## **CONTENTS**

List of Title	ed Ex	camples and Problems	хi
Foreword	by Michael Isaacson		xvii
Acknowled	dgme	ents	xix
Preface			ххі
Organizati	on, N	lotation, and Conventions	xxiii
Chapter 1	Mathematical Preliminaries by Pál Rózsa		
	1.1		1
	1.2	T	6
		The Rank of a Matrix	14
	1.4	J - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	19
		1.4.1 Homogeneous Case	19
	1.5	1.4.2 Nonhomogeneous Case	23
	1.5	List of Selected Publications Dealing with Linear Algebra and Matrices	26
Chapter 2	For	mats and Classification	27
	2.1	Formats for Physical Relations	27
		2.1.1 Numeric Format	27
		2.1.2 Symbolic Format	29
		2.1.3 Mixed Format	30
	2.2	Classification of Physical Quantities	32
		2.2.1 Variability	32
,		2.2.2 Dimensionality	33
Chapter 3		nensional Systems	37
	3.1	General Statements	37
		3.1.1 Monodimensional System	38
		3.1.2 Omnidimensional System	41
	2.2	3.1.3 Multidimensional System	42
		Classification	42
	3.3		43
		3.3.1 Preliminary Remarks	43

vi CONTENTS

		3.3.2 Structure	44
		(a) Fundamental Dimensions	44
		(b) Derived Dimensionless Units	50
		(c) Derived Dimensional Units with	
		Specific Names	53
		(d) Derived Dimensional Units without	
		Specific Names	53
		(e) Non-SI Units Permanently Permitted to	
		be Used with SI	56
		(f) Non-SI Units Temporarily Permitted to	
		be Used with SI	59
		(g) Prohibited Units	59
		3.3.3 Prefixes	59
		3.3.4 Rules of Etiquette in Writing Dimensions	63
		3.3.4.1 Problems	65
	3.4	Other Than SI Dimensional Systems	66
	J. <del>T</del>	3.4.1 Metric, Mass-based Systems	66
		(a) CGS System	66
		(b) SI (for reference only)	67
		3.4.2 Metric, Force-based System	67
		3.4.3 American/British Force (Engineering) System	67
•		3.4.4 American/British Mass (Scientific) System	67
	3.5	A Note on the Classification of Dimensional Systems	68
Chanter 4	Tra	nsformation of Dimensions	69
Chapter 4		nsformation of Dimensions Numerical Equivalences	<b>69</b>
Chapter 4	4.1	Numerical Equivalences	
Chapter 4	4.1 4.2	Numerical Equivalences Technique	69
Chapter 4	4.1 4.2	Numerical Equivalences	69 73
Chapter 4 Chapter 5	4.1 4.2 4.3 4.4	Numerical Equivalences Technique Examples	69 73 74
Chapter 5	4.1 4.2 4.3 4.4 <b>Ari</b>	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions	69 73 74 91
-	4.1 4.2 4.3 4.4 Ari	Numerical Equivalences Technique Examples Problems thmetic of Dimensions mensional Homogeneity	69 73 74 91 <b>95</b>
Chapter 5	4.1 4.2 4.3 4.4 <b>Ari</b>	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions mensional Homogeneity Equations	69 73 74 91 <b>95</b> <b>99</b> 99
Chapter 5	4.1 4.2 4.3 4.4 <b>Ari</b> <b>Dir</b> 6.1	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions mensional Homogeneity Equations	69 73 74 91 <b>95</b> <b>99</b>
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 <b>Ari</b> <b>Dir</b> 6.1 6.2 6.3	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions mensional Homogeneity Equations Graphs Problems	69 73 74 91 <b>95</b> <b>99</b> 110 126
Chapter 5	4.1 4.2 4.3 4.4 <b>Ari</b> <b>Dir</b> 6.1 6.2 6.3	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions mensional Homogeneity Equations Graphs	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b>
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 Ari Dir 6.1 6.2 6.3 Str	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  ructure of Physical Relations Monomial Power Form	69 73 74 91 <b>95</b> <b>99</b> 110 126
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 <b>Ari</b> 6.1 6.2 6.3 <b>Str</b> 7.1 7.2	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  ructure of Physical Relations Monomial Power Form The Dimensional Matrix	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b> 133
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 Ari Dir 6.1 6.2 6.3 Str 7.1	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  ructure of Physical Relations Monomial Power Form	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b>
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 <b>Ari</b> 6.1 6.2 6.3 <b>Str</b> 7.1 7.2	Numerical Equivalences Technique Examples Problems  Thmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  Fucture of Physical Relations Monomial Power Form The Dimensional Matrix Generating Products of Variables of Desired Dimension	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b> 133 134
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 <b>Ari</b> 6.1 6.2 6.3 <b>Str</b> 7.1 7.2 7.3	Numerical Equivalences Technique Examples Problems  Ithmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  Fucture of Physical Relations Monomial Power Form The Dimensional Matrix Generating Products of Variables of Desired Dimension Number of Independent Sets of Products of Given Dimension (I)	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b> 133 134 135
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 <b>Ari</b> 6.1 6.2 6.3 <b>Str</b> 7.1 7.2 7.3	Numerical Equivalences Technique Examples Problems  Ithmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  Fucture of Physical Relations Monomial Power Form The Dimensional Matrix Generating Products of Variables of Desired Dimension Number of Independent Sets of Products of Given Dimension (I)	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b> 133 134 135
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 Ari Dir 6.1 6.2 6.3 Str 7.1 7.2 7.3	Numerical Equivalences Technique Examples Problems  Ithmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  Fucture of Physical Relations Monomial Power Form The Dimensional Matrix Generating Products of Variables of Desired Dimension Number of Independent Sets of Products of Given Dimension (I) Completeness of the Set of Products of Variables Special Case: Matrix A is Singular	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b> 133 134 135
Chapter 5 Chapter 6	4.1 4.2 4.3 4.4 Ari Dir 6.1 6.2 6.3 Str 7.1 7.2 7.3 7.4	Numerical Equivalences Technique Examples Problems  thmetic of Dimensions  mensional Homogeneity Equations Graphs Problems  ructure of Physical Relations Monomial Power Form The Dimensional Matrix Generating Products of Variables of Desired Dimension Number of Independent Sets of Products of Given Dimension (I) Completeness of the Set of Products of Variables Special Case: Matrix A is Singular	69 73 74 91 <b>95</b> <b>99</b> 110 126 <b>133</b> 133 134 135

CONTENTS	vii

	7.8	Selectable and Nonselectable Dimensions in a	
		Product of Variables	151
	7.9	Minimum Number of Independent Products of	
	<b>-</b>	Variables of Given Dimension	152
		Constancy of the Sole Dimensionless Product	153
	7.11	Number of Dimensions Equals or Exceeds the	
		Number of Variables	157
		7.11.1 Number of Dimensions Equals the Number	
		of Variables	157
		7.11.2 Number of Dimensions Exceeds the Number	1.50
	7 12	of Variables Problems	159
			160
Chapter 8		tematic Determination of Complete Set	
		Products of Variables	163
	8.1	Dimensional Set; Derivation of Products of Variables	4.0
	0.1	of a Given Dimension	163
	8.2 8.3	Checking the Results The Fundamental Formula	171
	0.5	The Fundamental Formula	176
Chapter 9		nsformations	181
	9.1	Theorems Related to Some Specific Transformations	181
	9.2	Transformation between Systems of Different	
	0.0	D Matrices	202
	9.3	Transformation between Dimensional Sets	211
	9.4	Independence of Dimensionless Products of the	
		Dimensional System Used	225
Chapter 10		nber of Sets of Dimensionless Products	
		/ariables	229
		Distinct and Equivalent Sets	229
	10.2	Changes in a Dimensional Set Not Affecting the	
	10.0	Dimensionless Variables	231
	10.3	Prohibited Changes in a Dimensional Set	238
	10.4	10.3.1 Duplications	242
		Number of Distinct Sets	244
	10.5	Exceptions 10.5.1 Dimensionally Irralevent Verichle	250
		10.5.1 Dimensionally Irrelevant Variable 10.5.2 In Matrix C, One Row is a Multiple of	250
		Another Row	255
	10.6	Problems	255 259
			439
Chapter 11		evancy of Variables	263
	11.1	Dimensional Irrelevancy	263
		11.1.1 Condition	263
		11.1.2 Adding a Dimensionally Irrelevant Variable	~
		to a Set of Relevant Variables	267 268
			/n×

viii CONTENTS

	11.2	Physical Irrelevancy	274
	1	11.2.1 Condition	274
		11.2.2 Techniques to Identify a Physically	
		Irrelevant Variable	276
		Common Sense	277
		Existence of Dimensional Irrelevancy	277
		Heuristic Reasoning	280
		Tests Combined with Deft Interpretation	
		of Results	296
	112	Problems	312
	11.5	Fronchis	
Chapter 12	Eco	nomy of Graphical Presentation	317
-	12.1	Number of Curves and Charts	317
	12.2	Problems	329
Chapter 13	Fori	ms of Dimensionless Relations	333
<u>-</u>	13.1	General Classification	333
		Monomial is Mandatory	335
	13.3	Monomial is Impossible—Proven	338
	13.4	Monomial is Impossible—Not Proven	348
		Reconstructions	353
		13.5.1 Determination of Exponents of Monomials	353
		The Measurement Method	353
		The Analytic Method	354
		The Heuristic Reasoning Method	354
		13.5.2 Determination of Some Nonmonomials	366
	13.6	Problems	373
Chapter 14	Sed	uence of Variables in the	
Olimpio	Din	nensional Set	381
	14.1	Dimensionless Physical Variable is Present	381
	14.2	Physical Variables of Identical Dimensions are Present	385
	14.3	Independent and Dependent Variables	389
		Problems	399
Chapter 15	Alt	ernate Dimensions	401
_		thods of Reducing the Number of	
Chapter 10	Din	nensionless Variables	413
	16.1	Reduction of the Number of Physical Variables	414
		Presion of Dimensionless Variables	427
	16.2	Increasing the Number of Dimensions	433
	10.5	16.3.1 Dimension Splitting	433
		16.3.2 Importation of New Dimensions	449
		16.3.3 Using Both Mass and Force Dimensions	454
	167	1 Problems	460

CONTENTS

Chapter 17	Dimensional Modeling	463
	17.1 Introductory Remarks	463
	17.2 Homology	467
	17.3 Specific Similarities	468
	17.3.1 Geometric Similarity	468
	17.3.2 Kinematic Similarity	471
	17.3.3 Dynamic Similarity	471
	17.3.4 Thermal (or Thermic) Similarity	472
	17.4 Dimensional Similarity	472
	17.4.1 Scale Factors	479
	17.4.2 Model Law	479
	17.4.3 Categories and Relations	489
	Categories	489
	Relations	492
	17.4.4 Modeling Data Table	495
	17.5 Scale Effects	511
	17.6 Problems	523
Chapter 18	Forty-three Additional Applications	527
References:		
	Numerical Order	635
	Alphabetical Order (by Authors' Surname)	643
Appendices:	1	651
	1 Recommended Names and Symbols for Some	•
	Physical Quantities	653
	2 Some More-Important Physical Constants	657
	3 Some More-Important <i>Named</i> Dimensionless Variables	658
	4 Notes Attached to Figures	667
	5 Acronyms	695
	6 Solutions of Problems	696
	7 Proofs of Selected Theorems and Equations	770
:	8 Blank Modeling Data Table	775
Indices		
	Subject Index	776
	Surname Index	787