Detailed program of the course. Malematica per le applicazioni Economiche 2 Laboratorio. Tutti i paragrafi cerchiati nell'indice. degliappunti in rete, come riportato di seguto

Contents

Ι	Basic Linear Algebra	7
1	Systems of linear equations	9
	(1.1) Linear equations and solutions	. 9
	(1.2) Systems of linear equations, equivalent systems and elementary operations	. 10
	1.3 Systems in triangular and echelon form	. 11
	1.4 Reduction algorithm	. 12
	(1.5) Matrices	. 14
	(1.6) Systems of linear equations and matrices	. 18
	(1.7) Exercises	. 19
2	The Euclidean Space \mathbb{R}^n	21
	2.) Sum and scalar multiplication	. 21
	(2.2) Scalar product	. 22
	2.3 Norms and Distances	. 23
	(2.4) Exercises	. 25
3	Matrices	27
	(3.1) Matrix operations	. 28
	(3.2) Inverse matrices	. 33
	3.3 Elementary matrices	. 34
	3.4 Elementary column operations	. 41
	3.5 Exercises	. 44
4	Vector spaces	45
Ĵ	4) Definition	. 45
	4.2 Examples	. 47
	(4.3) Vector subspaces	. 48
	4.4 Linear combinations	. 49
	4.5 Row and column space of a matrix	50
	4.6 Linear dependence and independence	. 54
	4.7 Basis and dimension	. 60
·	(4.8) Coordinates	. 63
	(4.9) Row and column span	. 64
	4.10 Exercises	. 66
5	Determinant and rank of a matrix	67
	(5.1) Definition and properties of the determinant of a matrix	. 67
	(5.2) Rank of a matrix	. 71
	(5.3) Inverse matrices (continued)	. 72
	(5.4) Span of a matrix, linearly independent rows and columns, rank	. 74
	5.5 Exercises	. 76

3

$\gamma \alpha$	7.7	$\overline{\mathbf{n}}$	ידידו	\Tr	DCI.	
$\mathcal{I}\mathcal{O}$	ΥĽ	T	£л	ĽΥ	LD.	

			1
· · · · · · · · · · · · · · · · · · ·			
	4 CONTE	NTS	
		77	
	o Timear functions	11	
	6.1 Definition	777	
	(6.2) Kernel and Image of a linear function	78	
	(6.3) Nonsingular functions and isomorphisms	81	
	$\overrightarrow{6.4}$ Exercises	. 84	
· ,			
	7 Linear functions and matrices	85	
6	(71) From a linear function to the associated matrix	85	
	7.9 From a most interview to the approximate function	97	
	7.2 From a matrix to the associated inter function	01	
	(7.3) $\mathbb{M}(m,n)$ and $\mathcal{L}(V,U)$ are isomorphic	88	
<i>.</i>	(7.4) Some related properties of a linear function and associated matrix	90	
	(7.5) Some facts on $\mathcal{L}(\mathbb{R}^n,\mathbb{R}^m)$	93	
	$(\overline{\mathcal{I}}, 6)$ Examples of computation of $[l]_{u}^{u}$	95	
	(7.7) Exercises	96	
	7.8 Appendices	96	
i	7.8.1 The dual and double dual space of a vector space	90	
	7.9.0. We the set of a set of a vector space	00	1. The second
	1.8.2 Vector spaces as images or Kernels of well chosen linear functions	99	
		100	
	8 Solutions to systems of linear equations	103	
4	8.1) Some preliminary basic facts	103	,
	8.2 A solution method: Rouchè-Capelli's and Cramer's theorems	104	
	83 Exercises	113	
			:
	II Some topology in metric spaces	115	
	1	λ.	
	9 Metric spaces	117	
	1 Definitions and examples	117	
	0.2 Open and closed gets	191	
		10	· .
	9.2.1 Sets which are open or closed in metric subspaces.	125	
	9.3 Sequences \ldots	127	
	9.4 Sequential characterization of closed sets	. 130	
	9.5 Compactness	130	
	9.5.1 Compactness and bounded, closed sets	. 131	
	9.5.2 Sequential compactness	133	
	9.6. Completeness	130	
	0.61 Couplet accurrence	120	
	0.6.0 Complete metric encode	140	
	9.6.2 Complete metric spaces	140	
	9.6.3 Completeness and closedness	, 141	
	9.7 Fixed point theorem: contractions	. 142	
	9.8 Appendices	144	
	9.8.1 Some characterizations of open and closed sets	. 144	
	9.8.2 Norms and metrics	. 148	;
	(00) Evercises	151	. *
		101	
	10 Functions	153	
	10 1 Limita of functiona	150 150	
		103	
	10.2 Continuous Functions	154	1
1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	10.3 Continuous functions on compact sets	. 158	
	(10.4) Exercises	. 160	
	11 Correspondence, maximum theorem and a fixed point theorem	161	
	11.1 Continuous Correspondences	. 161	
	11.2 The Maximum Theorem	. 168	,
	11.3 Fixed point theorems	. 171	
	11 1 Application of the maximum theorem to the consumer problem	170	
	11.4 Application of the maximum metrem to the consumer problem	, 1 14	

III Differential calculus in Duchdean spaces		175
12 Partial derivatives and directional derivatives		177
(2.1) Partial Derivatives		177
$(12.2) Directional Derivatives \ldots \ldots$	• • •	178
13 Differentiability		185
13 Total Derivative and Differentiability		185
13.2 Total Derivatives in terms of Partial Derivatives.		187
14 Some Theorems		189
14.1 The chain rule		190
14.2 Mean value theorem		192
(14.3) A sufficient condition for differentiability		195
14.4 A sufficient condition for equality of mixed partial derivatives \ldots	•••	195
14.5 Taylor's theorem for real valued functions		195
15 Tranliait function theorem		197
15 1 Some intuition		197
15.2 Functions with full rank square Jacobian		199
15.2 The inverse function theorem		202
15.5 The implicit function theorem		204
15.5 Some geometrical remarks on the gradient		206
15.6 Extremum problems with equality constraints		206
157 Exercises on part III		208
IV Nonlinear programming		209
16 Convex sets		211
16 1 Definition		211
16.2 Separation of convex sets		211
16.3 Farkas' Lemma \ldots		213
		*.
		217
17 Concave functions	• • •	217
17 Concave functions 17.1 Different Kinds of Concave Functions	• • •	218
17 Concave functions 17.1 Different Kinds of Concave Functions 17.1 Concave Functions		
17 Concave functions 17.1 Different Kinds of Concave Functions 17.1.1 Concave Functions 17.1.2 Strictly Concave Functions		220
17 Concave functions 17.1 Different Kinds of Concave Functions 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions.	· · ·	220
17 Concave functions 17.1 Different Kinds of Concave Functions 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions. 17,1.4 Strictly Quasi-concave Functions.	 	220 222 226 226
17 Concave functions 17.1 Different Kinds of Concave Functions. 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions. 17,1.4 Strictly Quasi-concave Functions. 17,1.5 Pseudo-concave Functions. 17,1.5 Pseudo-concave Functions.	· · · · · ·	$ \begin{array}{r} 220 \\ 222 \\ $
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.1.8 Relationships among Different Kinds of Concavity	· · · ·	220 222 222 226 226 228 228 229 232
17 Concave functions 17.1 Different Kinds of Concave Functions. 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.1.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity.	· · · · · · · · · · · ·	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions. 17,1.4 Strictly Quasi-concave Functions. 17,1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 18 Maximization Problems	 	
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18 Maximization Problems 18.1 The case of inequality constraints: Kuhn-Tucker theorems	 	
17 Concave functions 17.1 Different Kinds of Concave Functions. 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions. 17,1.4 Strictly Quasi-concave Functions. 17,1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18 Maximization Problems 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.1.1 On uniqueness of the solution	 	
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18 Maximization Problems 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.1.1 On uniqueness of the solution 18.2 The Case of Equality Constraints: Lagrange Theorem.	· · · · · · · · · · · · · · · · · · ·	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.1.6 Strictly Quasi-concave Functions. 17.1.7 Pseudo-concave Functions. 17.1.8 Pseudo-concave Functions. 17.1.9 Pseudo-concave Functions. 17.1.1 Pseudo-concave Functions. 17.1.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 17.2.1 Hessians of the solution 18 Maximization Problems 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints.	· · · · · · · · · · · · · · · · · · ·	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18 Maximization Problems 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints. 18.4 Main Steps to Solve a (Nice) Maximization Problem	 	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.1 The case of Equality Constraints: Lagrange Theorem. 18.2 The Case of Equality and Inequality Constraints. 18.3 The Case of Both Equality and Inequality Constraints. 18.4 Main Steps to Solve a (Nice) Maximization Problem 18.4.1 Some problems and some solutions	· · · · · · · · · · · · · · · · · · ·	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2.1 Hessians and Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints. 18.4 Main Steps to Solve a (Nice) Maximization Problem 18.4.1 Some problems and some solutions 18.5 The Implicit Function Theorem and Comparative Statics Analysis	· · · · · · · · · · · · · · · · · · ·	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
 17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Different Kinds of Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18 Maximization Problems 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints. 18.4.1 Some problems and some solutions 18.5 The Implicit Function Theorem and Comparative Statics Analysis 18.5.1 Maximization problem without constraint 	· · · · · · · · · · · · · · · · · · ·	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.1.7 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints. 18.4 Main Steps to Solve a (Nice) Maximization Problem 18.5 The Implicit Function Theorem and Comparative Statics Analysis 18.5.1 Maximization problem without constraint 18.5.2 Maximization problem with equality constraints	· · · · · · · · · · · · · · · · · · ·	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints. 18.4 Main Steps to Solve a (Nice) Maximization Problem 18.5 The Implicit Function Theorem and Comparative Statics Analysis 18.5.1 Maximization problem without constraint 18.5.2 Maximization problem with equality constraints 18.5.3 Maximization problem with Inequality Constraints		$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions. 17,1.1 Concave Functions. 17,1.2 Strictly Concave Functions. 17,1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.2 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.1 On uniqueness of the solution 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints. 18.4 Main Steps to Solve a (Nice) Maximization Problem 18.5 The Implicit Function Theorem and Comparative Statics Analysis 18.5.1 Maximization problem without constraint 18.5.2 Maximization problem with equality Constraints 18.5.3 Maximization problem with Inequality Constraints 18.6 The Envelope Theorem and the meaning of multipliers		$\begin{array}{cccccccccccccccccccccccccccccccccccc$
17 Concave functions 17.1 Different Kinds of Concave Functions 17.1.1 Concave Functions. 17.1.2 Strictly Concave Functions. 17.1.3 Quasi-Concave Functions. 17.1.4 Strictly Quasi-concave Functions. 17.1.5 Pseudo-concave Functions. 17.1.6 Pseudo-concave Functions. 17.1.7 Relationships among Different Kinds of Concavity 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 17.2.1 Hessians and Concavity. 18 Maximization Problems 18.1 The case of inequality constraints: Kuhn-Tucker theorems 18.1.1 On uniqueness of the solution 18.2 The Case of Equality Constraints: Lagrange Theorem. 18.3 The Case of Both Equality and Inequality Constraints. 18.4 Main Steps to Solve a (Nice) Maximization Problem 18.5 The Implicit Function Theorem and Comparative Statics Analysis 18.5.1 Maximization problem without constraint 18.5.2 Maximization problem with equality constraints 18.5.3 Maximization problem with Inequality Constraints 18.6 The Envelope Theorem and the meaning of multipliers 18.6.1 The Envelope Theorem		$\begin{array}{cccccccccccccccccccccccccccccccccccc$

~1	
n	
v	

19 Applications	to Economics													257
19.1 The Walr	asian Consumer Problem			•										.257
19.2 Productio	m		•••						• •	• •				. 259
19.3 The dema	and for insurance													. 261
19.4 Exercises	on part IV				••									. 262
												3		
х.т. 11 ·														000
V Problem	Sets													263
20 Exording														265
20 Exercises 20.1 Linear Al	aepra			,										265
20.1 Entear m	ology in metric spaces		• • •		• •	•••	•••	• •		•••	•••	•••	•••	270
20.2 Some top	sic topology in metric spaces	aces							•••					270
20.2.2 Co	prrespondences							·						. 273
20.3 Differenti	al Calculus in Euclidean	Spaces.				•••								. 274
20.4 Nonlinear	Programming													. 277
	.													
21 Solutions														279
21.1 Linear Al	gebra		• •	• •	• •					•••	•••	• •	•••	279
21.2 Some top	ology in metric spaces .		• • •	• •			• • •	• •	• •		•••	• •	•••	. 288
21.2.1 Ba	asic topology in metric sp	aces	• •	• •	• •	• •	• • •			• •	•••	••	•••	. 288
21.2.2 Co	orrespondences	• • • • •	• •	• •	• • .	• •	• • •	• •	• •	• •	•••	•••	•••	. 294
21.3 Differenti	al Calculus in Euclidean	Spaces .	• •	• •		••		• •	• •	•••	• •	• •	• •	. 296
21.4 Nonlinear	Programming	\cdots	• •	• •	• •	•••		• •	• •	•••	•••	• •	•••	. 302
														7
	and the second													