## **Table of contents**

## DESIGN AND MIXED-MODEL ANALYSIS OF EXPERIMENTS

I.	Statistical inference			
	I.A	Overview of the process	0-1	
	I.B	Unbiased estimation for continuous random variables	0-3	
	I.C	Summary		
II.	Statistical inference in regression			
	II.A	The linear model in regression	0-1	
	II.B	Least squares estimation of the expectation model parameters		
		a) Least squares estimators		
		b) Properties of least squares estimators		
		c) Estimating linear functions of the parameters		
	II.C	Estimating the variance		
	II.D	Maximum likelihood estimation of the parameters		
		a) Maximum likelihood estimation of $\theta_{\underline{\cdot}}$		
		b) Maximum likelihood estimation of $\sigma^2$	0-19	
	II.E	ANOVA method of hypothesis testing in regression		
		a) The analysis of variance	0-20	
		b) Expected values of the mean squares		
		c) Distribution of the test statistic		
		d) Hypothesis tests on subvectors	0-30	
		e) Corrected sums of squares	0-35	
	II.F	Likelihood ratio testing in regression	0-37	
	II.G	Summary		
III.	Com	pletely Randomized Design	0-1	
	III.A	Design of a CRD		
	III.B	Models and estimation for a CRD	0-2	
	III.C	Hypothesis testing using the ANOVA method	0-7	
		a) Expressions for the sums of squares		
		b) Degrees of freedom		
		c) Expected mean squares		
		d) Distribution of the F statistic	0-17	
		e) Analysis of variance table		
		f) Analysis of the rat example		
	III.D	Computation in Genstat		
		a) Regression analysis		
		b) Mean-operator Analysis of Rat data		
	III.E	Diagnostic checking		
	III.F	Treatment differences		
		a) Multiple comparisons procedures		
		b) Fitting submodels		
	^	c) Orthogonal contrasts		
	III.G	Summary	0-44	

IV.	General principles in designing experiments0-				
	IV.A	Basic principles in designing experiments			
		a) Replication			
		b) Randomization			
		c) Blocking	0-6		
	IV.B	Experimental strategy			
		a) Selection	0-8		
		b) Comparison	0-8		
		c) Optimization			
	IV.C	Summary	. 0-10		
V.		omized Complete Block Design (RCBD)			
	V.A	Maximal model for an RCBD			
	V.B	Estimation of the parameters of the maximal model for an RCBD			
		a) Estimation for the less than full rank model			
		b) Estimation of the parameters for an RCBD			
	V.C	Hypothesis testing using the ANOVA method for an RCBD			
		a) Expressions for the sums of squares			
		b) Degrees of freedom			
		c) Expected mean squares			
		d) Distribution of the F statistic			
		e) Analysis of variance table			
	\/ D	f) Analysis of the penicillin example			
	V.D	Computation in Genstat			
		a) Obtaining a layout for an RCBD in Genstat			
	\	b) Doing the ANOVA in Genstat			
	V.E V.F				
	v.r V.G	Treatment differences  Fixed versus random effects			
	v.G				
		,			
		b) Generalized least squares estimation for $\mathbf{V} \neq \sigma^2 \mathbf{I}$	0-41		
		c) Analysis of variance for Blocks random			
	V.H	Sample size			
		a) Type I and II errors			
		<ul><li>b) Power of a hypothesis test about expectation model terms</li><li>c) Computing the required sample size for the CRD and</li></ul>			
		RCBD	0-56		
VI.	Latin squares designs0-1				
	VI.A	Design of Latin squares			
	VI.B	Maximal model for a Latin square	0-6		
	VI.C Parameter estimation under the maximal model for a La square				
	VI.D	Hypothesis testing using the ANOVA method for a Latin square	0-9		
		a) Expressions for the sums of squares			
		b) Degrees of freedom			
		c) Expected mean squares			
		d) Distribution of the F statistics			
		e) Analysis of variance table	0-16		
		f) Analysis of an example			
	VI.E	Diagnostic checking and computation in Genstat	0-18		

		Treatment differences		
	VI.G	Sample size	. 0-23	
VII.	Deter	mining the analysis of variance table	0-1	
		The procedure		
		The Latin square example		
		Rules for determining the analysis of variance table		
	VII.D	Determining the analysis of variance table – further examples	. 0-23	
VIII.	Sets of Latin squares			
		Case 1 — same intervals and areas		
	VIII.B	Case 2 — same areas different intervals	0-4	
		Case 3 — different intervals and areas		
	VIII.D	Summary of Latin square analyses	. 0-10	
IX.	Facto	rial experiments	0-1	
	IX.A	Design of factorial experiments	0-2	
	IX.B	Advantages of factorial experiments	0-5	
		a) Interaction in factorial experiments		
		b) Advantages over one-factor-at-a-time experiments	. 0-10	
	IX.C	Models for factorial experiments and the estimation of their	0.44	
		parameters		
		a) Models for two-factor CRD experiments	. 0-11	
		b) Estimation of the model parameters for two-factor CRD experiments	0-14	
	IX.D	Hypothesis testing using the ANOVA method for factorial		
		experiments	. 0-16	
		a) Expressions for the sums of squares	. 0-18	
		b) Degrees of freedom	. 0-21	
		c) Expected mean squares		
		d) Distribution of the F statistic		
		e) Hypothesis test		
	IX.E	Computation in Genstat and analysis of an example	. 0-27	
	IX.F	Diagnostic checking	. 0-32	
		a) Box-Cox transformations for correcting transformable non-		
		additivity		
	IX.G	Treatment differences		
		a) Multiple comparison procedures		
	137.1.1	b) Polynomial submodels		
	IX.H	Nested factorial structures		
	IX.I	Sample size		
	IX.J	Models and hypothesis testing for three-factor experiments		
		a) Using rules to determine the ANOVA table		
		b) Models		
		c) Sums of squares		
		d) Degrees of freedom		
		e) Expected mean squares f) Distribution of the F statistics		
		,		
		g) The hypothesis test	. 0-02	

Χ.	Facto	orial designs at two levels	0-1		
	X.A	Replicated 2 <sup>K</sup> experiments			
		a) Calculation of responses and Yates effects			
		b) Yates algorithm			
		c) Computation in Genstat	0-7		
		d) Treatment differences			
	X.B	Economy in experimentation			
		a) Initial analysis of variance			
		b) Analysis assuming no 3-factor or 4-factor interactions			
		c) Probability plot of Yates effects			
		d) Fitted values			
		e) Diagnostic checking			
		f) Computation in Genstat			
	X.C	Confounding in factorial experiments			
		a) Total confounding of effects			
		b) Partial confounding of effects			
		c) Computation in Genstat			
	X.D	Fractional factorial designs at two levels	0-37		
		a) Half-fractions of full factorial experiments			
		b) More on construction and use of half-factions			
		c) The concept of design resolution			
		d) Resolution III designs (also called main effect plans)			
		e) Table of fractional factorial designs			
		f) Generation of fractional factorial designs in Genstat			
		g) Computation in Genstat			
XI.	Split-plot experiments0				
	Xİ.A	Design of split-plot experiments			
	XI.B				
		a) Designing a standard split-plot experiment	0-3		
		b) Determining the analysis of variance table	0-5		
		c) Analysis of the example	0-7		
		d) Treatment differences for the standard split-plot	0-11		
		e) Computation in Genstat	0-13		
	XI.C	Systematic or Unreplicated Main Plots	0-14		
	XI.D	A Complex Split-Plot Experiment	0-16		
XII.	Dono	ated measurements experiments	0.1		
ΛII.		Introduction to repeated measurements experiments			
	XII.A	· · · · · · · · · · · · · · · · · · ·			
	AII.D	a) Determining the analysis of variance table	0-∠ 0-5		
		b) Analysis of the example			
		c) Computation in Genstat	0-7 ∩ <b>-</b> 1∕1		
	XII.C	Problems with ANOVA on individual measurements for all	0-14		
	timepoints				
	XII.D	.D Separate analyses of each timepoint			
	XII.E	· · · · · · · · · · · · · · · · · · ·			
	<b>.</b>	a) Ad hoc summary statistics			
		b) Summary statistics from fitted curves			
		c) Computation in Genstat			
		•			

XIII.			the design and analysis of experiments			
			nary of the content			
	XIII.B		ive features of the approach to mixed-model analysis			
		a)	Use of observational unit			
		b)	Inclusion of all factors from the experiment	0-5		
		c)	Division of the factors into unrandomized and randomized			
			factors	0-5		
		d)	Division into fixed and random factors based on model considerations	0-7		
		e)	Models do not involve constraints on the parameters and model comparison is emphasized	0-7		
		f)	Inference is model-based not randomization-based			
		g)	Role of randomization			
	XIII.C		ng the analysis in packages other than Genstat	. 0-10		
			lization to more than one randomization			
		a)	Grazing experiments	. 0-10		
		b)	Multiphase experiments			
aqA	endix /	A Introd	luction to GENSTAT	0-1		
	The Windows version					
			g Genstat			
	Data EntryEntering commands directly					
	The G	enstat la	anguage	0-5		
	COMMANDS					
	OPTIONS & PARAMETERS					
	SYSTEM WORDS					
	ITEMS 0-8					
	PUNCTUATION					
			OF ITEMS			
			STRUCTURES			
			VIATION			
			TENED PROGRAM			
			TES VERSUS TEXTS VERSUS FACTORS			
		SUMM	ARY OF RELEVANT COMMANDS	. 0-21		