C_1\cos(6.857811t - \phi_1)\begin{bmatrix} 1 \\ -0.257341 \end{bmatrix} + C_2\cos(9.584211t - \phi_2)\begin{bmatrix} 1 \\ 2.914417 \end{bmatrix} \qquad \text{(l)}$$

where the amplitudes C_1, C_2 and the phase angles ϕ_1, ϕ_2 must be determined from the initial displacements $x(0)$, $\theta(0)$ and the initial velocities $\dot{x}(0)$, $\dot{\theta}(0)$, as will be shown in Sec. 5.4.

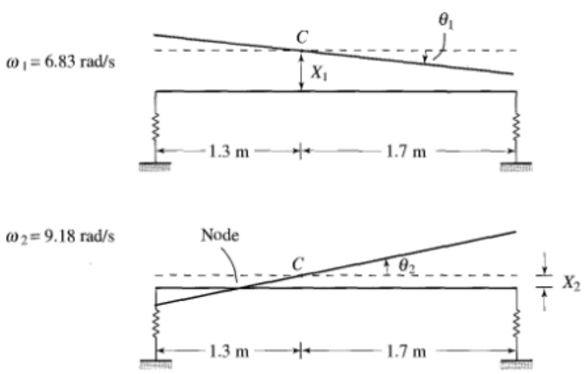

FIGURE 5.8
Natural modes for the automobile model of Fig. 5.5

Mass Matrix

$$\begin{pmatrix} 1500. & 0. \\ 0. & 2000. \end{pmatrix}$$

Stifness Matrix

$$\begin{pmatrix} 76\,000. & 21\,200. \\ 21\,200. & 176\,440. \end{pmatrix}$$

EigenFrequencies

$$\begin{pmatrix} 6.85781 \\ 9.58421 \end{pmatrix}$$

EigenVectors

$$\begin{pmatrix} -0.968447 & 0.324548 \\ 0.249221 & 0.945869 \end{pmatrix}$$

Checking Orthogonality

$$3.63798 \times 10^{-12}$$

$$\begin{pmatrix} \text{Mass Normalized EigenVectors} \\ \begin{pmatrix} -0.0247503 & 0.0073546 \\ 0.00636927 & 0.0214344 \end{pmatrix} \end{pmatrix}$$

$$\begin{pmatrix} \text{Unit Normalized EigenVectors} \\ \begin{pmatrix} 1. & 1. \\ -0.257341 & 2.91442 \end{pmatrix} \end{pmatrix}$$

0