

# Contents

<i>Symbols and Acronyms</i>	xiii
<b>1 • Introduction to Measurement</b>	1
Measurement	1
Some Measurement Issues	3
Item Response Theory	4
Classical Test Theory	5
Latent Class Analysis	7
Summary	9
<b>2 • The One-Parameter Model</b>	11
Conceptual Development of the Rasch Model	11
The One-Parameter Model	16
The One-Parameter Logistic Model and the Rasch Model	19
Assumptions Underlying the Model	20
An Empirical Data Set: The Mathematics Data Set	21
Conceptually Estimating an Individual's Location	22
Some Pragmatic Characteristics of Maximum Likelihood Estimates	26
The Standard Error of Estimate and Information	27
An Instrument's Estimation Capacity	31
Summary	34
<b>3 • Joint Maximum Likelihood Parameter Estimation</b>	39
Joint Maximum Likelihood Estimation	39
Indeterminacy of Parameter Estimates	41
How Large a Calibration Sample?	42
Example: Application of the Rasch Model to the Mathematics Data, JMLE	43
Summary	64
<b>4 • Marginal Maximum Likelihood Parameter Estimation</b>	68
Marginal Maximum Likelihood Estimation	68
Estimating an Individual's Location: Expected A Posteriori	75
Example: Application of the Rasch Model to the Mathematics Data, MMLE	80
Metric Transformation and the Total Characteristic Function	92
Summary	96



<b>5 • The Two-Parameter Model</b>	99
Conceptual Development of the Two-Parameter Model	99
Information for the Two-Parameter Model	101
Conceptual Parameter Estimation for the 2PL Model	103
How Large a Calibration Sample?	104
Metric Transformation, 2PL Model	106
Example: Application of the 2PL Model to the Mathematics Data, MMLE	107
Fit Assessment: An Alternative Approach for Assessing Invariance	110
Information and Relative Efficiency	114
Summary	118
<b>6 • The Three-Parameter Model</b>	123
Conceptual Development of the Three-Parameter Model	123
Additional Comments about the Pseudo-Guessing Parameter, $\chi_j$	126
Conceptual Parameter Estimation for the 3PL Model	127
How Large a Calibration Sample?	130
Assessing Conditional Independence	131
Example: Application of the 3PL Model to the Mathematics Data, MMLE	134
Assessing Person Fit: Appropriateness Measurement	142
Information for the Three-Parameter Model	144
Metric Transformation, 3PL Model	147
Handling Missing Responses	148
Issues to Consider in Selecting among the 1PL, 2PL, and 3PL Models	152
Summary	154
<b>7 • Rasch Models for Ordered Polytomous Data</b>	162
Conceptual Development of the Partial Credit Model	163
Conceptual Parameter Estimation of the PC Model	169
Example: Application of the PC Model to a Reasoning Ability Instrument, MMLE	169
The Rating Scale Model	179
Conceptual Estimation of the RS Model	184
Example: Application of the RS Model to an Attitudes Towards Condoms Scale, JMLE	184
How Large a Calibration Sample?	198
Information for the PC and RS Models	200
Metric Transformation, PC and RS Models	201
Summary	202
<b>8 • Non-Rasch Models for Ordered Polytomous Data</b>	209
The Generalized Partial Credit Model	209
Example: Application of the GPC Model to a Reasoning Ability Instrument, MMLE	214
Conceptual Development of the Graded Response Model	217
How Large a Calibration Sample?	223
Example: Application of the GR Model to an Attitudes Towards Condoms Scale, MMLE	224
Information for Graded Data	230
Metric Transformation, GPC and GR Models	233
Summary	234
<b>9 • Models for Nominal Polytomous Data</b>	237
Conceptual Development of the Nominal Response Model	238
How Large a Calibration Sample?	246
Example: Application of the NR Model to a Science Test, MMLE	248



Example: Mixed Model Calibration of the Science Test—NR and PC Models, MMLE	251	
Example: NR and PC Mixed Model Calibration of the Science Test, Collapsed Options, MMLE	254	
Information for the NR Model	259	
Metric Transformation, NR Model	261	
Conceptual Development of the Multiple-Choice Model	261	
Example: Application of the MC Model to a Science Test, MMLE	263	
Example: Application of the BS Model to a Science Test, MMLE	269	
Summary	272	
<b>10 • Models for Multidimensional Data</b>		<b>275</b>
Conceptual Development of a Multidimensional IRT Model	275	
Multidimensional Item Location and Discrimination	281	
Item Vectors and Vector Graphs	285	
The Multidimensional Three-Parameter Logistic Model	288	
Assumptions of the MIRT Model	288	
Estimation of the M2PL Model	289	
Information for the M2PL Model	290	
Indeterminacy in MIRT	291	
Metric Transformation, M2PL Model	294	
Example: Application of the M2PL Model, Normal-Ogive Harmonic Analysis Robust Method	296	
Obtaining Person Location Estimates	302	
Summary	303	
<b>11 • Linking and Equating</b>		<b>306</b>
Equating Defined	306	
Equating: Data Collection Phase	307	
Equating: Transformation Phase	309	
Example: Application of the Total Characteristic Function Equating Method	316	
Summary	318	
<b>12 • Differential Item Functioning</b>		<b>323</b>
Differential Item Functioning and Item Bias	324	
Mantel-Haenszel Chi-Square	327	
The TSW Likelihood Ratio Test	330	
Logistic Regression	331	
Example: DIF Analysis	334	
Summary	343	
<b>APPENDIX A. Maximum Likelihood Estimation of Person Locations</b>		<b>347</b>
Estimating an Individual's Location: Empirical Maximum Likelihood Estimation	347	
Estimating an Individual's Location: Newton's Method for MLE	348	
Revisiting Zero Variance Binary Response Patterns	354	
<b>APPENDIX B. Maximum Likelihood Estimation of Item Locations</b>		<b>356</b>
<b>APPENDIX C. The Normal Ogive Models</b>		<b>360</b>
Conceptual Development of the Normal Ogive Model	360	
The Relationship between IRT Statistics and Traditional Item Analysis Indices	365	
Relationship of the Two-Parameter Normal Ogive and Logistic Models	368	
Extending the Two-Parameter Normal Ogive Model to a Multidimensional Space	370	



<b>APPENDIX D. Computerized Adaptive Testing</b>	<b>373</b>
A Brief History	373
Fixed-Branching Techniques	374
Variable-Branching Techniques	375
Advantages of Variable-Branching over Fixed-Branching Methods	375
IRT-Based Variable-Branching Adaptive Testing Algorithm	376
<b>APPENDIX E. Miscellanea</b>	<b>382</b>
Linear Logistic Test Model (LLTM)	382
Using Principal Axis for Estimating Item Discrimination	384
Infinite Item Discrimination Parameter Estimates	385
Example: NOHARM Unidimensional Calibration	387
An Approximate Chi-Square Statistic for NOHARM	389
Mixture Models	391
Relative Efficiency, Monotonicity, and Information	393
FORTRAN Formats	395
Example: Mixed Model Calibration of the Science Test—NR and 2PL Models,	
MMLE	396
Example: Mixed Model Calibration of the Science Test—NR and GR Models,	
MMLE	399
Odds, Odds Ratios, and Logits	399
The Person Response Function	403
Linking: A Temperature Analogy Example	405
Should DIF Analyses Be Based on Latent Classes?	407
The Separation and Reliability Indices	408
Dependency in Traditional Item Statistics and Observed Scores	409
<b>References</b>	<b>419</b>
<b>Author Index</b>	<b>439</b>
<b>Subject Index</b>	<b>444</b>
<b>About the Author</b>	<b>448</b>