References

35. V. Chvátal: Linear Programming, Freeman, New York, 1983.


**References added for softcover edition**


Notation Table

Chapter 1

$\xi^i$: current in branch $i$ §1.1.2
$\eta_i$: voltage across branch $i$ §1.1.2
$\nu(A)$: index of polynomial matrix $A$ (1.2)
$A_{\text{str}}$: structured matrix associated with polynomial matrix $A$ (1.5)
$\nu_{\text{str}}(A)$: structural index of polynomial matrix (1.6)
$A$-$Q_1$: assumption on $Q$-part of mixed polynomial matrix §1.2.1
$A$-$T$: assumption on $T$-part of mixed polynomial matrix §1.2.1
$A$-$Q_2$: stronger assumption on $Q$-part of mixed polynomial matrix §1.2.3
$F$: field §1.3.1
$K$: ground field, subfield of $F$ §1.3.1
$A = Q + T$: mixed matrix (1.32)
$M$-$Q$: assumption on $Q$-part of mixed matrix §1.3.1
$M$-$T$: assumption on $T$-part of mixed matrix §1.3.1
$T$: set of independent parameters §1.3.1
$A(s) = Q(s) + T(s)$: mixed polynomial matrix (1.33)
$MP$-$Q_1$: assumption on $Q$-part of mixed polynomial matrix §1.3.1
$MP$-$T$: assumption on $T$-part of mixed polynomial matrix §1.3.1
$MP$-$Q_2$: stronger assumption on $Q$-part of mixed polynomial matrix §1.3.1

Chapter 2

$F$: field §2.1.1
$K$: ground field, subfield of $F$ §2.1.1
$Q$: field of rational numbers §2.1.1
$R$: field of real numbers §2.1.1
$K[X]$: ring of polynomials in $X$ over $K$ §2.1.1
deg $p$: degree of polynomial $p$ §2.1.1
$K(X)$: field of rational functions in $X$ over $K$ §2.1.1
$K[X,1/X]$: ring of Laurent polynomials in $X$ over $K$ §2.1.1
ord $f$: order of Laurent polynomial $f$ §2.1.1
$K(Y)$: field adjunction of $Y$ to $K$ §2.1.1
$K[Y]$: ring adjunction of $Y$ to $K$ §2.1.1
\( \dim_K F \): degree of transcendency of \( F \) over \( K \)  
\( \text{Row}(A) \): row set of matrix \( A \)  
\( \text{Col}(A) \): column set of matrix \( A \)  
\( A_{ij} \): \((i,j)\)-entry of matrix \( A \)  
\( A[I,J] \): submatrix of \( A \) with row set \( I \) and column set \( J \)  
\( \det A \): determinant of matrix \( A \)  
\( \text{GL}(n, F) \): set of nonsingular matrices of order \( n \) over \( F \)  
\( \text{BM}_\pm \): simultaneous exchange property of matroids  
\( \text{VM} \): axiom of valuated matroids  
\( \text{OM} \): axiom of oriented matroids  
\( \text{rank } A \): rank of matrix \( A \)  
\( \text{term-rank } A \): term-rank of matrix \( A \)  
\( G = (V, A) \): graph with vertex set \( V \) and arc set \( A \)  
\( \partial^+ a \): initial vertex of arc \( a \)  
\( \partial^- a \): terminal vertex of arc \( a \)  
\( \partial a \): set of vertices incident to arc \( a \)  
\( \delta^+ v \): set of arcs leaving vertex \( v \)  
\( \delta^- v \): set of arcs entering vertex \( v \)  
\( \delta v \): set of arcs incident to vertex \( v \)  
\( G \setminus U \): graph obtained from \( G \) by deleting vertices in \( U \)  
\( u \rightarrow v \): directed path exists from \( u \) to \( v \)  
\( \sim \): equivalence relation by reachability  
\( \preceq \): partial order among strong components  
\( G = (V^+, V^-; A) \): bipartite graph with bipartition \((V^+, V^-)\) of vertex set and arc set \( A \)  
\( G^k_0 \): dynamic graph of time-span \( k \)  
\( \mathcal{L} \): sublattice of \( 2^V \)  
\( \mathcal{L}_{\text{min}}(f) \): family of the minimizers of \( f \)  
\( \mathcal{P}(\mathcal{L}) \): partition determined by sublattice \( \mathcal{L} \)  
\( \mathcal{L}(\mathcal{P}) \): sublattice determined by partition \( \mathcal{P} \)  
\( A(V; V_0, V_\infty) \): collection of sublattices of \( 2^V \) with minimum \( V_0 \) and maximum \( V \setminus V_\infty \)  
\( \Pi(V; V_0, V_\infty) \): collection of pairs of a partition of \( V \) with two distinguished subsets \( V_0 \) and \( V_\infty \) and a partial order \( \preceq \)  
\( \prec \): \( \preceq \) and \( \neq \)  
\( \prec \cdot \): “covered by” relation with respect to a partial order  
\( \langle \cdot \rangle \): set of elements below with respect to a partial order  
\( \mathcal{L} = (S, \lor, \land) \): lattice with join \( \lor \) and meet \( \land \)  
\( M \): matching  
\( \partial^+ M \): set of vertices in \( V^+ \) incident to arcs in \( M \)  
\( \partial^- M \): set of vertices in \( V^- \) incident to arcs in \( M \)  
\( \partial M \): set of vertices incident to arcs in \( M \)  
\( \nu(G) \): size of a maximum matching in bipartite graph \( G \)  
\( (U^+, U^-) \): cover of bipartite graph \( G \)
Notation Table

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<td>$G = (V, A; X, Y)$</td>
<td>graph with vertex set $V$, arc set $A$, entrance $X$, and exit $Y$</td>
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<td>$N = (V, A, \tau, \xi, \gamma)$</td>
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<td>$\text{BM}_{\pm}$</td>
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<td>$\text{BM}<em>{\pm</em>{\text{loc}}}$</td>
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<td>$G(B, B')$</td>
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<td>$\kappa(U)$</td>
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<td>$\Gamma$</td>
<td>set of adjacent vertices</td>
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<td>$\mathbf{M}_1 \vee \mathbf{M}_2$</td>
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<td>$\mathbf{L} = (S, T, \Lambda)$</td>
<td>bimatroid with row set $S$, column set $T$, and family of linked pairs $\Lambda$</td>
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<td>$\text{Row} \mathbf{L}$</td>
<td>row set of bimatroid $\mathbf{L}$</td>
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<td>$\text{Col} \mathbf{L}$</td>
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<td>$\text{RM} \mathbf{L}$</td>
<td>row matroid of bimatroid $\mathbf{L}$</td>
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</table>
CM(L) : column matroid of bimatroid L  
G(L) : underlying bipartite graph of bimatroid L  
L \ Z : deletion of Z from bimatroid L  
(D(L), A(L), C(L)) : canonical partition of bimatroid L  
L[X, Y] : restriction of bimatroid L to (X, Y)  
L^* : dual of bimatroid L  
L^{-1} : inverse of bimatroid L  
L_1 \lor L_2 : union of bimatroids L_1 and L_2  
L_1 \star L_2 : product of bimatroids L_1 and L_2  
L \star M : matroid induced from matroid M by bimatroid L

Chapter 3

\[ D : (\text{multi})\text{set of numbers characterizing a physical system} \] (3.8)  
\[ Q : (\text{multi})\text{set of accurate numbers} \] (3.9)  
\[ T : (\text{multi})\text{set of inaccurate numbers} \] (3.9)  
GA1 : first generality assumption  
GA2 : second generality assumption  
GA3 : third generality assumption  
\[ A = Q + T : \text{mixed matrix} \] (3.13)  
M-Q : assumption on Q-part of mixed matrix  
M-T : assumption on T-part of mixed matrix  
\[ \text{MM}(K, F; m, n) : \text{set of } m \times n \text{ mixed matrices with respect to } (K, F) \]  
\[ \text{MM}(K, F) : \text{set of mixed matrices with respect to } (K, F) \]  
\[ A(s) = Q(s) + T(s) : \text{mixed polynomial matrix} \] (3.20)  
MP-Q1 : assumption on Q-part of mixed polynomial matrix  
MP-T : assumption on T-part of mixed polynomial matrix  
\[ \text{D}(F; m, n; Z_1, \ldots, Z_d) : \text{set of } m \times n \text{ dimensioned matrices with} \] 
\[ \text{ground field } F \text{ and fundamental quantities } Z_1, \ldots, Z_d \]  
\[ \text{D}(F; Z_1, \ldots, Z_d) : \text{set of dimensioned matrices with ground}\] 
\[ \text{field } F \text{ and fundamental quantities } Z_1, \ldots, Z_d \]  
\[ D_r : \text{diagonal matrix representing physical dimensions of rows} \] (3.27)  
\[ D_c : \text{diagonal matrix representing physical dimensions of columns} \] (3.28)  
\[ U(R; m, n) : \text{set of } m \times n \text{ totally unimodular matrices over ring } R \]  
\[ U(R) : \text{set of totally unimodular matrices over ring } R \]  
\[ F(Z_1, \ldots, Z_d) : \text{ring generated over } F \text{ by formal fractional} \] 
\[ \text{powers of } Z_1, \ldots, Z_d \]  
MP-Q2 : stronger assumption on Q-part of mixed polynomial matrix  

Chapter 4

\[ A = Q + T : \text{mixed matrix} \] (4.1)  
M-Q : assumption on Q-part of mixed matrix  
M-T : assumption on T-part of mixed matrix  
\[ \text{MM}(K, F; m, n) : \text{set of } m \times n \text{ mixed matrices with respect to } (K, F) \]
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<td>$\text{MM}(K, F)$</td>
<td>set of mixed matrices with respect to $(K, F)$</td>
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<td>$A = \begin{pmatrix} Q &amp; T \end{pmatrix}$</td>
<td>LM-matrix</td>
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<td>$LQ$</td>
<td>assumption on $Q$-part of LM-matrix</td>
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<td>$LT$</td>
<td>assumption on $T$-part of LM-matrix</td>
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<td>set of $(m_Q + m_T) \times n$ LM-matrices with respect to $(K, F)$</td>
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<td>term-rank of $T$-part</td>
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<td>$\psi(J, S_c)$</td>
<td>subspace determined by $(J, S_c)$</td>
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<td>$\mathcal{W}$</td>
<td>family of subspaces of $V$ compatible with $\Gamma$</td>
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<td>$p_{\text{PE}}$</td>
<td>PE-surplus function</td>
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<td>$\mathcal{L}<em>{\text{min}}(p</em>{\text{PE}})$</td>
<td>family of minimizers of PE-surplus function $p_{\text{PE}}$</td>
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<td>family of subspaces of $V$ with property</td>
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<td>partially ordered set determined by $\bar{A}$</td>
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<td>distributive lattice of order ideals of $\mathcal{P}(\bar{A})$</td>
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<td>$\psi(J, S_c)$</td>
<td>subspace determined by $(J, S_c)$</td>
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<tr>
<td>$\mathcal{W}^\circ$</td>
<td>family of subspaces of $V$ compatible with $\Gamma$</td>
</tr>
<tr>
<td>$\mathcal{Y}^\circ$</td>
<td>family of subspaces of $U$ compatible with $\Pi$</td>
</tr>
</tbody>
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Notation Table

\( \lambda \): GP-birank function \( (4.130) \)

\( \mathcal{L} \): lattice \( §4.9.2 \)

\( f \): submodular function \( §4.9.2 \)

\( \preceq \): partial order in \( \mathcal{L} \) \( §4.9.2 \)

\( \mathcal{L}_{\text{min}}(f; X) \): sublattice of minimizers of \( f \) not smaller than \( X \) \( (4.134) \)

\( D(f; X) \): minimum element of \( \mathcal{L}_{\text{min}}(f; X) \) \( (4.135) \)

\( K_{\text{PS}}(f) \): principal structure of \( (\mathcal{L}, f) \) \( (4.136) \)

\( \mathcal{L}_{\text{PS}}(f) \): principal sublattice of \( (\mathcal{L}, f) \) \( §4.9.2 \)

\( \mathcal{L}_{\text{min}}(f) \): family of minimizers of \( f \) \( (4.137) \)

\( D(f; v) \): minimum element of \( \mathcal{L}_{\text{min}}(f; v) \) \( §4.9.2 \)

\( B_{\text{row}} \): family of row-bases of a matrix \( (4.139) \)

\( q \): surplus function for horizontal principal structure \( (4.153) \)

\( \mathcal{L}_{\text{CCF}}(R, J) \): sublattice corresponding to \( \mathcal{P}_{\text{CCF}}(I, C) \) \( §4.9.5 \)

\( \mathcal{L}(\omega, \alpha) \): level set \( (5.42) \)

Chapter 5

\( d_k \): \( k \)th determinantal divisor \( (5.1) \)

\( e_k \): \( k \)th invariant factor (invariant polynomial) \( (5.2) \)

\( \delta_k \): highest degree of a minor of order \( k \) \( (5.3) \)

\( t_k \): contents at infinity \( (5.4) \)

\( \mathcal{M} = (V, \omega) \): valued matroid on \( V \) with valuation \( \omega \) \( §5.2.1 \)

\( \mathcal{M} = (V, B, \omega) \): valued matroid on \( V \) with family of bases \( B \) and valuation \( \omega \) \( §5.2.1 \)

\( \mathcal{V}_M \): exchange axiom of valued matroids \( §5.2.1 \)

\( \mathcal{M}[p] = (V, B, \omega[p]) \): similarity transformation of valued matroid \( \mathcal{M} \) \( (5.16) \)

\( \mathcal{M}^* = (V, B^*, \omega^*) \): dual of valued matroid \( \mathcal{M} \) \( §5.2.3 \)

\( \mathcal{M}^U_i = (V, B^U_i, \omega^U_i) \): restriction of valued matroid \( \mathcal{M} \) \( §5.2.3 \)

\( \mathcal{M}_{U,J} = (V, B_U, \omega^U) \): contraction of valued matroid \( \mathcal{M} \) \( §5.2.3 \)

\( \mathcal{M}_{k, S_0} = (V, B_k, \omega_k, S_0) \): truncation of valued matroid \( \mathcal{M} \) \( (5.19) \)

\( \mathcal{M}^{I,J_0} = (V, B_j, \omega^{I,J_0}) \): elongation of valued matroid \( \mathcal{M} \) \( (5.20) \)

\( \omega(B, u, v) \): exchange gain \( (5.21) \)

\( \mathcal{V}_B \): exchange axioms of valued bimatroids \( §5.2.5 \)

\( (S, T, \delta) \): valued bimatroid \( §5.2.5 \)

\( (S, T, \Lambda, \delta) \): valued bimatroid \( §5.2.5 \)

\( \mathcal{M}_1 \vee \mathcal{M}_2 \): union of valued matroids \( \mathcal{M}_1 \) and \( \mathcal{M}_2 \) \( §5.2.6 \)

\( \mathcal{V}_M_w \): weak exchange axiom of valued matroids \( §5.2.7 \)

\( \mathcal{V}_M_{\text{loc}} \): local exchange axiom of valued matroids \( §5.2.7 \)

\( \mathcal{V}_M_d \): variant of exchange axiom of valued matroids \( §5.2.7 \)

\( B_p \): set of maximizers of \( \omega[p] \) \( §5.2.7 \)

\( \mathcal{L}(\omega, \alpha) \): level set \( (5.42) \)
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<td>BL</td>
<td>exchange property of level sets</td>
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<tr>
<td>BL&lt;sub&gt;w&lt;/sub&gt;</td>
<td>weaker exchange property of level sets</td>
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<td>VIAP(k)</td>
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<td>(\Omega(M, B^+, B^-))</td>
<td>objective function of VIAP(k)</td>
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<td>diag ((s; p))</td>
<td>diagonal matrix with diagonal entries (s^{p_i})</td>
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**Chapter 6**

\[ A(s) = Q(s) + T(s) : \text{mixed polynomial matrix} \] (6.3)

MP-Q1 : assumption on \(Q\)-part of mixed polynomial matrix §6.1.1

MP-T : assumption on \(T\)-part of mixed polynomial matrix §6.1.1

MP-Q2 : stronger assumption on \(Q\)-part of mixed polynomial matrix §6.1.1

\[ A(s) = \begin{pmatrix} Q(s) \\ T(s) \end{pmatrix} : \text{LM-polynomial matrix} \] (6.5)

\(\delta_k\) : highest degree of a minor of order \(k\) (6.9)

\(o_k\) : lowest order of a minor of order \(k\) (6.11)

\(\delta_{k,LM}\) : highest degree of a minor of order \(m_Q + k\) for LM-matrix (6.16)

\(d_k\) : \(k\)th determinantal divisor (6.51)

\(e_k\) : \(k\)th invariant factor (invariant polynomial) (6.52)

\(\Sigma_A\) : Smith form of \(A\) §6.3.1

\[ D(s) = [A - sF \mid B] : \text{modal controllability matrix} \] (6.67)

\(G^n_0\) : dynamic graph of time-span \(n\) §6.4.2

\(\zeta\) : weight function for \(Q\)-part (6.74)

\(\xi_k\) : highest degree of a nonzero term in \(\det T_k[\text{Row}(T_k), J]\) §6.4.2

\(\eta_k\) : lowest degree of a nonzero term in \(\det \tilde{T}_k[\text{Row}(\tilde{T}_k), J]\) §6.4.2

\(\psi(s; A, B, C, K)\) : fixed polynomial of \((A, B, C)\) with respect to \(K\) (6.84)

\(K\) : feedback structure (6.85)

\(C_K\) : family of covers of feedback structure \(K\) (6.86)

\(S\) : set of nonzero entries of \(K\) §6.5.3

\(\psi(s)\) : fixed polynomial (6.95)

\(\zeta\) : weight function for \(Q\)-part (6.100)

\(\eta(J)\) : lowest degree of a nonzero term in \(\det \tilde{T}_K[\text{Row}(\tilde{T}_K), J]\) (6.101)

\(\Psi_0\) : index set (6.103)

\(\Psi_1\) : index set (6.104)

\(\Psi_2\) : index set (6.105)

**Chapter 7**

\(\delta_k\) : highest degree of a minor of order \(k\) (7.1)

\(\hat{\delta}_k\) : combinatorial counterpart of \(\delta_k\) (7.2)

\(A^\circ = (A^\circ_{ij})\) : leading coefficient matrix (7.3)
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