In[68]:=
```
(*Include del progetto*)
SetDirectory[NotebookDirectory[]];
<< libMathematica/ToMatlab.m
? ToMatlab
```

Symbol

ToMatlab [expr] converts the expression expr into matlab syntax and returns it as a String .

ToMatlab [expr , name] returns an assignment of expr into name as a String . name can be also a more complicated string , e.g., ToMatlab [If[t,a,b],"function y=iffun (t,a,b)\ny"].

Out[70]=

The special symbol Colon can be used to denote the matlab colon operator :, and Colon [a,b] for a:b, Colon [a,b,c] for a:b:c.

See also WriteMatlab and PrintMatlab .

All functions accept an optional last argument that is the maximum line width .

Regulation Problem

In[71]:=
```
As = {{-F/M , 0 , 0, 0}, {1, 0 , 0, 0}, {-F/(M*l), 0 , 0, g/l}, {0, 0 , 1, 0}} ;
n = Dimensions[As][[2]];   (*Dimensione Stato*)
Bs = Transpose[{{1/M , 0, 1/(M*l), 0}}];
m = Dimensions[Bs][[2]];   (*Dimensione Ingressi*)
Cs = {{0, 1, 0, 0}, {0, 0, 0, 1}};
p = Dimensions[Cs][[1]];   (*Dimensione Tutte Uscite*)
p1 = Dimensions[{Cs[[1]]}][[1]] ;  (*Dimensione Uscite Usate nel Regolatore*)
sLin = StateSpaceModel[{As, Bs, Cs, Transpose[{{0, 0}}]}] ;

(*Calcolo della matrice di Raggiungibilità*)
Rag = Join[Bs, As.Bs, As.As.Bs, As.As.As.Bs, 2];
Ragval = Rag /. {l → 1, M → 1, F → 1, g → 9.81};
Print["Rag=", MatrixForm[Rag], "\t Numerica:", MatrixForm[Ragval]]
Print["\t\t\t\trk=", MatrixRank[Ragval], "\t det=", Det[Ragval]]

(*Calcolo Della retroazione K stabilizzante*)
(*λ=1;*)
(*x={sDot,s,phiDot,phi}*)
(*Imponiamo che gli auto valori del pendolo siano più rapidi*)
K = StateFeedbackGains[sLin, {λ, λ, λ/2, λ/2}]; (* Si aspetta che u=-Kx*)
K = -K; (*per avere u=Kx*)
Print["Matrice K di retroazione dallo stato\nK=", MatrixForm[K]];
```

$$\text{Rag}=\begin{pmatrix} \frac{1}{M} & -\frac{F}{M^2} & \frac{F^2}{M^3} & -\frac{F^3}{M^4} \\ 0 & \frac{1}{M} & -\frac{F}{M^2} & \frac{F^2}{M^3} \\ \frac{1}{l\,M} & -\frac{F}{l\,M^2} & \frac{F^2}{l\,M^3}+\frac{g}{l^2\,M} & \frac{-\frac{F^3}{l\,M^3}-\frac{F\,g}{l^2\,M}}{M} \\ 0 & \frac{1}{l\,M} & -\frac{F}{l\,M^2} & \frac{F^2}{l\,M^3}+\frac{g}{l^2\,M} \end{pmatrix} \qquad \text{Numerica}: \begin{pmatrix} 1 & -1 & 1 & -1 \\ 0 & 1 & -1 & 1 \\ 1 & -1 & 10.81 & -10.81 \\ 0 & 1 & -1 & 10.81 \end{pmatrix}$$

rk=4 det=96.2361

Matrice K di retroazione dallo stato

$$K=\left(-\frac{-2\,F\,g+3\,l\,M\,\lambda^3}{2\,g} \quad \frac{l\,M\,\lambda^4}{4\,g} \quad \frac{3\,(2\,g\,l\,M\,\lambda+l^2\,M\,\lambda^3)}{2\,g} \quad -\frac{4\,g^2\,M+13\,g\,l\,M\,\lambda^2+l^2\,M\,\lambda^4}{4\,g}\right)$$

Latex delle matrici di Raggiungibilità

In[86]:= **TeXForm[MatrixForm[Rag]]**

Out[86]//TeXForm=

```
\left(
\begin{array}{cccc}
 \frac{1}{M} & -\frac{F}{M^2} & \frac{F^2}{M^3} & -\frac{F^3}{M^4} \\
 0 & \frac{1}{M} & -\frac{F}{M^2} & \frac{F^2}{M^3} \\
 \frac{1}{l  M} & -\frac{F}{l  M^2} & \frac{F^2}{l  M^3}+\frac{g}{l^2  M} & \frac{-\frac{F^3}{l  M^
 0 & \frac{1}{l  M} & -\frac{F}{l  M^2} & \frac{F^2}{l  M^3}+\frac{g}{l^2  M} \\
\end{array}
\right)
```

In[87]:= **TeXForm[MatrixForm[Ragval]]**

Out[87]//TeXForm=

```
\left(
\begin{array}{cccc}
 1 & -1 & 1 & -1 \\
 0 & 1 & -1 & 1 \\
 1 & -1 & 10.81 & -10.81 \\
 0 & 1 & -1 & 10.81 \\
\end{array}
\right)
```

Calcolo Equazioni di Silvester per ottenere Π e Γ

In[88]:=
```
a1 = ArrayFlatten[{{As, Bs}, {{Cs[[1]]}, 0}}];
S = {{0, 0, 0}, {0, 0, ω}, {0, -ω, 0}};
r = Dimensions[S][[2]];   (*Dimensione  esogeni*)
a2 = S;
d = ArrayFlatten[{{-IdentityMatrix[n], 0}, {0, ConstantArray[0, {p1, p1}]}}];
e = IdentityMatrix[r];
P = ArrayFlatten[{{Bs, 0, 0}}];
Q = {{0, -1, 0}};
a3 = ArrayFlatten[{{-P}, {-Q}}];

ap = LyapunovSolve[{a1, d}, {a2, e}, a3];
Π = ap[[1 ;; n, 1 ;; r]];
Γ = ap[[n + 1 ;; n + m, 1 ;; r]];
L = Γ - K.Π ;
```

Ricapitoliamo Dati ottenuti

In[101]:=
```
Print["n=", n, "\tm=", m, "\tp=", p, "\tp1=", p1, "\tr=", r]
Print["Sis lin:", sLin]
Print["Matrice K di retroazione dallo stato\nK=", MatrixForm[K]]
Print["Π,Γ:" MatrixForm[{{MatrixForm[Π], MatrixForm[Γ]}}]]
Print["Calcolo della matrice di compensazione errore L\nL=Γ-KΠ=", MatrixForm[L]]
```

n=4 m=1 p=2 p1=1 r=3

Sis lin:
$$\left(\begin{array}{cccc|c} -\frac{F}{M} & 0 & 0 & 0 & \frac{1}{M} \\ 1 & 0 & 0 & 0 & 0 \\ -\frac{F}{l\,M} & 0 & 0 & \frac{g}{l} & \frac{1}{l\,M} \\ 0 & 0 & 1 & 0 & 0 \\ \hline 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{array}\right)$$ S

Matrice K di retroazione dallo stato

$$K=\left(-\frac{-2\,F\,g+3\,l\,M\,\lambda^3}{2\,g}\quad \frac{l\,M\,\lambda^4}{4\,g}\quad \frac{3\,(2\,g\,l\,M\,\lambda+l^2\,M\,\lambda^3)}{2\,g}\quad -\frac{4\,g^2\,M+13\,g\,l\,M\,\lambda^2+l^2\,M\,\lambda^4}{4\,g}\right)$$

$$\Pi,\Gamma:\left(\begin{pmatrix} 0 & 0 & \omega \\ 0 & 1 & 0 \\ 0 & 0 & \frac{\omega^3}{g+l\,\omega^2} \\ 0 & \frac{\omega^2}{g+l\,\omega^2} & 0 \end{pmatrix}\quad \begin{pmatrix} -1 & -M\,\omega^2 & F\,\omega \end{pmatrix}\right)$$

Calcolo della matrice di compensazione errore L

$$L=\Gamma-K\Pi=\left(-1\quad -\frac{l\,M\,\lambda^4}{4\,g}-M\,\omega^2+\frac{(4\,g^2\,M+13\,g\,l\,M\,\lambda^2+l^2\,M\,\lambda^4)\,\omega^2}{4\,g\,(g+l\,\omega^2)}\quad F\,\omega+\frac{(-2\,F\,g+3\,l\,M\,\lambda^3)\,\omega}{2\,g}-\frac{3\,(2\,g\,l\,M\,\lambda+l^2\,M\,\lambda^3)\,\omega^3}{2\,g\,(g+l\,\omega^2)}\right)$$

EFRP

Verifichiamo ora che il sistema Linearizzato sia Osservabile

In[106]:=

In[107]:=
```
Ae = ArrayFlatten[{{As, P}, {0, S}}];
Be = Join[Bs, Transpose[{{0, 0, 0}}], 1];
Qe = ArrayFlatten[{{Q}, {0}}]
Ce = Join[Cs, Qe, 2];
De = Transpose[{{0, 0}}];
(*
extendedSis =StateSpaceModel[{Transpose[Ae],Transpose[Ce],Transpose[Be],Transpose[De]}];
Ae //MatrixForm
      Be //MatrixForm
     Ce//MatrixForm
    De //MatrixForm
*)
(*Calcolo della matrice di Osservabilità Estesa*)
Oss = Join[Ce, Ce.Ae, Ce.Ae.Ae, Ce.Ae.Ae.Ae,
   Ce.Ae.Ae.Ae.Ae, Ce.Ae.Ae.Ae.Ae.Ae, Ce.Ae.Ae.Ae.Ae.Ae.Ae, 1];
Ossval = Oss /. {l → 1, M → 1, F → 1, g → 9.81, ω → 1};
Print["Oss=", MatrixForm[Oss], "\t Numerica:", MatrixForm[Ossval]]
Print["\t\t\t\trk=", MatrixRank[Ossval]]

(*Calcolo dei Guadagni dell'osservatore
 DEVE ESSERE numerico per bug Mathematica*)
(*Esporto su Matlab Ae e Ce per il calcoloμ*)
```

Out[109]= {{0, −1, 0}, {0, 0, 0}}

$$Oss=\begin{pmatrix} 0 & 1 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & -\omega \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ -\frac{F}{M} & 0 & 0 & 0 & \frac{1}{M} & \omega^2 & 0 \\ -\frac{F}{l\,M} & 0 & 0 & \frac{g}{l} & \frac{1}{l\,M} & 0 & 0 \\ \frac{F^2}{M^2} & 0 & 0 & 0 & -\frac{F}{M^2} & 0 & \omega^3 \\ \frac{F^2}{l\,M^2} & 0 & \frac{g}{l} & 0 & -\frac{F}{l\,M^2} & 0 & 0 \\ -\frac{F^3}{M^3} & 0 & 0 & 0 & \frac{F^2}{M^3} & -\omega^4 & 0 \\ -\frac{F^3}{l\,M^3}-\frac{F\,g}{l^2\,M} & 0 & 0 & \frac{g^2}{l^2} & \frac{F^2}{l\,M^3}+\frac{g}{l^2\,M} & 0 & 0 \\ \frac{F^4}{M^4} & 0 & 0 & 0 & -\frac{F^3}{M^4} & 0 & -\omega^5 \\ -\frac{F\left(-\frac{F^3}{l\,M^3}-\frac{F\,g}{l^2\,M}\right)}{M} & 0 & \frac{g^2}{l^2} & 0 & \frac{-\frac{F^3}{l\,M^3}-\frac{F\,g}{l^2\,M}}{M} & 0 & 0 \\ -\frac{F^5}{M^5} & 0 & 0 & 0 & \frac{F^4}{M^5} & \omega^6 & 0 \\ \frac{F^2\left(-\frac{F^3}{l\,M^3}-\frac{F\,g}{l^2\,M}\right)}{M^2}-\frac{F\,g^2}{l^3\,M} & 0 & 0 & \frac{g^3}{l^3} & -\frac{F\left(-\frac{F^3}{l\,M^3}-\frac{F\,g}{l^2\,M}\right)}{M^2}+\frac{g^2}{l^3\,M} & 0 & 0 \end{pmatrix}$$

$$\text{Numerica}:\begin{pmatrix} 0 & 1 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 1 & 1 & 0 \\ -1 & 0 & 0 & 9.81 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & -1 & 0 & 1 \\ 1 & 0 & 9.81 & 0 & -1 & 0 & 0 \\ -1 & 0 & 0 & 0 & 1 & -1 & 0 \\ -10.81 & 0 & 0 & 96.2361 & 10.81 & 0 & 0 \\ 1 & 0 & 0 & 0 & -1 & 0 & -1 \\ 10.81 & 0 & 96.2361 & 0 & -10.81 & 0 & 0 \\ -1 & 0 & 0 & 0 & 1 & 1 & 0 \\ -107.046 & 0 & 0 & 944.076 & 107.046 & 0 & 0 \end{pmatrix}$$

rk=7

Latex delle matrici di Raggiungibilità

In[116]:=
```
TeXForm[MatrixForm[Oss]]
```

Out[116]//TeXForm=
```
\left(
\begin{array}{ccccccc}
 0 & 1 & 0 & 0 & 0 & -1 & 0 \\
 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
 1 & 0 & 0 & 0 & 0 & 0 & -\omega  \\
 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
 -\frac{F}{M} & 0 & 0 & 0 & \frac{1}{M} & \omega ^2 & 0 \\
 -\frac{F}{l  M} & 0 & 0 & \frac{g}{l} & \frac{1}{l  M} & 0 & 0 \\
 \frac{F^2}{M^2} & 0 & 0 & 0 & -\frac{F}{M^2} & 0 & \omega ^3 \\
 \frac{F^2}{l  M^2} & 0 & \frac{g}{l} & 0 & -\frac{F}{l  M^2} & 0 & 0 \\
 -\frac{F^3}{M^3} & 0 & 0 & 0 & \frac{F^2}{M^3} & -\omega ^4 & 0 \\
 -\frac{F^3}{l  M^3}-\frac{F  g}{l^2 M} & 0 & 0 & \frac{g^2}{l^2} & \frac{F^2}{l  M^3}+\frac{g}{l
 \frac{F^4}{M^4} & 0 & 0 & 0 & -\frac{F^3}{M^4} & 0 & -\omega ^5 \\
 -\frac{F \left(-\frac{F^3}{l  M^3}-\frac{F  g}{l^2 M}\right)}{M} & 0 & \frac{g^2}{l^2} & 0 & \
   M}}{M} & 0 & 0 \\
 -\frac{F^5}{M^5} & 0 & 0 & 0 & \frac{F^4}{M^5} & \omega ^6 & 0 \\
 \frac{F^2 \left(-\frac{F^3}{l  M^3}-\frac{F  g}{l^2 M}\right)}{M^2}-\frac{F  g^2}{l^3  M} & 0 &
   M}-\frac{F \left(-\frac{F^3}{l  M^3}-\frac{F  g}{l^2 M}\right)}{M^2} & 0 & 0 \\
\end{array}
\right)
```

In[117]:=
```
TeXForm[MatrixForm[Ossval]]
```

Out[117]//TeXForm=
```
\left(
\begin{array}{ccccccc}
 0 & 1 & 0 & 0 & 0 & -1 & 0 \\
 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
 1 & 0 & 0 & 0 & 0 & 0 & -1 \\
 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
 -1 & 0 & 0 & 0 & 1 & 1 & 0 \\
 -1 & 0 & 0 & 9.81 & 1 & 0 & 0 \\
 1 & 0 & 0 & 0 & -1 & 0 & 1 \\
 1 & 0 & 9.81 & 0 & -1 & 0 & 0 \\
 -1 & 0 & 0 & 0 & 1 & -1 & 0 \\
 -10.81 & 0 & 0 & 96.2361 & 10.81 & 0 & 0 \\
 1 & 0 & 0 & 0 & -1 & 0 & -1 \\
 10.81 & 0 & 96.2361 & 0 & -10.81 & 0 & 0 \\
 -1 & 0 & 0 & 0 & 1 & 1 & 0 \\
 -107.046 & 0 & 0 & 944.076 & 107.046 & 0 & 0 \\
\end{array}
\right)
```

Calcolo Matrici Linearizzate e di Controllo per Matlab

In[118]:=
```
(*num={l→1,M→ 1,F→1,g→9.81,ω→wD2}*)
num = {ω → wD2, λ → lam};
(*num={l→a,M→ b,F→c,g→d,ω→e};*)
{aa, bb, cc, dd} = Normal[sLin];
f = OpenWrite["Matrix.m"];
(*Matrici Sistema Linearizzato*)
WriteMatlab[aa /. num, f, "Alin"]
WriteMatlab[bb /. num, f, "Blin"]
WriteMatlab[cc /. num, f, "Clin"]
WriteMatlab[dd /. num, f, "Dlin"]
(*Matrici per stabilizzazione dallo stato*)
WriteMatlab[K /. num, f, "K"]
WriteMatlab[L /. num, f, "L"]
(*Matrici utility*)
WriteMatlab[Q /. num, f, "Q"]
WriteMatlab[P /. num, f, "Ptile"]
WriteMatlab[Γ /. num, f, "Gamma"]
WriteMatlab[Π /. num, f, "PiMat"]
WriteMatlab[Qe /. num, f, "Qe"]
(*Matrici per il calcolo in Matlab di G*)
WriteMatlab[Ae /. num, f, "Ae"]
WriteMatlab[Ce /. num, f, "Ce"]
Close[f];
```