

Листинг 2

```

In[1]:= ClearAll["Global`*"]
SetDirectory[NotebookDirectory[]];
Needs["FlowSolver`"]

In[4]:= readGraph2[file_, dir_] := Module[{
    fn = FileNameJoin[{dir, file}],
    stream, imod, umod, u, b
},
    stream = OpenRead[fn];
    imod = Read[stream, {Word, Number}][[2]];
    umod = Read[stream, {Word, Number}][[2]];

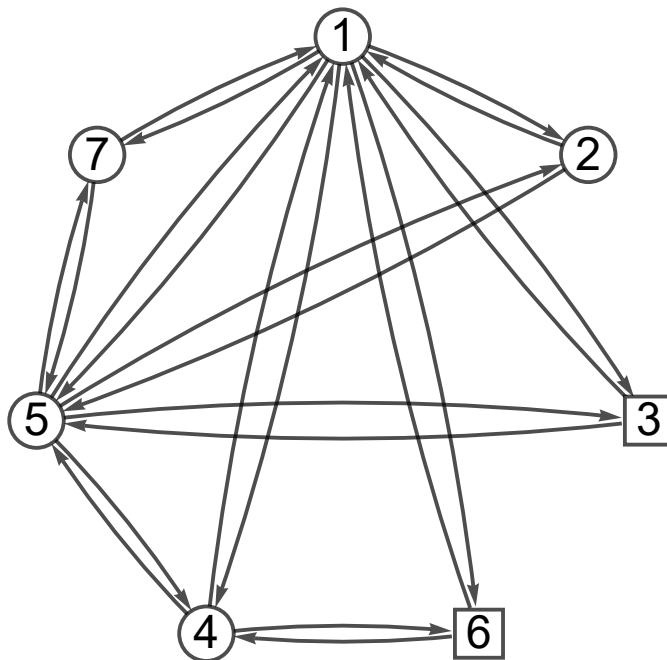
    u = ({#[[1]] ↔ #[[2]], #[[2]] ↔ #[[1]]} & /@ ReadList[stream, Expression, umod]) // Flatten;
    b = ConstantArray[0, imod];
    (b[[Read[StringToStream[StringTake[#, {5, -3}]], Number]]] = #2) & @@@
    ReadList[stream, {Word, Expression}, imod];
    {Graph[u, VertexSize -> Medium, VertexLabels -> Placed["Name", Center],
        VertexStyle -> Directive[White],
        VertexShapeFunction -> {xx_ -> If[SameQ[b[[xx]], x], "Square", "Circle"]},
        VertexLabelStyle -> Directive[Black, 24], GraphLayout -> "CircularEmbedding", b]}

In[5]:= forma[ff_] := ((ff /. {ξu→vu → ξu,v}) // TableForm)

In[101]:=
{g, b} = readGraph2["gr.txt", NotebookDirectory[]];
GraphPlot[g, EdgeStyle -> Directive[Black, Thick],
    VertexStyle -> Directive[EdgeForm[Thick], White], MultiedgeStyle -> .05]

```

Out[102]=



```
In[103]:= balanceEqs = (Total[x_# & /@ EdgeList[g, _ -> #]] - Total[x_# & /@ EdgeList[g, # -> _]]) ==
      MapIndexed[#1 /. x -> x_#2[[1]] &, b][[#]] & /@ VertexList[g];
balanceEqs //
      forma
```

Out[104]//TableForm=

```
x1,7 + x5,7 - x7,1 - x7,5 == 0
-x1,2 - x1,3 - x1,4 - x1,5 - x1,6 - x1,7 + x2,1 + x3,1 + x4,1 + x5,1 + x6,1 + x7,1 == 0
x1,5 + x2,5 + x3,5 + x4,5 - x5,1 - x5,2 - x5,3 - x5,4 - x5,7 + x7,5 == 0
x1,2 - x2,1 - x2,5 + x5,2 == 0
x1,3 - x3,1 - x3,5 + x5,3 == x3
x1,4 - x4,1 - x4,5 - x4,6 + x5,4 + x6,4 == 0
x1,6 + x4,6 - x6,1 - x6,4 == x6
```

```
In[105]:= M = {7};
Print["M = ", M];

M = {7}
```

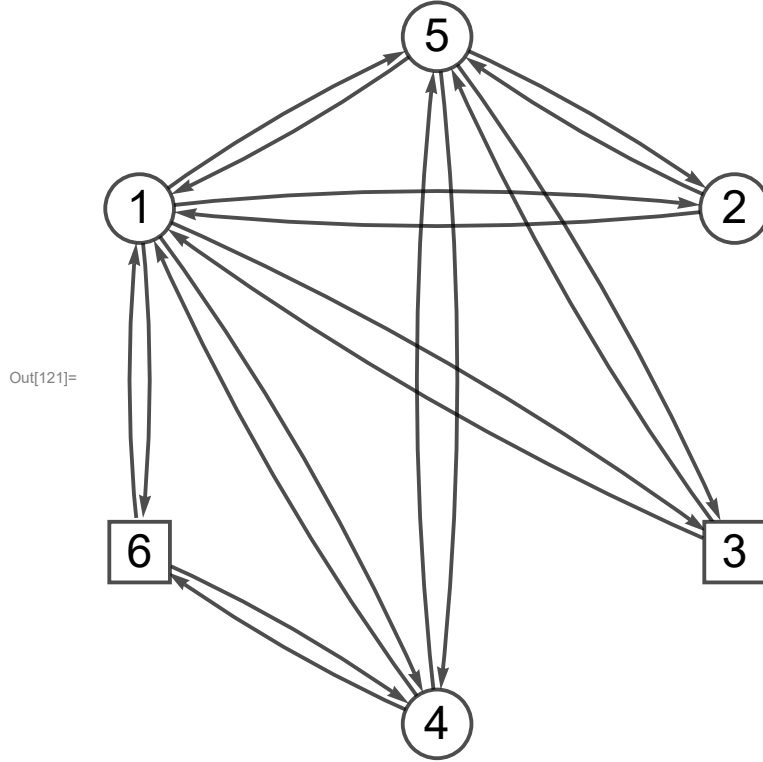
```
In[107]:= (*incl=
      DeleteCases[DeleteDuplicates[Cases[IncidenceList[g,#],i_<->j_->{i,j}]]//Flatten],
      v_/;v==#]&/@M*)
incl = (IncidenceList[g, #] & /@ M) // Flatten
```

Out[107]= {7 -> 1, 1 -> 7, 7 -> 5, 5 -> 7}

```

In[118]:= (*Do[If[MemberQ[M, j[[1]]], b[[j[[2]]] += f_j, b[[j[[1]]] -= f_j], {j, incL}]] *)
b̄ = Fold[If[MemberQ[M, #2[[1]]], ReplacePart[#, #2[[2]] → #[[#2[[2]]] + f_#2],
  ReplacePart[#, #2[[1]] → #[[#2[[1]]] - f_#2]] &, b, incL];
b̄ = Delete[b̄, #] &@@M;
nḡ = VertexDelete[g, M];
GraphPlot[nḡ, EdgeStyle → Directive[Black, Thick],
  VertexStyle → Directive[EdgeForm[Thick], White], MultiedgeStyle → .05]
b̄

```



Out[122]= $\{-f_{1 \rightarrow 7} + f_{7 \rightarrow 1}, 0, x, 0, -f_{5 \rightarrow 7} + f_{7 \rightarrow 5}, x\}$

```

In[123]:= CC[g_, M_] :=
  (DeleteDuplicates[Cases[IncidenceList[g, #], i_ → j_ /; j == #]] & /@ M) // Flatten

```

```

ii_i_ [g_] := Cases[IncidenceList[g, i], u_ → v_ /; u == i → v]

```

```

In[125]:= M+ = CC[g, M]

```

Out[125]= $\{1 \leftrightarrow 7, 5 \leftrightarrow 7\}$

```

In[126]:= b̄1 = Fold[Module[{bb = #1, i = #2[[1]], k = #2[[2]]},
  (ReplacePart[bb, {({# → bb[[#]] +  $\frac{p_{i \rightarrow \#}}{p_{i \rightarrow k}} f_{i \rightarrow k}, i \rightarrow bb[[i]] - \frac{p_{i \rightarrow \#}}{p_{i \rightarrow k}} f_{i \rightarrow k}$ }) &} /@ ii_i_ [nḡ]) //
  Flatten]] &, b̄, M+]

```

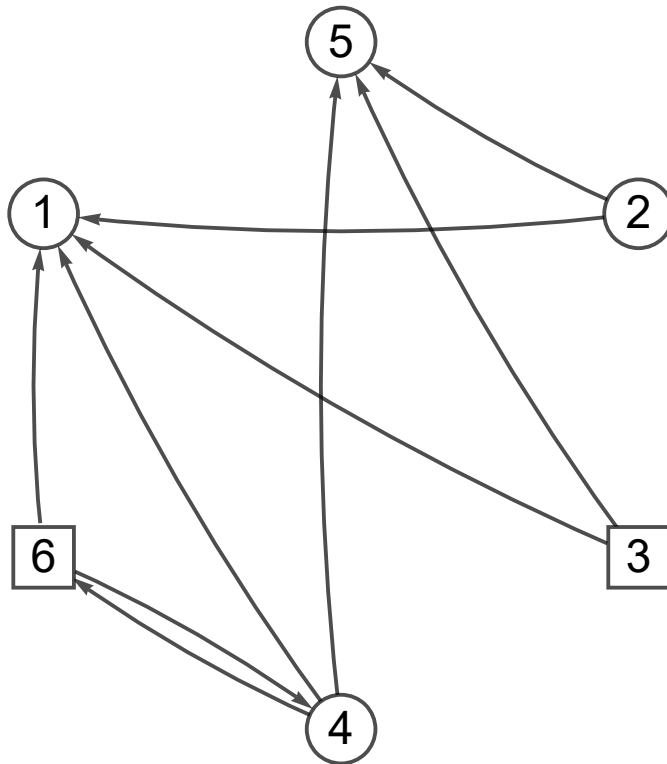
Out[126]= $\left\{-f_{1 \rightarrow 7} + f_{7 \rightarrow 1} - \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 5}}{p_{1 \rightarrow 7}} + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 1}}{p_{5 \rightarrow 7}}, \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 2}}{p_{1 \rightarrow 7}} + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 2}}{p_{5 \rightarrow 7}}, x + \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 3}}{p_{1 \rightarrow 7}} + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 3}}{p_{5 \rightarrow 7}}, \right.$
 $\left. \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 4}}{p_{1 \rightarrow 7}} + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 4}}{p_{5 \rightarrow 7}}, -f_{5 \rightarrow 7} + f_{7 \rightarrow 5} + \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 5}}{p_{1 \rightarrow 7}} - \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 2}}{p_{5 \rightarrow 7}}, x + \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 6}}{p_{1 \rightarrow 7}} \right\}$

```

In[128]:= GraphPlot[Fold[HighlightGraph[#1, u_  $\leftrightarrow$  v_ /; u == #2, GraphHighlightStyle  $\rightarrow$  "White"] &,
   $\overline{ng}$ , #[[1]] & /@M+], EdgeStyle  $\rightarrow$  Directive[Black, Thick],
  VertexStyle  $\rightarrow$  Directive[EdgeForm[Thick], White], MultiedgeStyle  $\rightarrow$  .05]

```

Out[128]=

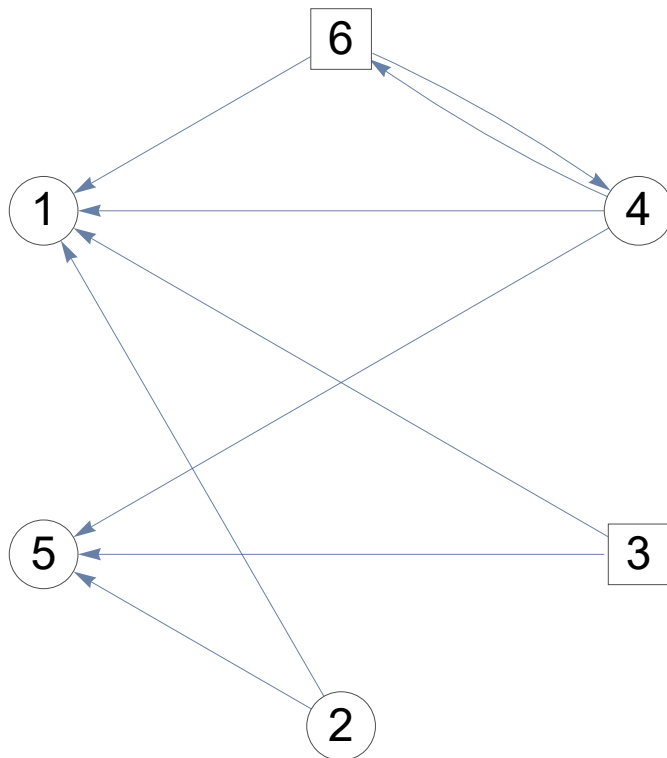


```

In[23]:=  $\overline{g1}$  = Fold[EdgeDelete[#1, u_  $\leftrightarrow$  v_ /; u == #2] &,  $\overline{ng}$ , #[[1]] & /@M+];
  GraphPlot[ $\overline{g1}$ , MultiedgeStyle  $\rightarrow$  .05]

```

Out[24]=



```
In[25]:= IIrem = VertexList[ $\overline{g1}$ ] ~ Complement ~ (M+[All, 1])
```

```
Out[25]= {2, 3, 4, 6}
```

```
In[26]:= λ = SparseArray[
  Replace[
    (EdgeList[ $\overline{g1}$ ] /. # & /@ Flatten[Module[{i = #, jf, Icur}, {Icur = iii+[ $\overline{g1}$ ];
      jf = First[Icur];
      ({(i ↔ jf) → 1, (i ↔ #) → -  $\frac{p_{i \rightarrow \#}}{p_{i \rightarrow jf}}$ }) & /@ Icur[[2 ;;]]]) & /@ IIrem, 1]),
    _ ↔ _ → 0, 2]]
```

```
Out[26]= SparseArray[ Specified elements: 10  
Dimensions: {5, 9}]
```

```
In[27]:= Grid[λ]
```

```
Out[27]=


|   |   |                                                    |   |                                                    |                                                    |   |   |                                                    |   |
|---|---|----------------------------------------------------|---|----------------------------------------------------|----------------------------------------------------|---|---|----------------------------------------------------|---|
| 1 | 0 | 0                                                  | 0 | 0                                                  | 0                                                  | 0 | 0 | $-\frac{p_{2 \rightarrow 1}}{p_{2 \rightarrow 5}}$ | 0 |
| 0 | 1 | $-\frac{p_{3 \rightarrow 1}}{p_{3 \rightarrow 5}}$ | 0 | 0                                                  | 0                                                  | 0 | 0 | 0                                                  | 0 |
| 0 | 0 | 0                                                  | 1 | $-\frac{p_{4 \rightarrow 5}}{p_{4 \rightarrow 1}}$ | 0                                                  | 0 | 0 | 0                                                  | 0 |
| 0 | 0 | 0                                                  | 1 | 0                                                  | $-\frac{p_{4 \rightarrow 6}}{p_{4 \rightarrow 1}}$ | 0 | 0 | 0                                                  | 0 |
| 0 | 0 | 0                                                  | 0 | 0                                                  | 0                                                  | 1 | 0 | $-\frac{p_{6 \rightarrow 1}}{p_{6 \rightarrow 4}}$ | 0 |


```

```
In[28]:= g =  $\overline{g1}$ ;
```

```
b =  $\overline{b1}$ ;
```

```
In[30]:= II* = Cases[MapIndexed[{#1, #2} &, b], {el_, i_} /; MemberQ[el, x] := i] // Flatten
```

```
Out[30]= {3, 6}
```

```
In[31]:= buildt = Timing[{t, g} = buildTree[g, II*];][[1]]
TableForm[t[[1 ;; 4]],
  TableHeadings → {"pred", "dir", "depth", "d"}, t // pred // Length // Range]]
```

```
Out[31]= 0.1875
```

```
Out[32]//TableForm=
```

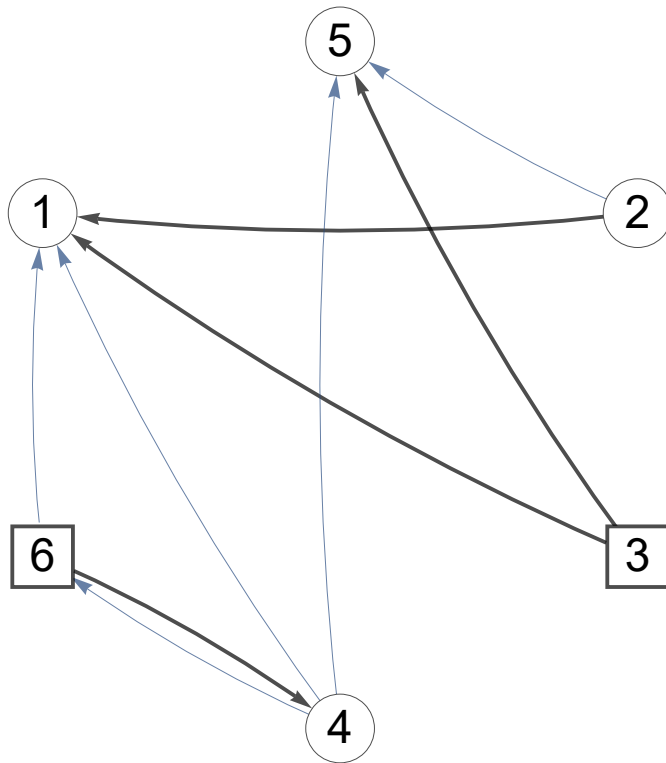
	1	2	3	4	5	6	7
pred	3	1	7	6	3	7	0
dir	1	-1	1	1	1	1	0
depth	2	3	1	2	2	1	0
d	2	5	1	7	6	4	3

```

In[87]:= GraphPlot[HighlightGraph[
  Fold[HighlightGraph[#1, Style[u_ ↔ v_ /; u == #2, White]] &,  $\overline{ng}$ , #[[1]] & /@ M+],
  {Style[u_ /; VertexQ[g, u] && pred[t][[u]] == 7, EdgeForm[Thick]], Style[u_ ↔ v_ /;
    (pred[t][[u]] == v && dir[t][[u]] == -1) || (pred[t][[v]] == u && dir[t][[v]] == 1),
    Directive[Black, Thick]}], GraphHighlightStyle → None], MultiedgeStyle → .05]

```

Out[87]=

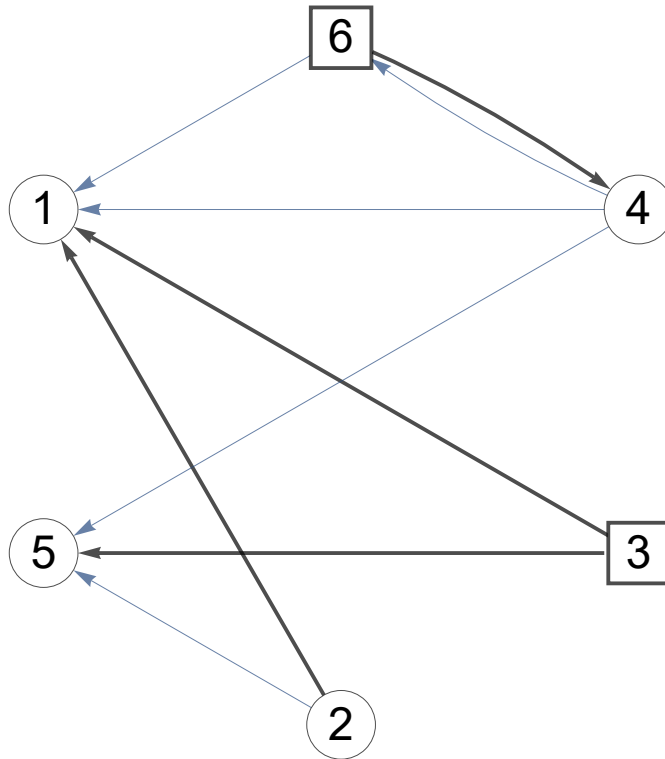


```

In[34]:= GraphPlot[
  HighlightGraph[g1, {Style[u_ /; VertexQ[g, u] && pred[t][[u]] == 7, EdgeForm[Thick]],
    Style[u_ -> v_ /; (pred[t][[u]] == v && dir[t][[u]] == -1) ||
      (pred[t][[v]] == u && dir[t][[v]] == 1), Directive[Black, Thick]}],
  GraphHighlightStyle -> None], MultiedgeStyle -> .05]

```

Out[34]=

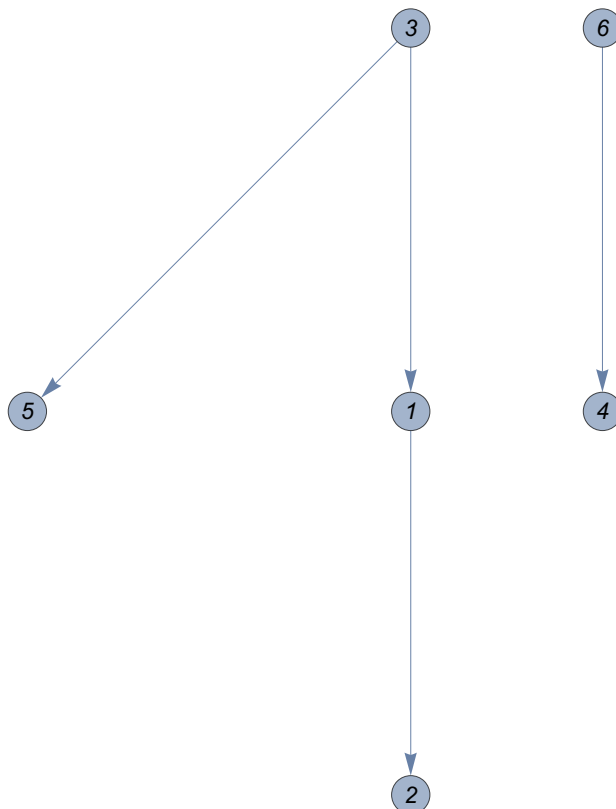


```

In[35]:= VertexDelete[t[[7]], 7] (*пометить на графе*)

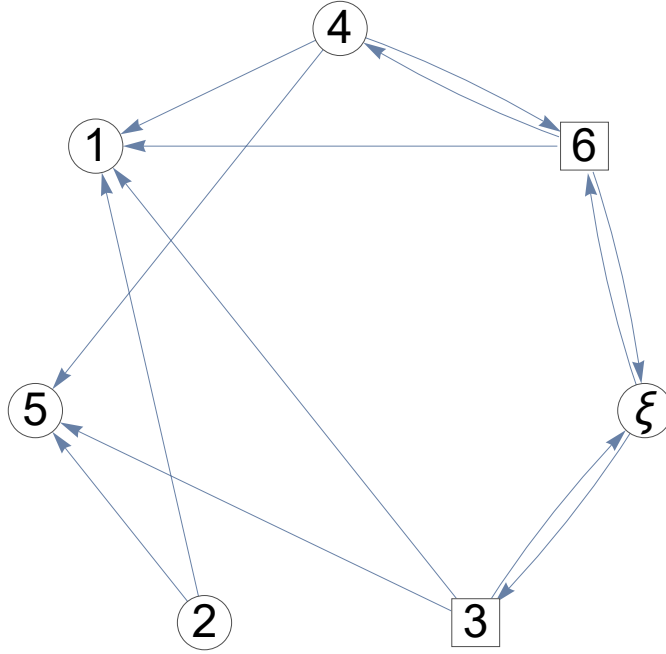
```

Out[35]=



```
In[36]:= GraphPlot[g, MultiedgeStyle -> .05]
```

```
Out[36]=
```



```
In[37]:= AppendTo[b, -Total[b]];
b = Simplify[b /. x -> 0]
```

$$\text{Out[38]} = \left\{ f_{7 \rightarrow 1} + f_{1 \rightarrow 7} \left(-1 - \frac{p_{1 \rightarrow 5}}{p_{1 \rightarrow 7}} \right) + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 1}}{p_{5 \rightarrow 7}}, \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 2}}{p_{1 \rightarrow 7}} + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 2}}{p_{5 \rightarrow 7}}, \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 3}}{p_{1 \rightarrow 7}} + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 3}}{p_{5 \rightarrow 7}}, \right. \\ \left. \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 4}}{p_{1 \rightarrow 7}} + \frac{f_{5 \rightarrow 7} p_{5 \rightarrow 4}}{p_{5 \rightarrow 7}}, f_{7 \rightarrow 5} + \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 5}}{p_{1 \rightarrow 7}} + f_{5 \rightarrow 7} \left(-1 - \frac{p_{5 \rightarrow 2}}{p_{5 \rightarrow 7}} \right), \frac{f_{1 \rightarrow 7} p_{1 \rightarrow 6}}{p_{1 \rightarrow 7}}, \right. \\ \left. -f_{7 \rightarrow 1} - f_{7 \rightarrow 5} - \frac{f_{1 \rightarrow 7} (p_{1 \rightarrow 2} + p_{1 \rightarrow 3} + p_{1 \rightarrow 4} + p_{1 \rightarrow 6} - p_{1 \rightarrow 7})}{p_{1 \rightarrow 7}} - \frac{f_{5 \rightarrow 7} (p_{5 \rightarrow 1} + p_{5 \rightarrow 3} + p_{5 \rightarrow 4} - p_{5 \rightarrow 7})}{p_{5 \rightarrow 7}} \right\}$$

```
In[39]:= balanceEqs =
  ((Total[x# & /@ EdgeList[g, _ -> #]] - Total[x# & /@ EdgeList[g, # -> _]]) /. 7 -> ξ) ==
  b[[#]] & /@ VertexList[g];
balanceEqs //
forma
```

```
Out[40]//TableForm=
```

$$\begin{aligned} x_{2,1} + x_{3,1} + x_{4,1} + x_{6,1} &= f_{7,1} + f_{1,7} \left(-1 - \frac{p_{1,5}}{p_{1,7}} \right) + \frac{f_{5,7} p_{5,1}}{p_{5,7}} \\ x_{2,5} + x_{3,5} + x_{4,5} &= f_{7,5} + \frac{f_{1,7} p_{1,5}}{p_{1,7}} + f_{5,7} \left(-1 - \frac{p_{5,2}}{p_{5,7}} \right) \\ -x_{2,1} - x_{2,5} &= \frac{f_{1,7} p_{1,2}}{p_{1,7}} + \frac{f_{5,7} p_{5,2}}{p_{5,7}} \\ -x_{3,1} - x_{3,5} - x_{3,\xi} + x_{\xi,3} &= \frac{f_{1,7} p_{1,3}}{p_{1,7}} + \frac{f_{5,7} p_{5,3}}{p_{5,7}} \\ -x_{4,1} - x_{4,5} - x_{4,6} + x_{6,4} &= \frac{f_{1,7} p_{1,4}}{p_{1,7}} + \frac{f_{5,7} p_{5,4}}{p_{5,7}} \\ x_{4,6} - x_{6,1} - x_{6,4} - x_{6,\xi} + x_{\xi,6} &= \frac{f_{1,7} p_{1,6}}{p_{1,7}} \\ x_{3,\xi} + x_{6,\xi} - x_{\xi,3} - x_{\xi,6} &= -f_{7,1} - f_{7,5} - \frac{f_{1,7} (p_{1,2} + p_{1,3} + p_{1,4} + p_{1,6} - p_{1,7})}{p_{1,7}} - \frac{f_{5,7} (p_{5,1} + p_{5,3} + p_{5,4} - p_{5,7})}{p_{5,7}} \end{aligned}$$


```
In[41]:= ps = partSolve[g, -b, t, x̃];
ps // forma
```

7

Out[42]//TableForm=

$$\begin{aligned}
\tilde{x}_{2,1} &\rightarrow -\frac{f_{1,7} p_{1,2}}{p_{1,7}} - \frac{f_{5,7} p_{5,2}}{p_{5,7}} \\
\tilde{x}_{2,5} &\rightarrow 0 \\
\tilde{x}_{3,1} &\rightarrow f_{7,1} + f_{1,7} \left(-1 - \frac{p_{1,5}}{p_{1,7}} \right) + \frac{f_{1,7} p_{1,2}}{p_{1,7}} + \frac{f_{5,7} p_{5,1}}{p_{5,7}} + \frac{f_{5,7} p_{5,2}}{p_{5,7}} \\
\tilde{x}_{3,5} &\rightarrow f_{7,5} + \frac{f_{1,7} p_{1,5}}{p_{1,7}} + f_{5,7} \left(-1 - \frac{p_{5,2}}{p_{5,7}} \right) \\
\tilde{x}_{3,7} &\rightarrow 0 \\
\tilde{x}_{4,1} &\rightarrow 0 \\
\tilde{x}_{4,5} &\rightarrow 0 \\
\tilde{x}_{4,6} &\rightarrow 0 \\
\tilde{x}_{6,1} &\rightarrow 0 \\
\tilde{x}_{6,4} &\rightarrow \frac{f_{1,7} p_{1,4}}{p_{1,7}} + \frac{f_{5,7} p_{5,4}}{p_{5,7}} \\
\tilde{x}_{6,7} &\rightarrow 0 \\
\tilde{x}_{7,3} &\rightarrow f_{7,1} + f_{7,5} + f_{1,7} \left(-1 - \frac{p_{1,5}}{p_{1,7}} \right) + \frac{f_{1,7} p_{1,2}}{p_{1,7}} + \frac{f_{1,7} p_{1,3}}{p_{1,7}} + \frac{f_{1,7} p_{1,5}}{p_{1,7}} + f_{5,7} \left(-1 - \frac{p_{5,2}}{p_{5,7}} \right) + \frac{f_{5,7} p_{5,1}}{p_{5,7}} + \frac{f_{5,7} p_{5,2}}{p_{5,7}} + \frac{f_{5,7} p_{5,4}}{p_{5,7}} \\
\tilde{x}_{7,6} &\rightarrow \frac{f_{1,7} p_{1,4}}{p_{1,7}} + \frac{f_{1,7} p_{1,6}}{p_{1,7}} + \frac{f_{5,7} p_{5,4}}{p_{5,7}}
\end{aligned}$$

```
In[43]:= Simplify[(balanceEqs /. {x → x̃, ξ → 7}) /. ps]
```

Out[43]= {True, True, True, True, True, True, True}

```
In[44]:= matrt = Timing[δMatr = δ1[g, t]];
roott = VertexCount[g];
```

```
TableForm[δMatr, TableHeadings → {uNb[g, t], δ[[2]] #[[1]] == roott & /@ EdgeList[g]}] // forma
```

Out[46]//TableForm=

	$\delta_{2,5}$	$\delta_{3,5}$	$\delta_{3,1}$	$\delta_{4,1}$	$\delta_{4,5}$	$\delta_{4,6}$	$\delta_{6,4}$	$\delta_{2,1}$	$\delta_{6,1}$	δ_3	δ_6	δ_7
2 → 5	1	-1	1	0	0	0	0	-1	0	0	0	0
4 → 1	0	0	-1	1	0	0	1	0	0	-1	1	0
4 → 5	0	-1	0	0	1	0	1	0	0	-1	1	0
4 → 6	0	0	0	0	0	1	1	0	0	0	0	0
6 → 1	0	0	-1	0	0	0	0	0	1	-1	1	0
3 → 7	0	0	0	0	0	0	0	0	0	1	0	1
6 → 7	0	0	0	0	0	0	0	0	0	0	1	0

```
In[47]:= λ = SparseArray[λ, {Length[λ], Length[λ[[1]]] + 4}];
(*λ=λ[[;;-2]]*)
```

```
In[48]:= dopEq = # == 0 & /@ Flatten[λ.{x# & /@ EdgeList[g]}T];
dopEq // forma
```

Out[49]//TableForm=

$$\begin{aligned}
-\frac{p_{2,1} x_{2,1}}{p_{2,5}} + x_{2,5} &== 0 \\
-\frac{p_{3,1} x_{3,1}}{p_{3,5}} + x_{3,5} &== 0 \\
x_{4,1} - \frac{p_{4,5} x_{4,5}}{p_{4,1}} &== 0 \\
x_{4,1} - \frac{p_{4,6} x_{4,6}}{p_{4,1}} &== 0 \\
-\frac{p_{6,1} x_{6,1}}{p_{6,4}} + x_{6,4} &== 0
\end{aligned}$$

```
In[50]:= Δ = λ. (δMatr)τ;
"cycle det's:"
Δ // forma
```

```
Out[51]= cycle det's:
```

```
Out[52]//TableForm=
```

$$\begin{array}{ccccccc} 1 + \frac{p_{2 \rightarrow 1}}{p_{2 \rightarrow 5}} & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 - \frac{p_{3 \rightarrow 1}}{p_{3 \rightarrow 5}} & \frac{p_{3 \rightarrow 1}}{p_{3 \rightarrow 5}} & -1 & 0 & \frac{p_{3 \rightarrow 1}}{p_{3 \rightarrow 5}} & 0 & 0 \\ 0 & 1 & -\frac{p_{4 \rightarrow 5}}{p_{4 \rightarrow 1}} & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -\frac{p_{4 \rightarrow 6}}{p_{4 \rightarrow 1}} & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & -\frac{p_{6 \rightarrow 1}}{p_{6 \rightarrow 4}} & 0 & 0 \end{array}$$

```
In[53]:= "Uc="
Uc = {1, 2, 3, 4, 5}
"Unc="
Unc = {6, 7}
```

```
Out[53]= Uc =
```

```
Out[54]= {1, 2, 3, 4, 5}
```

```
Out[55]= Unc =
```

```
Out[56]= {6, 7}
```

```
In[57]:= Δc = Δ[ [All, Uc] ];
Δnc = Δ[ [All, Unc] ];
"Δc="
Δc // MatrixForm
```

```
Out[59]= Δc =
```

```
Out[60]//MatrixForm=
```

$$\begin{pmatrix} 1 + \frac{p_{2 \rightarrow 1}}{p_{2 \rightarrow 5}} & 0 & 0 & 0 & 0 \\ -1 - \frac{p_{3 \rightarrow 1}}{p_{3 \rightarrow 5}} & \frac{p_{3 \rightarrow 1}}{p_{3 \rightarrow 5}} & -1 & 0 & \frac{p_{3 \rightarrow 1}}{p_{3 \rightarrow 5}} \\ 0 & 1 & -\frac{p_{4 \rightarrow 5}}{p_{4 \rightarrow 1}} & 0 & 0 \\ 0 & 1 & 0 & -\frac{p_{4 \rightarrow 6}}{p_{4 \rightarrow 1}} & 0 \\ 0 & 1 & 1 & 1 & -\frac{p_{6 \rightarrow 1}}{p_{6 \rightarrow 4}} \end{pmatrix}$$

```
In[61]:= "det (Δc) ="
Simplify[Det[Δc]] // forma
```

```
Out[61]= det (Δc) =
```

```
Out[62]//TableForm=
```

$$\frac{(p_{2,1} + p_{2,5}) (p_{3,5} p_{4,1} p_{4,6} p_{6,1} - p_{3,1} (p_{4,1} p_{4,6} p_{6,4} + p_{4,5} (p_{4,1} p_{6,4} + p_{4,6} (p_{6,1} + p_{6,4})))}{p_{2,5} p_{3,5} p_{4,1}^2 p_{6,4}}$$

```
In[63]:= "UT="
utind = Cases[t[[6]], ξ_ /; ξ ≠ 0];
UT = EdgeList[g][[utind]]
```

```
Out[63]= UT =
```

```
Out[65]= {3 ↔ 1, 2 ↔ 1, 7 ↔ 3, 6 ↔ 4, 3 ↔ 5, 7 ↔ 6}
```

```
In[66]:= "UNb="
          UNb = uNb[g, t]
```

```
Out[66]= UNb =
```

```
Out[67]= { 2 ↔ 5, 4 ↔ 1, 4 ↔ 5, 4 ↔ 6, 6 ↔ 1, 3 ↔ 7, 6 ↔ 7 }
```

```
In[68]:= A = -λ. { x̃# & /@ EdgeList[g] }T /. ps;
          "A="
          A // MatrixForm
```

```
Out[69]= A =
```

```
Out[70]//MatrixForm=
```

$$\begin{pmatrix} \frac{p_{2 \leftrightarrow 1} \left(-\frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2}}{p_{1 \leftrightarrow 7}} - \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} \right)}{p_{2 \leftrightarrow 5}} \\ -f_{7 \leftrightarrow 5} - \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5}}{p_{1 \leftrightarrow 7}} - f_{5 \leftrightarrow 7} \left(-1 - \frac{p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} \right) + \frac{p_{3 \leftrightarrow 1} \left(f_{7 \leftrightarrow 1} + f_{1 \leftrightarrow 7} \left(-1 - \frac{p_{1 \leftrightarrow 5}}{p_{1 \leftrightarrow 7}} \right) + \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2}}{p_{1 \leftrightarrow 7}} + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 1}}{p_{5 \leftrightarrow 7}} + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} \right)}{p_{3 \leftrightarrow 5}} \\ 0 \\ 0 \\ -\frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 4}}{p_{1 \leftrightarrow 7}} - \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 4}}{p_{5 \leftrightarrow 7}} \end{pmatrix}$$

```
β = A - Δnc. { x# & /@ UNb [ [Unc] ] }T;
"β="
β // forma
```

```
Out[89]= β =
```

```
Out[90]//TableForm=
```

$$\begin{pmatrix} \frac{p_{2,1} \left(-\frac{f_{1,7} p_{1,2}}{p_{1,7}} - \frac{f_{5,7} p_{5,2}}{p_{5,7}} \right)}{p_{2,5}} \\ -f_{7,5} - \frac{f_{1,7} p_{1,5}}{p_{1,7}} + \frac{f_{5,7} (p_{5,2} + p_{5,7})}{p_{5,7}} + \frac{p_{3,1} (f_{5,7} p_{1,7} (p_{5,1} + p_{5,2}) + (f_{1,7} (p_{1,2} - p_{1,5} - p_{1,7}) + f_{7,1} p_{1,7}) p_{5,7})}{p_{1,7} p_{3,5} p_{5,7}} \\ 0 \\ 0 \\ -\frac{f_{1,7} p_{1,4}}{p_{1,7}} - \frac{f_{5,7} p_{5,4}}{p_{5,7}} \end{pmatrix}$$

```
In[74]:= "решаем уравнение Δcxc=β:"
          xc = LinearSolve[Δc, β]
```

```
Out[74]= решаем уравнение Δcxc=β:
```

```
Out[75]= { { -  $\frac{p_{2 \leftrightarrow 1} (f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{5 \leftrightarrow 2} + f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2} p_{5 \leftrightarrow 7})}{p_{1 \leftrightarrow 7} (p_{2 \leftrightarrow 1} + p_{2 \leftrightarrow 5}) p_{5 \leftrightarrow 7}}$  },
```

$$\left\{ \left(p_{4 \leftrightarrow 5} p_{4 \leftrightarrow 6} \left(f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 1} p_{6 \leftrightarrow 1} + f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 1} p_{6 \leftrightarrow 1} + \right. \right.$$

$$f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 2} p_{6 \leftrightarrow 1} + f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 2} p_{6 \leftrightarrow 1} -$$

$$f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} +$$

$$f_{7 \leftrightarrow 1} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} + f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5} p_{2 \leftrightarrow 5}$$

$$p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} + f_{7 \leftrightarrow 1} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} -$$

$$f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} + f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1}$$

$$p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{7 \leftrightarrow 5} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} +$$

$$f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{7 \leftrightarrow 5} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} -$$

$$f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 4} p_{6 \leftrightarrow 4} - f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 4} p_{6 \leftrightarrow 4} -$$

$$f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 4} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 4} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 4} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 4} \left. \right) \right\} /$$

$$(p_{1 \leftrightarrow 7} (p_{2 \leftrightarrow 1} + p_{2 \leftrightarrow 5}) p_{5 \leftrightarrow 7} (-p_{3 \leftrightarrow 5} p_{4 \leftrightarrow 1} p_{4 \leftrightarrow 6} p_{6 \leftrightarrow 1} + p_{3 \leftrightarrow 1} p_{4 \leftrightarrow 5} p_{4 \leftrightarrow 6} p_{6 \leftrightarrow 1} +$$

$$p_{3 \leftrightarrow 1} p_{4 \leftrightarrow 1} p_{4 \leftrightarrow 5} p_{6 \leftrightarrow 4} + p_{3 \leftrightarrow 1} p_{4 \leftrightarrow 1} p_{4 \leftrightarrow 6} p_{6 \leftrightarrow 4} + p_{3 \leftrightarrow 1} p_{4 \leftrightarrow 5} p_{4 \leftrightarrow 6} p_{6 \leftrightarrow 4})),$$

$$\left\{ \left(p_{4 \leftrightarrow 1} p_{4 \leftrightarrow 6} \left(f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 1} p_{6 \leftrightarrow 1} + f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 1} p_{6 \leftrightarrow 1} + \right. \right.$$

$$f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 2} p_{6 \leftrightarrow 1} + f_{5 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 2} p_{6 \leftrightarrow 1} -$$

$$f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} +$$

$$f_{7 \leftrightarrow 1} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} + f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} -$$

$$f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} +$$

$$f_{7 \leftrightarrow 1} p_{1 \leftrightarrow 7} p_{2 \leftrightarrow 5} p_{3 \leftrightarrow 1} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} - f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2} p_{2 \leftrightarrow 1} p_{3 \leftrightarrow 5} p_{5 \leftrightarrow 7} p_{6 \leftrightarrow 1} -$$

[illegible]
$$\begin{aligned}
X_{3 \leftrightarrow 5} &\rightarrow f_{7 \leftrightarrow 5} + \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5}}{p_{1 \leftrightarrow 7}} + f_{5 \leftrightarrow 7} \left(-1 - \frac{p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} \right) - X_{2 \leftrightarrow 5} - X_{4 \leftrightarrow 5} \\
X_{3 \leftrightarrow 1} &\rightarrow f_{7 \leftrightarrow 1} + f_{1 \leftrightarrow 7} \left(-1 - \frac{p_{1 \leftrightarrow 5}}{p_{1 \leftrightarrow 7}} \right) + \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2}}{p_{1 \leftrightarrow 7}} + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 1}}{p_{5 \leftrightarrow 7}} + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} + X_{2 \leftrightarrow 5} - X_{4 \leftrightarrow 1} - X_{6 \leftrightarrow 1} \\
X_{6 \leftrightarrow 4} &\rightarrow \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 4}}{p_{1 \leftrightarrow 7}} + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 4}}{p_{5 \leftrightarrow 7}} + X_{4 \leftrightarrow 1} + X_{4 \leftrightarrow 5} + X_{4 \leftrightarrow 6} \\
X_{2 \leftrightarrow 1} &\rightarrow -\frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2}}{p_{1 \leftrightarrow 7}} - \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} - X_{2 \leftrightarrow 5} \\
X_{7 \leftrightarrow 3} &\rightarrow f_{7 \leftrightarrow 1} + f_{7 \leftrightarrow 5} + f_{1 \leftrightarrow 7} \left(-1 - \frac{p_{1 \leftrightarrow 5}}{p_{1 \leftrightarrow 7}} \right) + \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 2}}{p_{1 \leftrightarrow 7}} + \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 3}}{p_{1 \leftrightarrow 7}} + \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 5}}{p_{1 \leftrightarrow 7}} + f_{5 \leftrightarrow 7} \left(-1 - \frac{p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} \right) + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 1}}{p_{5 \leftrightarrow 7}} + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 2}}{p_{5 \leftrightarrow 7}} \\
X_{7 \leftrightarrow 6} &\rightarrow \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 4}}{p_{1 \leftrightarrow 7}} + \frac{f_{1 \leftrightarrow 7} p_{1 \leftrightarrow 6}}{p_{1 \leftrightarrow 7}} + \frac{f_{5 \leftrightarrow 7} p_{5 \leftrightarrow 4}}{p_{5 \leftrightarrow 7}} + X_{4 \leftrightarrow 1} + X_{4 \leftrightarrow 5} + X_{6 \leftrightarrow 1} + X_{6 \leftrightarrow 7}
\end{aligned}$$
[illegible]

```
Out[85]= {True, True, True, True, True}
```

In[86]:=