

Contents

Preface	x
About the Author	xiv
1 Introduction	1
1.1 The Nature of Work	7
1.2 Defining Work Systems	10
1.3 Types of Occupations	12
1.4 Productivity	15
1.5 Organization of the Book	19
 Part I Work Systems and How They Work	 25
2 Manual Work and Worker–Machine Systems	27
2.1 Manual Work Systems	29
2.2 Worker–Machine Systems	37
2.3 Automated Work Systems	45
2.4 Determining Worker and Machine Requirements	46
2.5 Machine Clusters	51
3 Work Flow and Batch Processing	59
3.1 Sequential Operations and Work Flow	60
3.2 Batch Processing	64
3.3 Defects in Sequential Operations and Batch Processing	69
3.4 Work Cells and Worker Teams	71
4 Manual Assembly Lines	85
4.1 Fundamentals of Manual Assembly Lines	86
4.2 Analysis of Single Model Assembly Lines	91
4.3 Line Balancing Algorithms	100
4.4 Other Considerations in Assembly Line Design	106
4.5 Alternative Assembly Systems	107

5	Logistics Operations	113
5.1	Introduction to Logistics	114
5.2	Transportation Operations	120
5.3	Material Handling	126
5.4	Quantitative Analysis of Material-Handling Operations	140
6	Service Operations and Office Work	153
6.1	Service Operations	153
6.2	Office Work	162
7	Projects and Project Management	133
7.1	Projects	174
7.2	Project Management	177
7.3	Project Scheduling Techniques	179
7.4	Project Crashing	192
7.5	Software for Projects	195
Part II Methods Engineering and Layout Planning		205
8	Introduction to Methods Engineering and Operations Analysis	207
8.1	Evolution and Scope of Methods Engineering	209
8.2	How to Apply Methods Engineering	210
8.3	Basic Data Collection and Analysis Techniques	216
8.4	Methods Engineering and Automation	225
9	Charting and Diagramming Techniques for Operations Analysis	232
9.1	Overview of Charting and Diagramming Techniques	233
9.2	Network Diagrams	234
9.3	Traditional Industrial Engineering Charting and Diagramming Techniques	235
9.4	Block Diagrams and Process Maps	246
10	Motion Study and Work Design	259
10.1	Basic Motion Elements and Work Analysis	260
10.2	Principles of Motion Economy and Work Design	263
11	Facility Layout Planning and Design	270
11.1	Types of Production Plant Layouts	279
11.2	Other Types of Layouts	286
11.3	Systematic Layout Planning	289

Part III Time Study and Work Measurement	317
12 Introduction to Work Measurement	319
12.1 Time Standards and How They Are Determined	320
12.2 Prerequisites for Valid Time Standards	326
12.3 Allowances in Time Standards	331
12.4 Accuracy, Precision, and Application Speed Ratio in Work Measurement	335
13 Direct Time Study	342
13.1 Direct Time Study Procedure	343
13.2 Number of Work Cycles to be Timed	351
13.3 Performance Rating	353
13.4 Time Study Equipment	356
14 Predetermined Motion Time Systems	368
14.1 Overview of Predetermined Motion Time Systems	370
14.2 Methods-Time Measurement (MTM)	373
14.3 Maynard Operation Sequence Technique (MOST)	382
15 Standard Data Systems	395
15.1 Using a Standard Data System	397
15.2 Developing a Standard Data System	401
15.3 Work Element Classification in Standard Data Systems	402
15.4 Analysis of Machine-Controlled Element Times	406
15.5 SDS Advantages and Disadvantages	413
16 Work Sampling	422
16.1 How Work Sampling Works	424
16.2 Statistical Basis of Work Sampling	425
16.3 Application Issues in Work Sampling	431
17 Computerized Work Measurement and Standards Maintenance	443
17.1 Computer Systems for Direct Time Study and Work Sampling	444
17.2 Computerized Systems Based on Predetermined Motion Times and Standard Data	450
17.3 Work Measurement Based on Expert Systems	453
17.4 Maintenance of Time Standards	455
18 The Economics and Applications of Time Standards	459
18.1 Economic Justification of Work Measurement	460
18.2 Applications of Time Standards and Time Study	469
19 Learning Curves	483
19.1 Learning Curve Theory	484
19.2 Why the Learning Curve Occurs	493

19.3	Determining the Learning Rate	495
19.4	Factors Affecting the Learning Curve	497
19.5	Learning Curve Applications	504
19.6	Time Standards Versus the Learning Curve	504
Part IV New Approaches in Process Improvement and Work Management		511
20	Lean Production	513
20.1	Elimination of Waste	516
20.2	Just-in-Time Production	518
20.3	Autonomation	526
20.4	Worker Involvement	531
21	Six Sigma and Other Quality Programs	540
21.1	Overview and Statistical Basis of Six Sigma	541
21.2	The Six Sigma DMAIC Procedure	545
21.3	Other Quality Programs	554
Appendix 21A: Sigma Levels, Defects per Million, Fraction Defect Rate, and Yield in Six Sigma		556
Part V Ergonomics and Human Factors in the Workplace		563
22	Introduction to Ergonomics and Human Factors	565
22.1	Overview of Ergonomics	568
22.2	Human–Machine Systems	571
22.3	Topic Areas in Ergonomics	575
23	Physical Ergonomics: Work Physiology and Anthropometry	580
23.1	Human Physiology	581
23.2	Muscular Effort and Work Physiology	587
23.3	Anthropometry	598
24	Cognitive Ergonomics: The Human Sensory System and Information Processing	609
24.1	The Human Sensory System	610
24.2	Perception	621
24.3	Attention Resources	623
24.4	Memory	626
24.5	Response Selection and Execution	629
24.6	Common Cognitive Tasks	633
24.7	Design Guidelines for Cognitive Work	639

25	The Physical Work Environment	645
25.1	The Visual Environment and Lighting	645
25.2	The Auditory Environment and Noise	654
25.3	Climate Control in the Work Environment	660
26	Occupational Safety and Health	668
26.1	Industrial Accidents and Injuries	669
26.2	Occupational Disorders and Diseases	676
26.3	Occupational Safety Health Laws and Agencies	676
26.4	Safety and Health Performance Metrics	680
	Part VI Traditional Topics in Work Management	685
27	Work Organization	687
27.1	Organization Principles	688
27.2	Organization Structures	695
28	Worker Motivation and the Social Organization at Work	707
28.1	Motivation and Job Satisfaction	707
28.2	The Social Organization at Work	714
29	Job Evaluation and Performance Appraisal	719
29.1	Job Evaluation	720
29.2	Performance Appraisal	732
30	Compensation Systems	735
30.1	Overview of Compensation Systems	736
30.2	Time-Based Pay Systems	738
30.3	Direct Wage Incentive Systems	741
30.4	Gain Sharing	754
30.5	Profit Sharing	758
	Appendix: Statistical Tables	765
A1	Standard Normal Distribution	765
A2	Student t Distribution	766
	Index	767