

TENTH EDITION



PRINCIPLES OF

# Operations Management

SUSTAINABILITY AND SUPPLY CHAIN MANAGEMENT

JAY  
HEIZER

BARRY  
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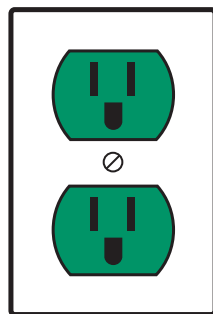
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Sustainability and Supply Chain Management

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TENTH EDITION

# PRINCIPLES OF OPERATIONS MANAGEMENT

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Sustainability and Supply Chain Management

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**Cover Photos:** Alaska Airlines  
**Printer/Binder:** Courier Kendallville  
**Cover Printer:** Phoenix Color/Hagerstown

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#### **Library of Congress Cataloging-in-Publication Data**

Render, Barry.

Principles of operations management : sustainability and supply chain management / Jay Heizer, Jesse H. Jones Professor of Business Administration, Texas Lutheran University, Barry Render, Charles Harwood Professor of Operations Management, Crummer Graduate School of Business, Rollins College, Chuck Munson, Professor of Operations Management, Washington State University. -- Tenth edition.

pages cm

Original edition: Principles of operations management: building and managing world-class operations / Barry Render, Jay Heizer. c1995.

Includes bibliographical references and index.

ISBN 978-0-13-418198-1 -- ISBN 0-13-418198-0

1. Production management. 2. Operations research. I. Heizer, Jay. II. Munson, Chuck. III. Title. IV. Title: Operations management.

TS155.R383 1995

658.5--dc23

2015036748

10 9 8 7 6 5 4 3 2 1

**PEARSON**

ISBN 10: 0-13-418198-0  
ISBN 13: 978-0-13-418198-1

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**To Karen Heizer Herrmann, all a sister could ever be**

J.H.

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**To Donna, Charlie, and Jesse**

B.R.

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**To Kim, Christopher, and Mark Munson for their unwavering support,  
and to Bentonville High School teachers Velma Reed and Cheryl Gregory,  
who instilled in me the importance of detail and a love of learning**

C.M.

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**CHUCK MUNSON**

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# Brief Table of Contents

<b>PART ONE</b>	<b>Introduction to Operations Management</b>	<b>1</b>
<b>Chapter 1</b>	<b>Operations and Productivity</b>	<b>1</b>
<b>Chapter 2</b>	<b>Operations Strategy in a Global Environment</b>	<b>29</b>
<b>Chapter 3</b>	<b>Project Management</b>	<b>59</b>
<b>Chapter 4</b>	<b>Forecasting</b>	<b>105</b>
<b>PART TWO</b>	<b>Designing Operations</b>	<b>159</b>
<b>Chapter 5</b>	<b>Design of Goods and Services</b>	<b>159</b>
◆	Supplement 5 Sustainability in the Supply Chain	193
<b>Chapter 6</b>	<b>Managing Quality</b>	<b>213</b>
◆	Supplement 6 Statistical Process Control	245
<b>Chapter 7</b>	<b>Process Strategy</b>	<b>279</b>
◆	Supplement 7 Capacity and Constraint Management	307
<b>Chapter 8</b>	<b>Location Strategies</b>	<b>337</b>
<b>Chapter 9</b>	<b>Layout Strategies</b>	<b>367</b>
<b>Chapter 10</b>	<b>Human Resources, Job Design, and Work Measurement</b>	<b>407</b>
<b>PART THREE</b>	<b>Managing Operations</b>	<b>441</b>
<b>Chapter 11</b>	<b>Supply Chain Management</b>	<b>441</b>
◆	Supplement 11 Supply Chain Management Analytics	471
<b>Chapter 12</b>	<b>Inventory Management</b>	<b>487</b>
<b>Chapter 13</b>	<b>Aggregate Planning and S&amp;OP</b>	<b>529</b>
<b>Chapter 14</b>	<b>Material Requirements Planning (MRP) and ERP</b>	<b>563</b>
<b>Chapter 15</b>	<b>Short-Term Scheduling</b>	<b>599</b>
<b>Chapter 16</b>	<b>Lean Operations</b>	<b>635</b>
<b>Chapter 17</b>	<b>Maintenance and Reliability</b>	<b>659</b>
<b>ONLINE TUTORIALS</b>		
1. Statistical Tools for Managers T1-1		
2. Acceptance Sampling T2-1		
3. The Simplex Method of Linear Programming T3-1		
4. The MODI and VAM Methods of Solving Transportation Problems T4-1		
5. Vehicle Routing and Scheduling T5-1		

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# Table of Contents

About the Authors	viii
Preface	xxiii

## PART ONE Introduction to Operations Management

1

### Chapter 1 Operations and Productivity 1

<b>GLOBAL COMPANY PROFILE: HARD ROCK CAFE</b>	<b>2</b>
What Is Operations Management?	4
Organizing to Produce Goods and Services	4
The Supply Chain	6
Why Study OM?	6
What Operations Managers Do	7
The Heritage of Operations Management	8
Operations for Goods and Services	11
<i>Growth of Services</i>	11
<i>Service Pay</i>	12
The Productivity Challenge	13
<i>Productivity Measurement</i>	14
<i>Productivity Variables</i>	15
<i>Productivity and the Service Sector</i>	17
Current Challenges in Operations Management	18
Ethics, Social Responsibility, and Sustainability	19
Summary	20
Key Terms	20
Ethical Dilemma	20
Discussion Questions	20
Using Software for Productivity Analysis	21
Solved Problems	21
Problems	22
<b>CASE STUDIES</b>	<b>24</b>
<i>Uber Technologies, Inc.</i>	24
<i>Frito-Lay: Operations Management in Manufacturing Video Case</i>	25
<i>Hard Rock Cafe: Operations Management in Services Video Case</i>	25
Endnotes	26
Rapid Review	27
Self Test	28

### Chapter 2 Operations Strategy in a Global Environment 29

<b>GLOBAL COMPANY PROFILE: BOEING</b>	<b>30</b>
A Global View of Operations and Supply Chains	32
<i>Cultural and Ethical Issues</i>	35

Developing Missions and Strategies	35
<i>Mission</i>	36
<i>Strategy</i>	36
Achieving Competitive Advantage Through Operations	36
<i>Competing on Differentiation</i>	37
<i>Competing on Cost</i>	38
<i>Competing on Response</i>	39
Issues in Operations Strategy	40
Strategy Development and Implementation	41
<i>Key Success Factors and Core Competencies</i>	41
<i>Integrating OM with Other Activities</i>	43
<i>Building and Staffing the Organization</i>	43
<i>Implementing the 10 Strategic OM Decisions</i>	44
Strategic Planning, Core Competencies, and Outsourcing	44
<i>The Theory of Comparative Advantage</i>	46
<i>Risks of Outsourcing</i>	46
<i>Rating Outsource Providers</i>	47
Global Operations Strategy Options	49
Summary	50
Key Terms	50
Ethical Dilemma	51
Discussion Questions	51
Using Software to Solve Outsourcing Problems	51
Solved Problems	52
Problems	53
<b>CASE STUDIES</b>	<b>55</b>
<i>Rapid-Lube</i>	55
<i>Strategy at Regal Marine Video Case</i>	55
<i>Hard Rock Cafe's Global Strategy Video Case</i>	55
<i>Outsourcing Offshore at Darden Video Case</i>	56
Endnotes	56
Rapid Review	57
Self Test	58

### Chapter 3 Project Management 59

<b>GLOBAL COMPANY PROFILE: BECHTEL GROUP</b>	<b>60</b>
The Importance of Project Management	62

Project Planning 62  
*The Project Manager* 63  
*Work Breakdown Structure* 64  
Project Scheduling 65  
Project Controlling 66  
Project Management Techniques: PERT and CPM 67  
*The Framework of PERT and CPM* 67  
*Network Diagrams and Approaches* 68  
*Activity-on-Node Example* 69  
*Activity-on-Arrow Example* 71  
Determining the Project Schedule 71  
*Forward Pass* 72  
*Backward Pass* 74  
*Calculating Slack Time and Identifying the Critical Path(s)* 75  
Variability in Activity Times 77  
*Three Time Estimates in PERT* 77  
*Probability of Project Completion* 79  
Cost-Time Trade-Offs and Project Crashing 82  
A Critique of PERT and CPM 85  
Using Microsoft Project to Manage Projects 86  
Summary 88  
Key Terms 88  
Ethical Dilemma 89  
Discussion Questions 89  
Using Software to Solve Project Management Problems 89  
Solved Problems 90  
Problems 93  
**CASE STUDIES 98**  
*Southwestern University: (A)* 98  
*Project Management at Arnold Palmer Hospital Video Case* 99  
*Managing Hard Rock's Rockfest Video Case* 100  
Endnotes 102  
Rapid Review 103  
Self Test 104

**Chapter 4 Forecasting 105**

**GLOBAL COMPANY PROFILE: WALT DISNEY PARKS & RESORTS 106**  
What is Forecasting? 108  
*Forecasting Time Horizons* 108  
*Types of Forecasts* 109

The Strategic Importance of Forecasting 109  
*Supply-Chain Management* 109  
*Human Resources* 110  
*Capacity* 110  
Seven Steps in the Forecasting System 110  
Forecasting Approaches 111  
*Overview of Qualitative Method* 111  
*Overview of Quantitative Methods* 112  
Time-Series Forecasting 112  
*Decomposition of a Time Series* 112  
*Naive Approach* 113  
*Moving Averages* 114  
*Exponential Smoothing* 116  
*Measuring Forecast Error* 117  
*Exponential Smoothing with Trend Adjustment* 120  
*Trend Projections* 124  
*Seasonal Variations in Data* 126  
*Cyclical Variations in Data* 131  
Associative Forecasting Methods: Regression and Correlation Analysis 131  
*Using Regression Analysis for Forecasting* 131  
*Standard Error of the Estimate* 133  
*Correlation Coefficients for Regression Lines* 134  
*Multiple-Regression Analysis* 136  
Monitoring and Controlling Forecasts 138  
*Adaptive Smoothing* 139  
*Focus Forecasting* 139  
Forecasting in the Service Sector 140  
Summary 141  
Key Terms 141  
Ethical Dilemma 141  
Discussion Questions 142  
Using Software in Forecasting 142  
Solved Problems 144  
Problems 146

**CASE STUDIES 153**

*Southwestern University: (B)* 153  
*Forecasting Ticket Revenue for Orlando Magic Basketball Games Video Case* 154  
*Forecasting at Hard Rock Cafe Video Case* 155  
Endnotes 156  
Rapid Review 157  
Self Test 158

**PART TWO Designing Operations**

**Chapter 5 Design of Goods and Services 159**

**GLOBAL COMPANY PROFILE: REGAL MARINE 160**  
Goods and Services Selection 162

*Product Strategy Options Support Competitive Advantage* 163  
*Product Life Cycles* 164  
*Life Cycle and Strategy* 164

<i>Product-by-Value Analysis</i>	165
Generating New Products	165
Product Development	166
<i>Product Development System</i>	166
<i>Quality Function Deployment (QFD)</i>	166
<i>Organizing for Product Development</i>	169
<i>Manufacturability and Value Engineering</i>	170
Issues for Product Design	171
<i>Robust Design</i>	171
<i>Modular Design</i>	171
<i>Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)</i>	171
<i>Virtual Reality Technology</i>	172
<i>Value Analysis</i>	173
<i>Sustainability and Life Cycle Assessment (LCA)</i>	173
Product Development Continuum	173
<i>Purchasing Technology by Acquiring a Firm</i>	174
<i>Joint Ventures</i>	174
<i>Alliances</i>	175
Defining a Product	175
<i>Make-or-Buy Decisions</i>	176
<i>Group Technology</i>	177
Documents for Production	178
<i>Product Life-Cycle Management (PLM)</i>	178
Service Design	179
<i>Process-Chain-Network (PCN) Analysis</i>	179
<i>Adding Service Efficiency</i>	181
<i>Documents for Services</i>	181
Application of Decision Trees to Product Design	182
Transition to Production	184
Summary	184
Key Terms	185
Ethical Dilemma	185
Discussion Questions	185
Solved Problem	186
Problems	186
<b>CASE STUDIES</b>	<b>189</b>
<i>De Mar's Product Strategy</i>	189
<i>Product Design at Regal Marine</i> Video Case	189
Endnotes	190
Rapid Review	191
Self Test	192
<b>Supplement 5 Sustainability in the Supply Chain</b>	<b>193</b>
Corporate Social Responsibility	194
Sustainability	195
<i>Systems View</i>	195
<i>Commons</i>	195
<i>Triple Bottom Line</i>	195

Design and Production for Sustainability	198
<i>Product Design</i>	198
<i>Production Process</i>	200
<i>Logistics</i>	200
<i>End-of-Life Phase</i>	203
Regulations and Industry Standards	203
<i>International Environmental Policies and Standards</i>	204
Summary	205
Key Terms	205
Discussion Questions	205
Solved Problems	206
Problems	207
<b>CASE STUDIES</b>	<b>208</b>
<i>Building Sustainability at the Orlando Magic's Amway Center</i> Video Case	208
<i>Green Manufacturing and Sustainability at Frito-Lay</i> Video Case	209
Endnotes	210
Rapid Review	211
Self Test	212
<b>Chapter 6 Managing Quality</b>	<b>213</b>
<b>GLOBAL COMPANY PROFILE: ARNOLD PALMER HOSPITAL</b>	<b>214</b>
Quality and Strategy	216
Defining Quality	217
<i>Implications of Quality</i>	217
<i>Malcolm Baldrige National Quality Award</i>	218
<i>ISO 9000 International Quality Standards</i>	218
<i>Cost of Quality (COQ)</i>	218
<i>Ethics and Quality Management</i>	219
Total Quality Management	219
<i>Continuous Improvement</i>	220
<i>Six Sigma</i>	221
<i>Employee Empowerment</i>	222
<i>Benchmarking</i>	222
<i>Just-in-Time (JIT)</i>	224
<i>Taguchi Concepts</i>	224
<i>Knowledge of TQM Tools</i>	225
Tools of TQM	226
<i>Check Sheets</i>	226
<i>Scatter Diagrams</i>	227
<i>Cause-and-Effect Diagrams</i>	227
<i>Pareto Charts</i>	227
<i>Flowcharts</i>	228
<i>Histograms</i>	229
<i>Statistical Process Control (SPC)</i>	229
The Role of Inspection	230
<i>When and Where to Inspect</i>	230
<i>Source Inspection</i>	231



*Service Industry Inspection* 232  
*Inspection of Attributes versus Variables* 233  
 TQM in Services 233  
 Summary 235  
 Key Terms 235  
 Ethical Dilemma 235  
 Discussion Questions 236  
 Solved Problems 236  
 Problems 237  
**CASE STUDIES 239**  
     *Southwestern University: (C)* 239  
     *The Culture of Quality at Arnold Palmer Hospital Video Case* 240  
     *Quality Counts at Alaska Airlines Video Case* 240  
     *Quality at the Ritz-Carlton Hotel Company Video Case* 242  
 Endnotes 242  
 Rapid Review 243  
 Self Test 244  
**Supplement 6 Statistical Process Control 245**  
 Statistical Process Control (SPC) 246  
     *Control Charts for Variables* 248  
     *The Central Limit Theorem* 248  
     *Setting Mean Chart Limits ( $\bar{x}$ -Charts)* 250  
     *Setting Range Chart Limits (R-Charts)* 253  
     *Using Mean and Range Charts* 254  
     *Control Charts for Attributes* 256  
     *Managerial Issues and Control Charts* 259  
 Process Capability 260  
     *Process Capability Ratio ( $C_p$ )* 260  
     *Process Capability Index ( $C_{pk}$ )* 261  
 Acceptance Sampling 262  
     *Operating Characteristic Curve* 263  
     *Average Outgoing Quality* 264  
 Summary 265  
 Key Terms 265  
 Discussion Questions 265  
 Using Software for SPC 266  
 Solved Problems 267  
 Problems 269  
**CASE STUDIES 274**  
     *Bayfield Mud Company* 274  
     *Frito-Lay's Quality-Controlled Potato Chips Video Case* 275  
     *Farm to Fork: Quality at Darden Restaurants Video Case* 276  
 Endnotes 276  
 Rapid Review 277  
 Self Test 278

**Chapter 7 Process Strategy 279**  
**GLOBAL COMPANY PROFILE: HARLEY-DAVIDSON 280**  
 Four Process Strategies 282  
     *Process Focus* 282  
     *Repetitive Focus* 283  
     *Product Focus* 284  
     *Mass Customization Focus* 284  
     *Process Comparison* 286  
 Selection of Equipment 288  
 Process Analysis and Design 288  
     *Flowchart* 289  
     *Time-Function Mapping* 289  
     *Process Charts* 289  
     *Value-Stream Mapping* 290  
     *Service Blueprinting* 292  
 Special Considerations for Service Process Design 293  
 Production Technology 294  
     *Machine Technology* 294  
     *Automatic Identification Systems (AISs) and RFID* 295  
     *Process Control* 295  
     *Vision Systems* 296  
     *Robots* 296  
     *Automated Storage and Retrieval Systems (ASRSs)* 296  
     *Automated Guided Vehicles (AGVs)* 296  
     *Flexible Manufacturing Systems (FMSs)* 297  
     *Computer-Integrated Manufacturing (CIM)* 297  
 Technology in Services 298  
 Process Redesign 298  
 Summary 299  
 Key Terms 299  
 Ethical Dilemma 300  
 Discussion Questions 300  
 Solved Problem 300  
 Problems 301  
**CASE STUDIES 302**  
     *Rochester Manufacturing's Process Decision* 302  
     *Process Strategy at Wheeled Coach Video Case* 302  
     *Alaska Airlines: 20-Minute Baggage Process—Guaranteed! Video Case* 303  
     *Process Analysis at Arnold Palmer Hospital Video Case* 304  
 Endnotes 304  
 Rapid Review 305  
 Self Test 306  
**Supplement 7 Capacity and Constraint Management 307**  
 Capacity 308  
     *Design and Effective Capacity* 309

<i>Capacity and Strategy</i>	311	Key Terms	353
<i>Capacity Considerations</i>	311	Ethical Dilemma	354
<i>Managing Demand</i>	312	Discussion Questions	354
<i>Service-Sector Demand and Capacity Management</i>	313	Using Software to Solve Location Problems	354
Bottleneck Analysis and the Theory of Constraints	314	Solved Problems	355
<i>Theory of Constraints</i>	317	Problems	357
<i>Bottleneck Management</i>	317	<b>CASE STUDIES</b>	<b>362</b>
Break-Even Analysis	318	<i>Southern Recreational Vehicle Company</i>	362
<i>Single-Product Case</i>	319	<i>Locating the Next Red Lobster Restaurant Video Case</i>	362
<i>Multiproduct Case</i>	320	<i>Where to Place the Hard Rock Cafe Video Case</i>	363
Reducing Risk with Incremental Changes	322	Endnote	364
Applying Expected Monetary Value (EMV) to Capacity Decisions	323	Rapid Review	365
Applying Investment Analysis to Strategy-Driven Investments	324	Self Test	366
<i>Investment, Variable Cost, and Cash Flow</i>	324	<b>Chapter 9 Layout Strategies</b>	<b>367</b>
<i>Net Present Value</i>	324	<b>GLOBAL COMPANY PROFILE: McDONALD'S</b>	<b>368</b>
Summary	326	The Strategic Importance of Layout Decisions	370
Key Terms	327	Types of Layout	370
Discussion Questions	327	Office Layout	371
Using Software for Break-Even Analysis	327	Retail Layout	372
Solved Problems	328	<i>Servescapes</i>	375
Problems	330	Warehouse and Storage Layouts	375
<b>CASE STUDY</b>	<b>333</b>	<i>Cross-Docking</i>	376
<i>Capacity Planning at Arnold Palmer Hospital Video Case</i>	333	<i>Random Stocking</i>	377
Endnote	334	<i>Customizing</i>	377
Rapid Review	335	Fixed-Position Layout	377
Self Test	336	Process-Oriented Layout	378
<b>Chapter 8 Location Strategies</b>	<b>337</b>	<i>Computer Software for Process-Oriented Layouts</i>	382
<b>GLOBAL COMPANY PROFILE: FEDEX</b>	<b>338</b>	Work Cells	383
The Strategic Importance of Location	340	<i>Requirements of Work Cells</i>	383
Factors That Affect Location Decisions	341	<i>Staffing and Balancing Work Cells</i>	384
<i>Labor Productivity</i>	342	<i>The Focused Work Center and the Focused Factory</i>	386
<i>Exchange Rates and Currency Risk</i>	342	Repetitive and Product-Oriented Layout	386
<i>Costs</i>	342	<i>Assembly-Line Balancing</i>	387
<i>Political Risk, Values, and Culture</i>	343	Summary	392
<i>Proximity to Markets</i>	343	Key Terms	392
<i>Proximity to Suppliers</i>	344	Ethical Dilemma	392
<i>Proximity to Competitors (Clustering)</i>	344	Discussion Questions	392
Methods of Evaluating Location Alternatives	344	Using Software to Solve Layout Problems	393
<i>The Factor-Rating Method</i>	345	Solved Problems	394
<i>Locational Cost-Volume Analysis</i>	346	Problems	396
<i>Center-of-Gravity Method</i>	348	<b>CASE STUDIES</b>	<b>402</b>
<i>Transportation Model</i>	349	<i>State Automobile License Renewals</i>	402
Service Location Strategy	350	<i>Laying Out Arnold Palmer Hospital's New Facility Video Case</i>	402
Geographic Information Systems	351	<i>Facility Layout at Wheeled Coach Video Case</i>	404
Summary	353	Endnotes	404
		Rapid Review	405
		Self Test	406

**Chapter 10 Human Resources, Job Design, and Work Measurement 407**

**GLOBAL COMPANY PROFILE: RUSTY WALLACE'S NASCAR RACING TEAM 408**

Human Resource Strategy for Competitive Advantage 410  
*Constraints on Human Resource Strategy 410*  
 Labor Planning 411  
*Employment-Stability Policies 411*  
*Work Schedules 411*  
*Job Classifications and Work Rules 412*  
 Job Design 412  
*Labor Specialization 412*  
*Job Expansion 413*  
*Psychological Components of Job Design 413*  
*Self-Directed Teams 414*  
*Motivation and Incentive Systems 415*  
 Ergonomics and the Work Environment 415  
 Methods Analysis 417  
 The Visual Workplace 420  
 Labor Standards 420

*Historical Experience 421*  
*Time Studies 421*  
*Predetermined Time Standards 425*  
*Work Sampling 427*

Ethics 430  
 Summary 430  
 Key Terms 430  
 Ethical Dilemma 431  
 Discussion Questions 431  
 Solved Problems 432  
 Problems 434

**CASE STUDIES 437**

*Jackson Manufacturing Company 437*  
*The "People" Focus: Human Resources at Alaska Airlines Video Case 437*  
*Hard Rock's Human Resource Strategy Video Case 438*

Endnotes 438  
 Rapid Review 439  
 Self Test 440

**PART THREE Managing Operations**

**Chapter 11 Supply Chain Management 441**

**GLOBAL COMPANY PROFILE: DARDEN RESTAURANTS 442**

The Supply Chain's Strategic Importance 444  
 Sourcing Issues: Make-or-Buy and Outsourcing 446  
*Make-or-Buy Decisions 447*  
*Outsourcing 447*  
 Six Sourcing Strategies 447  
*Many Suppliers 447*  
*Few Suppliers 447*  
*Vertical Integration 448*  
*Joint Ventures 448*  
*Keiretsu Networks 448*  
*Virtual Companies 449*  
 Supply Chain Risk 449  
*Risks and Mitigation Tactics 450*  
*Security and JIT 451*  
 Managing the Integrated Supply Chain 451  
*Issues in Managing the Integrated Supply Chain 451*  
*Opportunities in Managing the Integrated Supply Chain 452*  
 Building the Supply Base 454  
*Supplier Evaluation 454*  
*Supplier Development 454*  
*Negotiations 455*

*Contracting 455*  
*Centralized Purchasing 455*  
*E-Procurement 456*  
 Logistics Management 456  
*Shipping Systems 456*  
*Warehousing 457*  
*Third-Party Logistics (3PL) 458*  
 Distribution Management 459  
 Ethics and Sustainable Supply Chain Management 460  
*Supply Chain Management Ethics 460*  
*Establishing Sustainability in Supply Chains 460*  
 Measuring Supply Chain Performance 461  
*Assets Committed to Inventory 461*  
*Benchmarking the Supply Chain 463*  
*The SCOR Model 463*

Summary 464  
 Key Terms 465  
 Ethical Dilemma 465  
 Discussion Questions 465  
 Solved Problems 465  
 Problems 466

**CASE STUDIES 467**

*Darden's Global Supply Chains Video Case 467*

*Supply Chain Management at Regal Marine*

*Video Case 467*

*Arnold Palmer Hospital's Supply Chain*

*Video Case 468*

Endnote 468

Rapid Review 469

Self Test 470

### **Supplement 11 Supply Chain Management Analytics 471**

Techniques for Evaluating Supply Chains 472

Evaluating Disaster Risk in the Supply Chain 472

Managing the Bullwhip Effect 474

*A Bullwhip Effect Measure 475*

Supplier Selection Analysis 476

Transportation Mode Analysis 477

Warehouse Storage 478

Summary 479

Discussion Questions 480

Solved Problems 480

Problems 482

Rapid Review 485

Self Test 486

### **Chapter 12 Inventory Management 487**

#### **GLOBAL COMPANY PROFILE: AMAZON.COM 488**

The Importance of Inventory 490

*Functions of Inventory 490*

*Types of Inventory 490*

Managing Inventory 491

*ABC Analysis 491*

*Record Accuracy 493*

*Cycle Counting 493*

*Control of Service Inventories 494*

Inventory Models 495

*Independent vs. Dependent Demand 495*

*Holding, Ordering, and Setup Costs 495*

Inventory Models for Independent Demand 496

*The Basic Economic Order Quantity (EOQ) Model 496*

*Minimizing Costs 497*

*Reorder Points 501*

*Production Order Quantity Model 502*

*Quantity Discount Models 505*

Probabilistic Models and Safety Stock 508

*Other Probabilistic Models 511*

Single-Period Model 513

Fixed-Period (*P*) Systems 514

Summary 515

Key Terms 515

Ethical Dilemma 515

Discussion Questions 515

Using Software to Solve Inventory Problems 516

Solved Problems 517

Problems 520

#### **CASE STUDIES 524**

*Zhou Bicycle Company 524*

*Parker Hi-Fi Systems 525*

*Managing Inventory at Frito-Lay Video Case 525*

*Inventory Control at Wheeled Coach Video Case 526*

Endnotes 526

Rapid Review 527

Self Test 528

### **Chapter 13 Aggregate Planning and S&OP 529**

#### **GLOBAL COMPANY PROFILE: FRITO-LAY 530**

The Planning Process 532

Sales and Operations Planning 533

The Nature of Aggregate Planning 534

Aggregate Planning Strategies 535

*Capacity Options 535*

*Demand Options 536*

*Mixing Options to Develop a Plan 537*

Methods for Aggregate Planning 538

*Graphical Methods 538*

*Mathematical Approaches 543*

Aggregate Planning in Services 545

*Restaurants 546*

*Hospitals 546*

*National Chains of Small Service Firms 546*

*Miscellaneous Services 546*

*Airline Industry 547*

Revenue Management 547

Summary 550

Key Terms 550

Ethical Dilemma 551

Discussion Questions 551

Using Software for Aggregate Planning 552

Solved Problems 554

Problems 555

#### **CASE STUDIES 559**

*Andrew-Carter, Inc. 559*

*Using Revenue Management to Set Orlando Magic Ticket Prices Video Case 560*

Endnote 560

Rapid Review 561

Self Test 562

### **Chapter 14 Material Requirements Planning (MRP) and ERP 563**

#### **GLOBAL COMPANY PROFILE: WHEELED COACH 564**

Dependent Demand 566

Dependent Inventory Model Requirements 566  
    *Master Production Schedule* 567  
    *Bills of Material* 568  
    *Accurate Inventory Records* 570  
    *Purchase Orders Outstanding* 570  
    *Lead Times for Components* 570  
MRP Structure 571  
MRP Management 575  
    *MRP Dynamics* 575  
    *MRP Limitations* 575  
Lot-Sizing Techniques 576  
Extensions of MRP 580  
    *Material Requirements Planning II (MRP II)* 580  
    *Closed-Loop MRP* 581  
    *Capacity Planning* 581  
MRP in Services 583  
    *Distribution Resource Planning (DRP)* 584  
Enterprise Resource Planning (ERP) 584  
    *ERP in the Service Sector* 587  
Summary 587  
Key Terms 587  
Ethical Dilemma 587  
Discussion Questions 588  
Using Software to Solve MRP Problems 588  
Solved Problems 589  
Problems 592  
**CASE STUDIES 595**  
    *When 18,500 Orlando Magic Fans Come to Dinner*  
    *Video Case* 595  
    *MRP at Wheeled Coach* *Video Case* 596  
Endnotes 596  
Rapid Review 597  
Self Test 598

**Chapter 15 Short-Term Scheduling 599**  
**GLOBAL COMPANY PROFILE: ALASKA AIRLINES 600**  
The Importance of Short-Term Scheduling 602  
Scheduling Issues 602  
    *Forward and Backward Scheduling* 603  
    *Finite and Infinite Loading* 604  
    *Scheduling Criteria* 604  
Scheduling Process-Focused Facilities 605  
Loading Jobs 605  
    *Input-Output Control* 606  
    *Gantt Charts* 607  
    *Assignment Method* 608  
Sequencing Jobs 611  
    *Priority Rules for Sequencing Jobs* 611  
    *Critical Ratio* 614

*Sequencing N Jobs on Two Machines: Johnson's Rule* 615  
    *Limitations of Rule-Based Sequencing Systems* 616  
Finite Capacity Scheduling (FCS) 617  
Scheduling Services 618  
    *Scheduling Service Employees with Cyclical Scheduling* 620  
Summary 621  
Key Terms 621  
Ethical Dilemma 621  
Discussion Questions 622  
Using Software for Short-Term Scheduling 622  
Solved Problems 624  
Problems 627  
**CASE STUDIES 630**  
    *Old Oregon Wood Store* 630  
    *From the Eagles to the Magic: Converting the Amway Center* *Video Case* 631  
    *Scheduling at Hard Rock Cafe* *Video Case* 632  
Endnotes 632  
Rapid Review 633  
Self Test 634

**Chapter 16 Lean Operations 635**

**GLOBAL COMPANY PROFILE: TOYOTA MOTOR CORPORATION 636**  
Lean Operations 638  
    *Eliminate Waste* 638  
    *Remove Variability* 639  
    *Improve Throughput* 640  
Lean and Just-in-Time 640  
    *Supplier Partnerships* 640  
    *Lean Layout* 642  
    *Lean Inventory* 643  
    *Lean Scheduling* 646  
    *Lean Quality* 649  
Lean and the Toyota Production System 649  
    *Continuous Improvement* 649  
    *Respect for People* 649  
    *Processes and Standard Work Practice* 650  
Lean Organizations 650  
    *Building a Lean Organization* 650  
    *Lean Sustainability* 652  
Lean in Services 652  
Summary 653  
Key Terms 653  
Ethical Dilemma 653  
Discussion Questions 653  
Solved Problem 653  
Problems 654

**CASE STUDIES 655***Lean Operations at Alaska Airlines Video Case 655**JIT at Arnold Palmer Hospital Video Case 656*

Endnote 656

Rapid Review 657

Self Test 658

**Chapter 17 Maintenance and Reliability 659****GLOBAL COMPANY PROFILE: ORLANDO UTILITIES  
COMMISSION 660**The Strategic Importance of Maintenance  
and Reliability 662

Reliability 663

*System Reliability 663**Providing Redundancy 665*

Maintenance 667

*Implementing Preventive Maintenance 667**Increasing Repair Capabilities 670**Autonomous Maintenance 670*

Total Productive Maintenance 671

Summary 671

Key Terms 671

Ethical Dilemma 671

Discussion Questions 671

Using Software to Solve Reliability Problems 672

Solved Problems 672

Problems 672

**CASE STUDY 674***Maintenance Drives Profits at Frito-Lay**Video Case 674*

Rapid Review 675

Self Test 676

**Appendix A1****Bibliography B1****Name Index I1****General Index I5**

---

**ONLINE TUTORIALS**


---

**1. Statistical Tools for Managers T1-1**

- Discrete Probability Distributions T1-2
  - Expected Value of a Discrete Probability Distribution* T1-3
  - Variance of a Discrete Probability Distribution* T1-3
- Continuous Probability Distributions T1-4
  - The Normal Distribution* T1-4
- Summary T1-7
- Key Terms T1-7
- Discussion Questions T1-7
- Problems T1-7
- Bibliography T1-7

**2. Acceptance Sampling T2-1**

- Sampling Plans T2-2
  - Single Sampling* T2-2
  - Double Sampling* T2-2
  - Sequential Sampling* T2-2
- Operating Characteristic (OC) Curves T2-2
- Producer's and Consumer's Risk T2-3
- Average Outgoing Quality T2-5
- Summary T2-6
- Key Terms T2-6
- Solved Problem T2-7
- Discussion Questions T2-7
- Problems T2-7

**3. The Simplex Method of Linear Programming T3-1**

- Converting the Constraints to Equations T3-2
- Setting Up the First Simplex Tableau T3-2
- Simplex Solution Procedures T3-4
- Summary of Simplex Steps for Maximization Problems T3-6
- Artificial and Surplus Variables T3-7
- Solving Minimization Problems T3-7
- Summary T3-8
- Key Terms T3-8
- Solved Problem T3-8

- Discussion Questions T3-8
- Problems T3-9

**4. The MODI and VAM Methods of Solving Transportation Problems T4-1**

- MODI Method T4-2
  - How to Use the MODI Method* T4-2
  - Solving the Arizona Plumbing Problem with MODI* T4-2
- Vogel's Approximation Method: Another Way to Find an Initial Solution T4-4
- Discussion Questions T4-8
- Problems T4-8

**5. Vehicle Routing and Scheduling T5-1**

- Introduction T5-2
  - Service Delivery Example: Meals-for-ME* T5-2
- Objectives of Routing and Scheduling Problems T5-2
- Characteristics of Routing and Scheduling Problems T5-3
  - Classifying Routing and Scheduling Problems* T5-3
  - Solving Routing and Scheduling Problems* T5-4
- Routing Service Vehicles T5-5
  - The Traveling Salesman Problem* T5-5
  - Multiple Traveling Salesman Problem* T5-8
  - The Vehicle Routing Problem* T5-9
  - Cluster First, Route Second Approach* T5-10
- Scheduling Service Vehicles T5-11
  - The Concurrent Scheduler Approach* T5-13
- Other Routing and Scheduling Problems T5-13
- Summary T5-14
- Key Terms T5-15
- Discussion Questions T5-15
- Problems T5-15
- Case Study: Routing and Scheduling of Phlebotomists T5-17
- Bibliography T5-17

# Preface

Welcome to your operations management (OM) course. In this book, we present a state-of-the-art view of the operations function. Operations is an exciting area of management that has a profound effect on productivity. Indeed, few other activities have as much impact on the quality of our lives. The goal of this text is to present a broad introduction to the field of operations in a realistic, practical manner. Even if you are not planning on a career in the operations area, you will likely be working with people in operations. Therefore, having a solid understanding of the role of operations in an organization will be of substantial benefit to you. This book will also help you understand how OM affects society and your life. Certainly, you will better understand what goes on behind the scenes when you attend a concert or major sports event; purchase a bag of Frito-Lay potato chips; buy a meal at an Olive Garden or a Hard Rock Cafe; place an order through [Amazon.com](https://www.amazon.com); board a flight on Alaska Airlines; or enter a hospital for medical care. More than one and a half million readers of our earlier editions seem to have endorsed this premise.

We welcome comments by email from our North American readers and from students using the International edition, the Indian edition, the Arabic edition, and our editions in Portuguese, Spanish, Turkish, Indonesian, and Chinese. Hopefully, you will find this material useful, interesting, and even exciting.

## New to This Edition

We've made significant revisions to this edition, and want to share some of the changes with you.

### *Four New Video Case Studies Featuring Alaska Airlines*

In this edition, we take you behind the scenes of Alaska Airlines, consistently rated as one of the top carriers in the country. This fascinating organization opened its doors—and planes—so we could examine leading edge OM in the airlines industry. We observe: the quality program at Alaska Air (Chapter 6); the process analysis behind the airline's 20-minute baggage retrieval guarantee (Chapter 7); how Alaska empowers its employees (Chapter 10); and the airline's use of Lean, 5s, kaizen, and Gemba walks (Chapter 16).

Our prior editions focused on integrated *Video Case Studies* for the Orlando Magic basketball team, Frito-Lay, Darden Restaurants, Hard Rock Cafe, Arnold Palmer Hospital, Wheeled Coach Ambulances, and Regal Marine. These *Video Case Studies* appear in this edition as well, along with the five new ones for Alaska Airlines. All of our videos are created by the authors, with the outstanding coauthorship of Beverly Amer at Northern Arizona University, to explicitly match with text content and terminology.



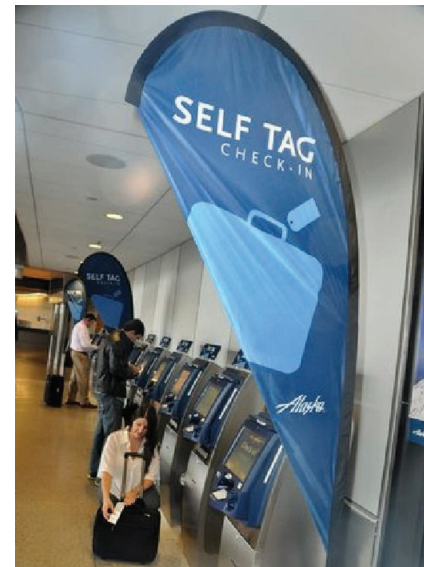
**Alaska Airlines: 20-Minute Baggage Process—Guaranteed!**



Alaska Airlines is unique among the nine major U.S. carriers not only for its extensive flight coverage of remote towns throughout Alaska (it also covers the U.S., Hawaii, and Mexico from its primary hub in Seattle). It is also one of the smallest independent airlines, with 10,300 employees, including 3,000 flight attendants and 1,500 pilots. What makes it really unique, though, is its ability to build state-of-the-art processes, using the latest technology, that yield high customer satisfaction. Indeed, J. D. Power and Associates has ranked Alaska Airlines highest in North America for seven years in a row for customer satisfaction.

Alaska Airlines was the first to sell tickets via the Internet, first to offer Web check-in and print boarding passes online, and first with kiosk check-in. As Wayne Newton, Director of System Operation Control, states, “We are passionate about our processes. If it’s not measured, it’s not managed.”

One of the processes Alaska is most proud of is its baggage handling system. Passengers can check in at kiosks, tag their own bags with bar code stickers, and deliver them to a customer service agent at the carousel, which carries the bags through the vast underground system that eventually delivers the bags to a baggage handler. En route, each bag passes through TSA automated screening and is manually opened or inspected if it appears suspicious. With the help of bar code readers, conveyer belts automatically sort and transfer bags to their location (called a “pier”) at the tarmac level. A baggage handler then loads the bags onto a cart and takes it to



**Creating Your Own Excel Spreadsheets**

We continue to provide two free decision support software programs, Excel OM for Windows and Mac and POM for Windows, to help you and your students solve homework problems and case studies. These excellent packages are found in MyOMLab and at our text’s Student Download Page.

Many instructors also encourage students to develop their own Excel spreadsheet models to tackle OM issues. With this edition, we provide numerous examples at chapter end on how to do so. “Creating Your Own Excel Spreadsheets” examples now appear in Chapters 1, 2, 4, 8, 12 (2 examples), and 13, Supplement 6, and Supplement 7. We hope these nine samples will help expand students’ spreadsheet capabilities.

Using Software for Productivity Analysis

This section presents three ways to solve productivity problems with computer software. First, you can create your own Excel spreadsheets to conduct productivity analysis. Second, you can use the Excel OM software that comes with this text. Third, POM for Windows is another program that is available with this text.

**CREATING YOUR OWN EXCEL SPREADSHEETS**

Program 1.1 illustrates how to build an Excel spreadsheet for the data in Example 2.

	A	B	C	D	E
1	Collins Title Insurance Ltd.	Enter the values for the old system in column B and the new system in Column C.			
2	Productivity Increase Computations				
3					
4	Parameters	Old System	New System		
5	Length of Workday (hours)	8	8		
6	Number of Workers	4	4		
7	Labor Hours per Day	32	32	=C5*C6	
8	Payroll Cost per Day	\$640	\$640		
9	Overhead Expenses	\$400	\$800		
10	Output (Titles per Day)	8	14		
11		=B10/B7		Productivity = Output/Input	
12					
13	Solutions	Old System	New System	% Increase	
14	Labor Productivity (Titles per Labor-Hour)	0.25	0.4375	75.00%	
15	Multifactor Productivity (Titles per Dollar)	0.0077	0.0097	26.39%	
16		=C10/(C8+C9)		=(C14-B14)/B14	
	Actions	Copy C7 to B7, Copy B14 to C14, Copy C15 to B15, and Copy D14 to D15			
		Create a row for each of the inputs used for the productivity measure. Put the output in the last row.			

Program 1.1

**✕ USING EXCEL OM**

Excel OM is an Excel “add-in” with 24 Operations Management decision support “Templates.” To access the templates, double-click on the *Excel OM* tab at the top of the page, then in the menu bar choose the appropriate chapter (in this case Chapter 1), from either the “Chapter” or “Alphabetic” tab on the left. Each of Excel OM’s 24 modules includes instructions for that particular module. The instructions can be turned on or off via the “instruction” tab in the menu bar.

**P USING POM FOR WINDOWS**

POM for Windows is decision support software that includes 24 Operations Management modules. The modules are accessed by double-clicking on *Module* in the menu bar, and then double-clicking on the appropriate (in this case *Productivity*) item. Instructions are provided for each module just below the menu bar.

## Expanding and Reordering Our Set of Homework Problems

We believe that a vast selection of quality homework problems, ranging from easy to challenging (denoted by one to four dots), is critical for both instructors and students. Instructors need a broad selection of problems to choose from for homework, quizzes, and exams—without reusing the same set from semester to semester. We take pride in having more problems—by far, with 618—than any other OM text. We added dozens of new problems this edition. The following table illustrates the selection by chapter.

Chapter	Number of Problems	Chapter	Number of Problems	Chapter	Number of Problems
1	18	Supplement 6	55	Supplement 11	20
2	12	7	17	12	53
3	33	Supplement 7	45	13	26
4	59	8	34	14	32
5	28	9	27	15	27
Supplement 5	19	10	46	16	12
6	21	11	8	17	24

Further, with the majority of our adopters now using the **MyOMLab** learning system in their classes, we have reorganized all the homework problems—both those appearing in the printed text, as well as the Additional Homework Problems that are available in **MyOMLab**—by topic heading. We are identifying all problems by topic (see the following example).

The list of all problems by topic also appears at the end of each boxed example, as well as in the Rapid Review that closes each chapter. These handy references should make it easier to assign problems for homework, quizzes, and exams. A rich set of assignable problems and cases makes the learning experience more complete and pedagogically sound.

### CHAPTER 5 | DESIGN OF GOODS AND SERVICES 187

*Problem 5.3 is available in MyOMLab.*

#### Problems 5.4–5.8 relate to Product Development

- **5.4** Construct a house of quality matrix for a wrist-watch. Be sure to indicate specific customer wants that you think the general public desires. Then complete the matrix to show how an operations manager might identify specific attributes that can be measured and controlled to meet those customer desires.
- **5.5** Using the house of quality, pick a real product (a good or service) and analyze how an existing organization satisfies customer requirements.
- **5.6** Prepare a house of quality for a mousetrap.
- **5.7** Conduct an interview with a prospective purchaser of a new bicycle and translate the customer's *wants* into the specific *hows* of the firm.
- **5.8** Using the house of quality sequence, as described in Figure 5.4 on page 169, determine how you might deploy resources to achieve the desired quality for a product or service whose production process you understand.

#### Problems 5.9–5.17 relate to Defining a Product

- **5.9** Prepare a bill of material for (a) a pair of eyeglasses and its case or (b) a fast-food sandwich (visit a local sandwich

#### Problems 5.21–5.28 relate to the Application of Decision Trees to Product Design

- **5.21** The product design group of Iyengar Electric Supplies, Inc., has determined that it needs to design a new series of switches. It must decide on one of three design strategies. The market forecast is for 200,000 units. The better and more sophisticated the design strategy and the more time spent on value engineering, the less will be the variable cost. The chief of engineering design, Dr. W. L. Berry, has decided that the following costs are a good estimate of the initial and variable costs connected with each of the three strategies:
  - a) *Low-tech*: A low-technology, low-cost process consisting of hiring several new junior engineers. This option has a fixed cost of \$45,000 and variable-cost probabilities of .3 for \$.55 each, .4 for \$.50, and .3 for \$.45.
  - b) *Subcontract*: A medium-cost approach using a good outside design staff. This approach would have a fixed cost of \$65,000 and variable-cost probabilities of .7 of \$.45, .2 of \$.40, and .1 of \$.35.
  - c) *High-tech*: A high-technology approach using the very best of the inside staff and the latest computer-aided design technology. This approach has a fixed cost of \$75,000 and variable-cost probabilities of .9 of \$.40 and .1 of \$.35.

What is the best decision based on an expected monetary value (EMV) criterion? (*Note*: We want the lowest EMV, as we are dealing with costs in this problem.) **Px**

- **5.22** MacDonald Products, Inc., of Clarkson, New York, has the option of (a) proceeding immediately with production of

### Jay, Barry, and Chuck’s OM Blog

As a complement to this text, we have created a companion blog, with coordinated features to help teach the OM course. There are teaching tips, highlights of OM items in the news (along with class discussion questions and links), video tips, guest posts by instructors using our text, sample OM syllabi from dozens of colleges, and much more—all arranged by chapter. To learn more about any chapter topics, visit [www.heizerrenderOM.wordpress.com](http://www.heizerrenderOM.wordpress.com). As you prepare your lectures and syllabus, scan our blog for discussion ideas, teaching tips, and classroom exercises.

### Lean Operations

In previous editions, we sought to explicitly differentiate the concepts of just-in-time, Lean, and Toyota Production System in Chapter 16. However, there is significant overlap and interchangeability among those three concepts, so we have revised Chapter 16 to incorporate the three concepts into an overall concept of “Lean.” The chapter suggests that students view Lean as a comprehensive integrated operations strategy that sustains competitive advantage and results in increased returns to all stakeholders.

## Chapter-by-Chapter Changes

To highlight the extent of the revisions in this edition, here are a few of the changes, on a chapter-by-chapter basis.

### Chapter 1: Operations and Productivity

We updated Table 1.4 to reflect employment in various sectors and expanded our discussion of Lean operations. Our new case, Uber Technologies, introduces productivity by discussing the disruptive nature of the Uber business model. In addition, there is a new “Creating Your Own Excel Spreadsheets” example for both labor productivity and multifactor productivity.

### Chapter 2: Operations Strategy in a Global Environment

We have updated Figure 2.1 to better reflect changes in the growth of world trade and Figure 2.5 to reflect product life cycle changes. The Minute Lube case has been revised as Rapid Lube. Example 1 (National Architects) has been expanded to clarify factor rating calculations and is also demonstrated with a “Creating Your Own Excel Spreadsheets” presentation.

### Chapter 3: Project Management

We rewrote and updated the Bechtel Global Company Profile and added a new section on well-defined projects with the “agile” and “waterfall” approaches. There are two new OM in Action boxes: “Agile Project Management at Mastek,” and “Behind the Tour de France.”

### Chapter 4: Forecasting

We created a new table comparing the MAD, MSE, and MAPE forecasting error measures. There is also a new OM in Action box called “NYC’s Potholes and Regression Analysis.”

### Chapter 5: Design of Goods and Services

We expanded our treatment of *concurrent engineering* and added two new discussion questions. Solved Problem 5.1 has been revised.

### Supplement 5: Sustainability in the Supply Chain

We wrote a new introductory section on Corporate Social Responsibility. There is also a new OM in Action box called “Blue Jeans and Sustainability” and 10 new homework problems.

### Chapter 6: Managing Quality

We added new material to expand our discussion of Taguchi’s quality loss function. There is a new section on SERVQUAL, and a new video case study, “Quality Counts at Alaska Airlines,” appears here.

### Supplement 6: Statistical Process Control

We added a figure on the relationship between sample size and sampling distribution. We also added raw data to Examples S2 and S3 to illustrate how ranges are computed. There is a new Excel spreadsheet to show students how to make their own  $c$ -chart, and we have added three new homework problems.

### Chapter 7: Process Strategy

We wrote a new section on machine technology and additive manufacturing. There are two new discussion questions and three new homework problems. Our second new video case study is called “Alaska Airlines: 20-Minute Baggage Process—Guaranteed!”

### Supplement 7: Capacity and Constraint Management

We added a new Table S7.1, which compares and clarifies three capacity measurements, with an example of each. There is a new treatment of expected output and actual output in Example S2. The discussion of bottleneck time versus throughput time has also been expanded. Example S3, capacity analysis with parallel processes, has been revised. We have also added a new “Creating Your Own Excel Spreadsheets” example for a break-even model. Finally, we updated the Arnold Palmer Hospital capacity planning case with recent data.

### Chapter 8: Location Strategies

We added two new OM in Action boxes: “Iowa—Home of Corn and Facebook” and “Denmark’s Meat Cluster.” We changed the notation for the center-of-gravity model to simplify the equation and provided a new “Creating Your Own Excel Spreadsheets” presentation for the center-of-gravity example.

### Chapter 9: Layout Strategies

We created a new Muther grid for office relationship charting and added a spread of five layouts showing how offices have evolved over time. There is a new OM in Action box called “Amazon Lets Loose the Robots,” and there is a new graphic example of Proplanner’s Flow Path Calculator. We have included a formula for idle time as a second measure of balance assignment efficiency and added new technology issues to the Arnold Palmer Hospital video case.

### Chapter 10: Human Resources, Job Design, and Work Measurement

We added a new OM in Action box, “The Missing Perfect Chair,” and revised the Operations Chart as a service example. Our third new video case study is “The ‘People’ Focus: Human Resources at Alaska Airlines.”

### Chapter 11: Supply Chain Management

We added “outsourcing” as a supply chain risk in Table 11.3.

### Supplement 11: Supply Chain Management Analytics

We added a major section on the topic of Warehouse Storage, with a new model for allocating inventory to storage locations. There is a new discussion question and three new homework problems.

### Chapter 12: Inventory Management

New Programs 12.1 and 12.2 illustrate “Creating Your Own Excel Spreadsheets” for both the production run model and the single-period inventory model. The Excel function NORMSINV is introduced throughout the chapter. The Quantity Discount Model section is totally rewritten to illustrate the *feasible solution* shortcut. Solved Problem 12.5 is likewise redone with the new approach.

### Chapter 13: Aggregate Planning and S&OP

We added a new OM in Action box, “Revenue Management Makes Disney the ‘King’ of the Broadway Jungle.” We also provided a new “Creating Your Own Excel Spreadsheets” example for the transportation method for aggregate planning, using the Solver approach.

## Chapter 14: Material Requirements Planning (MRP) and ERP

The MRP II example now includes greenhouse gasses.

## Chapter 15: Short-Term Scheduling

We begin this chapter with a new Global Company Profile featuring Alaska Airlines and the scheduling issues it faces in its northern climate. We have added two new graphics to help illustrate Forward and Backward Scheduling. There is also a new section called Performance Criteria, detailing how the choice of priority rule depends on four quantifiable criteria. We now explicitly define the performance criteria for sequencing jobs as separate numbered equations. Also, we provide an explicit formula for job lateness. There is a new OM in Action box called “Starbucks’ Controversial Scheduling Software.”

## Chapter 16: Lean Operations

This chapter saw a major reorganization and rewrite with an enhanced focus on Lean operations. There is more material on supplier partnerships and building lean organizations. A new OM in Action box describes the use of kaizen at San Francisco General Hospital, and we have added a new video case study called “Lean Operations at Alaska Airlines.”

## Chapter 17: Maintenance and Reliability

There are no major changes in this chapter.

# Student Resources

To liven up the course and help students learn the content material, we have made available the following resources:

- ◆ *Forty-one exciting Video Case Studies (videos located at MyOMLab):* These *Video Case Studies* feature real companies (Alaska Airlines, The Orlando Magic, Frito-Lay, Darden Restaurants, Regal Marine, Hard Rock Cafe, Ritz-Carlton, Wheeled Coach, and Arnold Palmer Hospital) and allow students to watch short videos, read about the key topics, and answer questions. These case studies can also be assigned without using class time to show the videos. Each of them was developed and written by the text authors to specifically supplement the book’s content. Instructors who wish to use these in class, and who don’t have access to MyOMLab, should contact their Pearson Publishing Representative for access to the MyOMLab materials.
- ◆ *POM for Windows software (located at MyOMLab and at the Student Download Page, [www.pearsonhighered.com/heizer](http://www.pearsonhighered.com/heizer)):* POM for Windows is a powerful tool for easily solving OM problems. Its 24 modules can be used to solve most of the homework problems in the text.
- ◆ *Excel OM problem-solving software (located at MyOMLab and at the Student Download Page, [www.pearsonhighered.com/heizer](http://www.pearsonhighered.com/heizer)):* Excel OM is our exclusive user-friendly Excel add-in. Excel OM automatically creates worksheets to model and solve problems. Users select a topic from the pull-down menu and fill in the data, and then Excel will display and graph (where appropriate) the results. This software is great for student homework, what-if analysis, and classroom demonstrations. This edition includes a new version of Excel OM that is compatible with Microsoft Excel 2013 for Windows, Excel 2011 and 2016 for Mac, and earlier versions of Excel. Professor Howard Weiss, Temple University, developed both Excel OM for Windows and Mac, and POM for Windows to accompany our text and its problem set.
- ◆ *Excel OM data files (located at MyOMLab and at the Student Download Page, [www.pearsonhighered.com/heizer](http://www.pearsonhighered.com/heizer)):* These data files are prepared for specific examples and allow users to solve all the marked text examples without reentering any data.
- ◆ *Active Models (located at MyOMLab and at the Student Download Page, [www.pearsonhighered.com/heizer](http://www.pearsonhighered.com/heizer)):* These 28 Active Models are Excel-based OM simulations, designed to help students understand the quantitative methods shown in the textbook examples. Students may change the data in order to see how the changes affect the answers.

- ◆ *Virtual tours (located at MyOMLab)*: These company tours provide direct links to companies—ranging from a hospital to an auto manufacturer—that practice key OM concepts. After touring each Web site, students are asked questions directly related to the concepts discussed in the chapter.
- ◆ *Online Tutorial Chapters (located at MyOMLab and at the Student Download Page, [www.pearsonhighered.com/heizer](http://www.pearsonhighered.com/heizer))*: “Statistical Tools for Managers,” “Acceptance Sampling,” “The Simplex Method of Linear Programming,” “The MODI and VAM Methods of Solving Transportation Problems,” and “Vehicle Routing and Scheduling” are provided as additional material.
- ◆ *Additional practice problems (located at MyOMLab)*: These problems provide problem-solving experience. They supplement the examples and solved problems found in each chapter.
- ◆ *Additional case studies (located at MyOMLab and at the Student Download Page, [www.pearsonhighered.com/heizer](http://www.pearsonhighered.com/heizer))*: Over two dozen additional case studies supplement the ones in the text. Detailed solutions appear in the Solutions Manual.
- ◆ *Virtual office hours (located at MyOMLab)*: Professors Heizer, Render, and Munson walk students through all 73 Solved Problems in a series of 5- to 20-minute explanations. These have been updated with this new edition.

## Instructor Resources

At the Instructor Resource Center, [www.pearsonhighered.com/irc](http://www.pearsonhighered.com/irc), instructors can easily register to gain access to a variety of instructor resources available with this text in downloadable format. If assistance is needed, our dedicated technical support team is ready to help with the media supplements that accompany this text. Visit <http://247.pearsoned.com> for answers to frequently asked questions and toll-free user support phone numbers.

The following supplements are available with this text:

### Instructor’s Resource Manual

The Instructor’s Resource Manual, updated by co-author Chuck Munson, contains many useful resources for instructors—PowerPoint presentations with annotated notes, course outlines, video notes, blog highlights, learning techniques, Internet exercises and sample answers, case analysis ideas, additional teaching resources, and faculty notes.

### Instructor’s Solutions Manual

The Instructor’s Solutions Manual, written by the authors, contains the answers to all of the discussion questions, *Ethical Dilemmas*, Active Models, and cases in the text, as well as worked-out solutions to all the end-of-chapter problems, additional homework problems, and additional case studies.

### PowerPoint Presentations

An extensive set of PowerPoint presentations, created by Professor Jeff Heyl of Lincoln University, is available for each chapter. With well over 2,000 slides, this set has excellent color and clarity.

### Test Bank/TestGen® Computerized Test Bank

The test bank, updated by James Roh, contains a variety of true/false, multiple-choice, short-answer, and essay questions, along with a selection of written problems, for each chapter. Test questions are annotated with the following information:

- ◆ Difficulty level
- ◆ Type: multiple-choice, true/false, short-answer, essay, problem
- ◆ Learning objective
- ◆ AACSB (see the description that follows)

TestGen®, Pearson Education’s test-generating software, is PC/MAC compatible and preloaded with all the test bank questions. The test program permits instructors to edit, add, and delete questions from the test bank to create customized tests.

# AACSB

*The Association to Advance Collegiate Schools of Business (AACSB)*

The test bank has connected select questions to the general knowledge and skill guidelines found in the AACSB Assurance of Learning standards.

AACSB is a not-for-profit corporation of educational institutions, corporations, and other organizations devoted to the promotion and improvement of higher education in business administration and accounting. A collegiate institution offering degrees in business administration or accounting may volunteer for AACSB accreditation review. The AACSB makes initial accreditation decisions and conducts periodic reviews to promote continuous quality improvement in management education. Pearson Education is a proud member of the AACSB and is pleased to provide advice to help you apply AACSB assurance of learning standards.

What are AACSB assurance of learning standards? One of the criteria for AACSB accreditation is quality of the curricula. Although no specific courses are required, the AACSB expects a curriculum to include learning experiences in the following areas:

- ◆ Written and oral communication
- ◆ Ethical understanding and reasoning
- ◆ Analytical thinking
- ◆ Information technology
- ◆ Interpersonal relations and teamwork
- ◆ Diverse and multicultural work environments
- ◆ Reflective thinking
- ◆ Application of knowledge

Questions that test skills relevant to these guidelines are appropriately tagged. For example, a question regarding clothing manufactured for U.S. firms by 10-year olds in Asia would receive the Ethical understanding and reasoning tag.

Tagged questions help you measure whether students are grasping the course content that aligns with the AACSB guidelines noted. In addition, the tagged questions may help instructors identify potential applications of these skills. This in turn may suggest enrichment activities or other educational experiences to help students achieve these skills.

## Video Package

Designed and created by the authors specifically for their Heizer/Render/Munson texts, the video package contains the following 41 videos:

- ◆ Frito-Lay: Operations Management in Manufacturing (Chapter 1)
- ◆ Hard Rock Cafe: Operations Management in Services (Chapter 1)
- ◆ Strategy at Regal Marine (Chapter 2)
- ◆ Hard Rock Cafe's Global Strategy (Chapter 2)
- ◆ Outsourcing Offshore at Darden (Chapter 2)
- ◆ Project Management at Arnold Palmer Hospital (Chapter 3)
- ◆ Managing Hard Rock's Rockfest (Chapter 3)
- ◆ Forecasting Ticket Revenue for Orlando Magic Basketball Games (Chapter 4)
- ◆ Forecasting at Hard Rock Cafe (Chapter 4)
- ◆ Product Design at Regal Marine (Chapter 5)
- ◆ Building Sustainability at the Orlando Magic's Amway Center (Supplement 5)
- ◆ Green Manufacturing and Sustainability at Frito-Lay (Supplement 5)
- ◆ Quality Counts at Alaska Airlines (Chapter 6)
- ◆ The Culture of Quality at Arnold Palmer Hospital (Chapter 6)
- ◆ Quality at the Ritz-Carlton Hotel Company (Chapter 6)
- ◆ Frito-Lay's Quality-Controlled Potato Chips (Supplement 6)

- ◆ Farm to Fork: Quality at Darden Restaurants (Supplement 6)
- ◆ Alaska Airlines: 20-Minute Baggage Process—Guaranteed! (Chapter 7)
- ◆ Process Strategy at Wheeled Coach (Chapter 7)
- ◆ Process Analysis at Arnold Palmer Hospital (Chapter 7)
- ◆ Capacity Planning at Arnold Palmer Hospital (Supplement 7)
- ◆ Locating the Next Red Lobster Restaurant (Chapter 8)
- ◆ Where to Place the Hard Rock Cafe (Chapter 8)
- ◆ Facility Layout at Wheeled Coach (Chapter 9)
- ◆ Laying Out Arnold Palmer Hospital’s New Facility (Chapter 9)
- ◆ The “People” Focus: Human Resources at Alaska Airlines (Chapter 10)
- ◆ Hard Rock’s Human Resource Strategy (Chapter 10)
- ◆ Darden’s Global Supply Chains (Chapter 11)
- ◆ Supply Chain Management at Regal Marine (Chapter 11)
- ◆ Arnold Palmer Hospital’s Supply Chain (Chapter 11)
- ◆ Managing Inventory at Frito-Lay (Chapter 12)
- ◆ Inventory Control at Wheeled Coach (Chapter 12)
- ◆ Using Revenue Management to Set Orlando Magic Ticket Prices (Chapter 13)
- ◆ When 18,500 Orlando Magic Fans Come to Dinner (Chapter 14)
- ◆ MRP at Wheeled Coach (Chapter 14)
- ◆ From the Eagles to the Magic: Converting the Amway Center (Chapter 15)
- ◆ Scheduling at Hard Rock Cafe (Chapter 15)
- ◆ Lean Operations at Alaska Airlines (Chapter 16)
- ◆ JIT at Arnold Palmer Hospital (Chapter 16)
- ◆ Maintenance Drives Profits at Frito-Lay (Chapter 17)

## Acknowledgments

We thank the many individuals who were kind enough to assist us in this endeavor. The following professors provided insights that guided us in this edition (their names are in bold) and in prior editions:

### **ALABAMA**

#### **John Mittenthal**

*University of Alabama*

#### Philip F. Musa

*University of Alabama at Birmingham*

#### **William Petty**

*University of Alabama*

#### Doug Turner

*Auburn University*

### **ALASKA**

#### Paul Jordan

*University of Alaska*

### **ARIZONA**

#### Susan K. Norman

*Northern Arizona University*

#### Scott Roberts

*Northern Arizona University*

#### Vicki L. Smith-Daniels

*Arizona State University*

#### **Susan K. Williams**

*Northern Arizona University*

### **CALIFORNIA**

#### Jean-Pierre Amor

*University of San Diego*

#### Moshen Attaran

*California State University–Bakersfield*

#### Ali Behnezhad

*California State University–Northridge*

#### Joe Biggs

*California Polytechnic State University*

#### Lesley Buehler

*Ohlone College*

#### **Rick Hesse**

*Pepperdine*

#### Ravi Kathuria

*Chapman University*

#### Richard Martin

*California State University–Long Beach*

#### **Ozgur Ozluk**

*San Francisco State University*

#### Zinovy Radovilsky

*California State University–Hayward*

#### Robert J. Schlesinger

*San Diego State University*

#### V. Udayabhanu

*San Francisco State University*

#### Rick Wing

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### **COLORADO**

#### Peter Billington

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**Gregory Stock**

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*Quinnipiac University*

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**FLORIDA**

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Rita Gibson

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Jim Gilbert

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**Wende Huehn-Brown**

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**Adam Munson**

*University of Florida*

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John Miller

*Mercer University*

**Nikolay Osadchiy**

*Emory University*

Spyros Reveliotis

*Georgia Institute of Technology*

**ILLINOIS**

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*Chicago State University*

**Lori Cook**

*DePaul University*

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*University of Illinois–Chicago*

Zafar Malik

*Governors State University*

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B.P. Lingeraj

*Indiana University*

Frank Pianki

*Anderson University*

Stan Stockton

*Indiana University*

**Jerry Wei**

*University of Notre Dame*

Jianghua Wu

*Purdue University*

Xin Zhai

*Purdue University*

**IOWA**

**Debra Bishop**

*Drake University*

Kevin Watson

*Iowa State University*

Lifang Wu

*University of Iowa*

**KANSAS**

William Barnes

*Emporia State University*

George Heinrich

*Wichita State University*

Sue Helms

*Wichita State University*

Hugh Leach

*Washburn University*

M.J. Riley

*Kansas State University*

Teresita S. Salinas

*Washburn University*

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*Wichita State University*

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Grace Greenberg  
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**NEW MEXICO**

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**NEW YORK**

Theodore Boreki  
*Hofstra University*

John Drabouski  
*DeVry University*

Richard E. Dulski  
*Daemen College*

Jonatan Jelen  
*Baruch College*

Beate Klingenberg  
*Marist College*

Donna Mosier  
*SUNY Potsdam*

Elizabeth Perry  
*SUNY Binghamton*

William Reisel  
*St. John's University*

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Girish Shambu  
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Rajendra Tibrewala  
*New York Institute of Technology*

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Emma Jane Riddle  
*Winthrop University*

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Joseph Blackburn  
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Hugh Daniel  
*Lipscomb University*

Cliff Welborn  
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Warren W. Fisher  
*Stephen F. Austin State University*

Garland Hunnicutt  
*Texas State University*

Gregg Lattier  
*Lee College*

Henry S. Maddux III  
*Sam Houston State University*

Arunachalam Narayanan  
*Texas A&M University*

Ranga V. Ramasesh  
*Texas Christian University*

Victor Sower  
*San Houston State University*

Cecelia Temponi  
*Texas State University*  
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Dwayne Whitten  
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Bruce M. Woodworth  
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Madeline Thimmes (retired)  
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*Howard University*

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*West Virginia University*  
James S. Hawkes  
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**WISCONSIN**

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*University of Wisconsin–Oshkosh*

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Steven Harrod  
*Technical University of Denmark*  
Robert D. Klassen  
*University of Western Ontario*  
Ronald Lau  
*Hong Kong University of Science and Technology*

In addition, we appreciate the wonderful people at Pearson Education who provided both help and advice: Stephanie Wall, our superb editor-in-chief; Lenny Ann Kucenski, our dynamo marketing manager; Linda Albelli, our editorial assistant; Courtney Kamauf and Andra Skaalrud for their fantastic and dedicated work on MyOMLab; Jeff Holcomb, our project manager team lead; Claudia Fernandes, our program manager; Jacqueline Martin, our senior project manager; and Heidi Allgair, our project manager at Cenveo® Publisher Services. We are truly blessed to have such a fantastic team of experts directing, guiding, and assisting us.

In this edition, we were thrilled to be able to include one of the country's premier airlines, Alaska Airlines, in our ongoing Video Case Study series. This was possible because of the wonderful efforts of COO/EVP-Operations Ben Minicucci, and his superb management team. This included John Ladner (Managing Director, Seattle Station Operations), Wayne Newton (Managing Director, Station Operations Control), Mike McQueen (Director, Schedule Planning), Chad Koehnke (Director, Planning and Resource Allocation), Cheryl Schulz (Executive Assistant to EVP Minicucci), Jeffrey Butler (V.P. Airport Operations & Customer Service), Dan Audette (Manager of Operations Research and Analysis), Allison Fletcher (Process Improvement Manager), Carlos Zendejas (Manager Line-Flying Operations, Pilots), Robyn Garner (Flight Attendant Trainer), and Nikki Meier and Sara Starbuck (Process Improvement Facilitators). We are grateful to all of these fine people, as well as the many others that participated in the development of the videos and cases during our trips to the Seattle headquarters.

We also appreciate the efforts of colleagues who have helped to shape the entire learning package that accompanies this text. Professor Howard Weiss (Temple University) developed the Active Models, Excel OM, and POM for Windows software; Professor Jeff Heyl (Lincoln University) created the PowerPoint presentations; and Professor James Roh (Rowan University) updated the test bank. Beverly Amer (Northern Arizona University) produced and directed the video series; Professors Keith Willoughby (Bucknell University) and Ken Klassen (Brock University) contributed the two Excel-based simulation games; and Professor Gary LaPoint (Syracuse University) developed the Microsoft Project crashing exercise and the dice game for SPC. We have been fortunate to have been able to work with all these people.

*We wish you a pleasant and productive introduction to operations management.*

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## TWO VERSIONS ARE AVAILABLE

This text is available in two versions: *Operations Management*, 12th edition, a hardcover, and *Principles of Operations Management*, 10th edition, a paperback. Both books include the identical core Chapters 1–17. However, *Operations Management*, 12th edition also includes six business analytics modules in Part IV.

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### **PART I INTRODUCTION TO OPERATIONS MANAGEMENT**

1. Operations and Productivity
2. Operations Strategy in a Global Environment
3. Project Management
4. Forecasting

### **PART II DESIGNING OPERATIONS**

5. Design of Goods and Services
- S5. Sustainability in the Supply Chain
6. Managing Quality
- S6. Statistical Process Control
7. Process Strategy
- S7. Capacity and Constraint Management
8. Location Strategies
9. Layout Strategies
10. Human Resources, Job Design, and Work Measurement

### **PART III MANAGING OPERATIONS**

11. Supply Chain Management
- S11. Supply Chain Management Analytics
12. Inventory Management
13. Aggregate Planning and S&OP
14. Material Requirements Planning (MRP) and ERP
15. Short-Term Scheduling
16. Lean Operations
17. Maintenance and Reliability

### **PART IV BUSINESS ANALYTICS MODULES**

- A. Decision-Making Tools
- B. Linear Programming
- C. Transportation Models
- D. Waiting-Line Models
- E. Learning Curves
- F. Simulation

### **ONLINE TUTORIALS**

1. Statistical Tools for Managers
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4. The MODI and VAM Methods of Solving Transportation Problems
5. Vehicle Routing and Scheduling

**PRINCIPLES OF OPERATIONS  
MANAGEMENT, 10TH EDITION**  
**ISBN: 0-13-418198-0**

### **PART I INTRODUCTION TO OPERATIONS MANAGEMENT**

1. Operations and Productivity
2. Operations Strategy in a Global Environment
3. Project Management
4. Forecasting

### **PART II DESIGNING OPERATIONS**

5. Design of Goods and Services
- S5. Sustainability in the Supply Chain
6. Managing Quality
- S6. Statistical Process Control
7. Process Strategy
- S7. Capacity and Constraint Management
8. Location Strategies
9. Layout Strategies
10. Human Resources, Job Design, and Work Measurement

### **PART III MANAGING OPERATIONS**

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# PRINCIPLES OF OPERATIONS MANAGEMENT

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Sustainability and Supply Chain Management

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# Operations and Productivity

# 1

CHAPTER

## CHAPTER OUTLINE

### GLOBAL COMPANY PROFILE: *Hard Rock Cafe*

- ◆ What Is Operations Management? 4
- ◆ Organizing to Produce Goods and Services 4
- ◆ The Supply Chain 6
- ◆ Why Study OM? 6
- ◆ What Operations Managers Do 7
- ◆ The Heritage of Operations Management 8
- ◆ Operations for Goods and Services 11
- ◆ The Productivity Challenge 13
- ◆ Current Challenges in Operations Management 18
- ◆ Ethics, Social Responsibility, and Sustainability 19



Alaska Airlines

**10**  
**OM**  
STRATEGY  
DECISIONS

- Design of Goods and Services
- Managing Quality
- Process Strategy
- Location Strategies
- Layout Strategies
- Human Resources
- Supply-Chain Management
- Inventory Management
- Scheduling
- Maintenance



**GLOBAL COMPANY PROFILE**  
*Hard Rock Cafe*

# Operations Management at Hard Rock Cafe

Operations managers throughout the world are producing products every day to provide for the well-being of society. These products take on a multitude of forms. They may be washing machines at Whirlpool, motion pictures at DreamWorks, rides at Disney World, or food at Hard Rock Cafe. These firms produce thousands of complex products every day—to be delivered as the customer ordered them, when the customer wants them, and where the customer wants them. Hard Rock does this for over 35 million guests worldwide every year. This is a challenging task, and the operations manager's job, whether at Whirlpool, DreamWorks, Disney, or Hard Rock, is demanding.



Andre Jenny/Alamy

Hard Rock Cafe in Orlando, Florida, prepares over 3,500 meals each day. Seating more than 1,500 people, it is one of the largest restaurants in the world. But Hard Rock's operations managers serve the hot food hot and the cold food cold.

Operations managers are interested in the attractiveness of the layout, but they must be sure that the facility contributes to the efficient movement of people and material with the necessary controls to ensure that proper portions are served.



Demetrio Carrasco/Rough Guides/Dorling Kindersley, Ltd.



Lots of work goes into designing, testing, and costing meals. Then suppliers deliver quality products on time, every time, for well-trained cooks to prepare quality meals. But none of that matters unless an enthusiastic waitstaff, such as the one shown here, holding guitars previously owned by members of U2, is doing its job.


Efficient kitchen layouts, motivated personnel, tight schedules, and the right ingredients at the right place at the right time are required to delight the customer.



Orlando-based Hard Rock Cafe opened its first restaurant in London in 1971, making it over 45 years old and the granddaddy of theme restaurants. Although other theme restaurants have come and gone, Hard Rock is still going strong, with 150 restaurants in more than 53 countries—and new restaurants opening each year. Hard Rock made its name with rock music memorabilia, having started when Eric Clapton, a regular customer, marked his favorite bar stool by hanging his guitar on the wall in the London cafe. Now Hard Rock has 70,000 items and millions of dollars invested in memorabilia. To keep customers coming back time and again, Hard Rock creates value in the form of good food and entertainment.

The operations managers at Hard Rock Cafe at Universal Studios in Orlando provide more than 3,500 custom products—in this case meals—every day. These products are designed, tested, and then analyzed for cost of

ingredients, labor requirements, and customer satisfaction. On approval, menu items are put into production—and then only if the ingredients are available from qualified suppliers. The production process, from receiving, to cold storage, to grilling or baking or frying, and a dozen other steps, is designed and maintained to yield a quality meal. Operations managers, using the best people they can recruit and train, also prepare effective employee schedules and design efficient layouts.

Managers who successfully design and deliver goods and services throughout the world understand operations. In this text, we look not only at how Hard Rock’s managers create value but also how operations managers in other services, as well as in manufacturing, do so. Operations management is demanding, challenging, and exciting. It affects our lives every day. Ultimately, operations managers determine how well we live. 

# LEARNING OBJECTIVES

- LO 1.1** *Define* operations management 4
- LO 1.2** *Explain* the distinction between goods and services 11
- LO 1.3** *Explain* the difference between production and productivity 13
- LO 1.4** *Compute* single-factor productivity 14
- LO 1.5** *Compute* multifactor productivity 15
- LO 1.6** *Identify* the critical variables in enhancing productivity 16

## STUDENT TIP

Let's begin by defining what this course is about.

## What Is Operations Management?

### LO 1.1 *Define* operations management

#### VIDEO 1.1

Operations Management at Hard Rock

#### VIDEO 1.2

Operations Management at Frito-Lay

### Production

The creation of goods and services.

### Operations management (OM)

Activities that relate to the creation of goods and services through the transformation of inputs to outputs.

Operations management (OM) is a discipline that applies to restaurants like Hard Rock Cafe as well as to factories like Ford and Whirlpool. The techniques of OM apply throughout the world to virtually all productive enterprises. It doesn't matter if the application is in an office, a hospital, a restaurant, a department store, or a factory—the production of goods and services requires operations management. And the *efficient* production of goods and services requires effective applications of the concepts, tools, and techniques of OM that we introduce in this book.

As we progress through this text, we will discover how to manage operations in an economy in which both customers and suppliers are located throughout the world. An array of informative examples, charts, text discussions, and pictures illustrates concepts and provides information. We will see how operations managers create the goods and services that enrich our lives.

In this chapter, we first define *operations management*, explaining its heritage and exploring the exciting role operations managers play in a huge variety of organizations. Then we discuss production and productivity in both goods- and service-producing firms. This is followed by a discussion of operations in the service sector and the challenge of managing an effective and efficient production system.

**Production** is the creation of goods and services. **Operations management (OM)** is the set of activities that creates value in the form of goods and services by transforming inputs into outputs. Activities creating goods and services take place in all organizations. In manufacturing firms, the production activities that create goods are usually quite obvious. In them, we can see the creation of a tangible product such as a Sony TV or a Harley-Davidson motorcycle.

In an organization that does not create a tangible good or product, the production function may be less obvious. We often call these activities *services*. The services may be “hidden” from the public and even from the customer. The product may take such forms as the transfer of funds from a savings account to a checking account, the transplant of a liver, the filling of an empty seat on an airplane, or the education of a student. Regardless of whether the end product is a good or service, the production activities that go on in the organization are often referred to as operations, or *operations management*.

## STUDENT TIP

Operations is one of the three functions that every organization performs.

## Organizing to Produce Goods and Services

To create goods and services, all organizations perform three functions (see Figure 1.1). These functions are the necessary ingredients not only for production but also for an organization's survival. They are:

1. *Marketing*, which generates the demand, or at least takes the order for a product or service (nothing happens until there is a sale).
2. *Production/operations*, which creates, produces, and delivers the product.
3. *Finance/accounting*, which tracks how well the organization is doing, pays the bills, and collects the money.

Universities, churches or synagogues, and businesses all perform these functions. Even a volunteer group such as the Boy Scouts of America is organized to perform these three basic

Figure 1.1

**Organization Charts for Two Service Organizations and One Manufacturing Organization**

(A) a bank, (B) an airline, and (C) a manufacturing organization. The blue areas are OM activities.

**STUDENT TIP**

The areas in blue indicate the significant role that OM plays in both manufacturing and service firms.

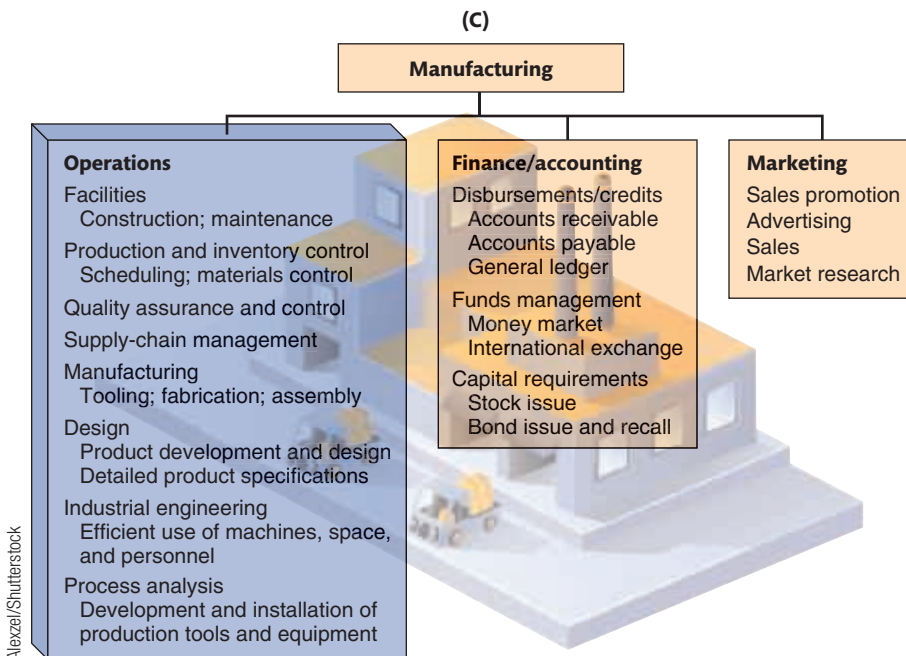
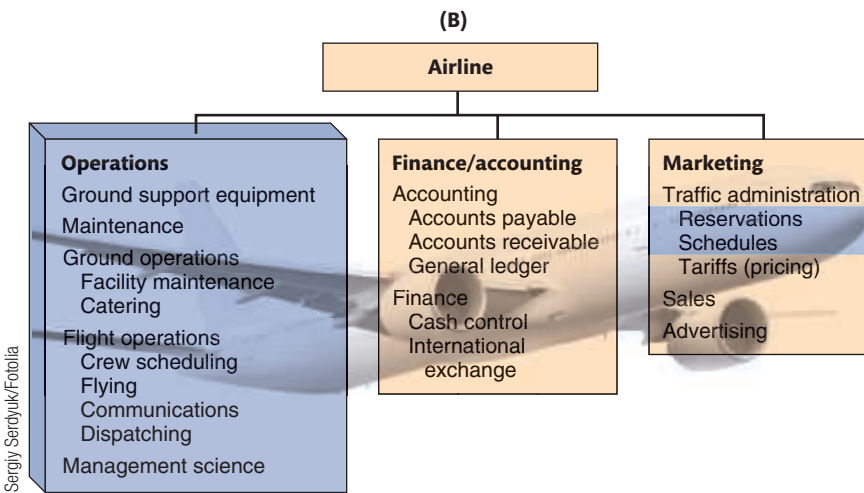
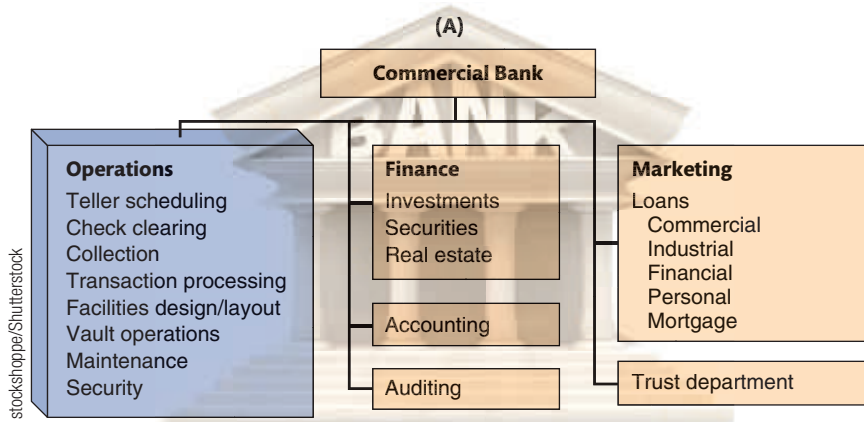
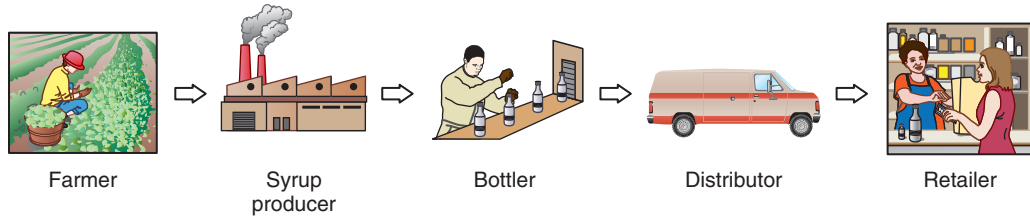


Figure 1.2

**Soft Drink Supply Chain**

A supply chain for a bottle of Coke requires a beet or sugar cane farmer, a syrup producer, a bottler, a distributor, and a retailer, each adding value to satisfy a customer. Only with collaborations between all members of the supply chain can efficiency and customer satisfaction be maximized. The supply chain, in general, starts with the provider of basic raw materials and continues all the way to the final customer at the retail store.



functions. Figure 1.1 shows how a bank, an airline, and a manufacturing firm organize themselves to perform these functions. The blue-shaded areas show the operations functions in these firms.

## The Supply Chain

Through the three functions—marketing, operations, and finance—value for the customer is created. However, firms seldom create this value by themselves. Instead, they rely on a variety of suppliers who provide everything from raw materials to accounting services. These suppliers, when taken together, can be thought of as a *supply chain*. A **supply chain** (see Figure 1.2) is a global network of organizations and activities that supply a firm with goods and services.

As our society becomes more technologically oriented, we see increasing specialization. Specialized expert knowledge, instant communication, and cheaper transportation also foster specialization and worldwide supply chains. It just does not pay for a firm to try to do everything itself. The expertise that comes with specialization exists up and down the supply chain, adding value at each step. When members of the supply chain collaborate to achieve high levels of customer satisfaction, we have a tremendous force for efficiency and competitive advantage. Competition in the 21st century is not between companies; it is between *supply chains*.

**Supply chain**

A global network of organizations and activities that supplies a firm with goods and services.

**STUDENT TIP**

Good OM managers are scarce and, as a result, career opportunities and pay are excellent.

## Why Study OM?

We study OM for four reasons:

1. OM is one of the three major functions of any organization, and it is integrally related to all the other business functions. All organizations market (sell), finance (account), and produce (operate), and it is important to know how the OM activity functions. Therefore, we study *how people organize themselves for productive enterprise*.
2. We study OM because we want to know *how goods and services are produced*. The production function is the segment of our society that creates the products and services we use.
3. We study OM to *understand what operations managers do*. Regardless of your job in an organization, you can perform better if you understand what operations managers do. In addition, understanding OM will help you explore the numerous and lucrative career opportunities in the field.
4. We study OM *because it is such a costly part of an organization*. A large percentage of the revenue of most firms is spent in the OM function. Indeed, OM provides a major opportunity for an organization to improve its profitability and enhance its service to society. Example 1 considers how a firm might increase its profitability via the production function.

### Example 1

#### EXAMINING THE OPTIONS FOR INCREASING CONTRIBUTION

Fisher Technologies is a small firm that must double its dollar contribution to fixed cost and profit in order to be profitable enough to purchase the next generation of production equipment. Management has determined that if the firm fails to increase contribution, its bank will not make the loan and the equipment cannot be purchased. If the firm cannot purchase the equipment, the limitations of the old equipment will force Fisher to go out of business and, in doing so, put its employees out of work and discontinue producing goods and services for its customers.

**APPROACH** ► Table 1.1 shows a simple profit-and-loss statement and three strategic options (marketing, finance/accounting, and operations) for the firm. The first option is a *marketing option*, where excellent marketing management may increase sales by 50%. By increasing sales by 50%, contribution will in turn increase 71%. But increasing sales 50% may be difficult; it may even be impossible.

**TABLE 1.1** Options for Increasing Contribution

	Options for Increasing Contribution			
	CURRENT	MARKETING OPTION <sup>a</sup> INCREASE SALES REVENUE 50%	FINANCE/ACCOUNTING OPTION <sup>b</sup> REDUCE FINANCE COSTS 50%	OM OPTION <sup>c</sup> REDUCE PRODUCTION COSTS 20%
Sales	\$100,000	\$150,000	\$100,000	\$100,000
Costs of goods	<u>-80,000</u>	<u>-120,000</u>	<u>-80,000</u>	<u>-64,000</u>
Gross margin	20,000	30,000	20,000	36,000
Finance costs	<u>-6,000</u>	<u>-6,000</u>	<u>-3,000</u>	<u>-6,000</u>
Subtotal	14,000	24,000	17,000	30,000
Taxes at 25%	<u>-3,500</u>	<u>-6,000</u>	<u>-4,250</u>	<u>-7,500</u>
Contribution <sup>d</sup>	\$ 10,500	\$ 18,000	\$ 12,750	\$ 22,500

<sup>a</sup>Increasing sales 50% increases contribution by \$7,500, or 71% (7,500/10,500).  
<sup>b</sup>Reducing finance costs 50% increases contribution by \$2,250, or 21% (2,250/10,500).  
<sup>c</sup>Reducing production costs 20% increases contribution by \$12,000, or 114% (12,000/10,500).  
<sup>d</sup>Contribution to fixed cost (excluding finance costs) and profit.

The second option is a *finance/accounting option*, where finance costs are cut in half through good financial management. But even a reduction of 50% is still inadequate for generating the necessary increase in contribution. Contribution is increased by only 21%.  
 The third option is an *OM option*, where management reduces production costs by 20% and increases contribution by 114%.

**SOLUTION** ► Given the conditions of our brief example, Fisher Technologies has increased contribution from \$10,500 to \$22,500. It may now have a bank willing to lend it additional funds.

**INSIGHT** ► The OM option not only yields the greatest improvement in contribution but also may be the only feasible option. Increasing sales by 50% and decreasing finance cost by 50% may both be virtually impossible. Reducing operations cost by 20% may be difficult but feasible.

**LEARNING EXERCISE** ► What is the impact of only a 15% decrease in costs in the OM option? [Answer: A \$19,500 contribution; an 86% increase.]

Example 1 underscores the importance of the effective operations activity of a firm. Development of increasingly effective operations is the approach taken by many companies as they face growing global competition.

## What Operations Managers Do

All good managers perform the basic functions of the management process. The management process consists of *planning, organizing, staffing, leading, and controlling*. Operations managers apply this management process to the decisions they make in the OM function. The **10 strategic OM decisions** are introduced in Table 1.2. Successfully addressing each of these decisions requires planning, organizing, staffing, leading, and controlling.

**Where Are the OM Jobs?** How does one get started on a career in operations? The 10 strategic OM decisions identified in Table 1.2 are made by individuals who work in the disciplines shown in the blue areas of Figure 1.1. Business students who know their accounting,

### 10 Strategic OM Decisions

- Design of goods and services
- Managing quality
- Process strategy
- Location strategies
- Layout strategies
- Human resources
- Supply-chain management
- Inventory management
- Scheduling
- Maintenance

**STUDENT TIP** 

An operations manager must successfully address the 10 decisions around which this text is organized.

**TABLE 1.2****Ten Strategic Operations Management Decisions**

DECISION	CHAPTER(S)
1. <i>Design of goods and services</i> : Defines much of what is required of operations in each of the other OM decisions. For instance, product design usually determines the lower limits of cost and the upper limits of quality, as well as major implications for sustainability and the human resources required.	5, Supplement 5
2. <i>Managing quality</i> : Determines the customer's quality expectations and establishes policies and procedures to identify and achieve that quality.	6, Supplement 6
3. <i>Process and capacity strategy</i> : Determines how a good or service is produced (i.e., the process for production) and commits management to specific technology, quality, human resources, and capital investments that determine much of the firm's basic cost structure.	7, Supplement 7
4. <i>Location strategy</i> : Requires judgments regarding nearness to customers, suppliers, and talent, while considering costs, infrastructure, logistics, and government.	8
5. <i>Layout strategy</i> : Requires integrating capacity needs, personnel levels, technology, and inventory requirements to determine the efficient flow of materials, people, and information.	9
6. <i>Human resources and job design</i> : Determines how to recruit, motivate, and retain personnel with the required talent and skills. People are an integral and expensive part of the total system design.	10
7. <i>Supply chain management</i> : Decides how to integrate the supply chain into the firm's strategy, including decisions that determine what is to be purchased, from whom, and under what conditions.	11, Supplement 11
8. <i>Inventory management</i> : Considers inventory ordering and holding decisions and how to optimize them as customer satisfaction, supplier capability, and production schedules are considered.	12, 14, 16
9. <i>Scheduling</i> : Determines and implements intermediate- and short-term schedules that effectively and efficiently utilize both personnel and facilities while meeting customer demands.	13, 15
10. <i>Maintenance</i> : Requires decisions that consider facility capacity, production demands, and personnel necessary to maintain a reliable and stable process.	17

statistics, finance, and OM have an opportunity to assume entry-level positions in all of these areas. As you read this text, identify disciplines that can assist you in making these decisions. Then take courses in those areas. The more background an OM student has in accounting, statistics, information systems, and mathematics, the more job opportunities will be available. About 40% of *all* jobs are in OM.

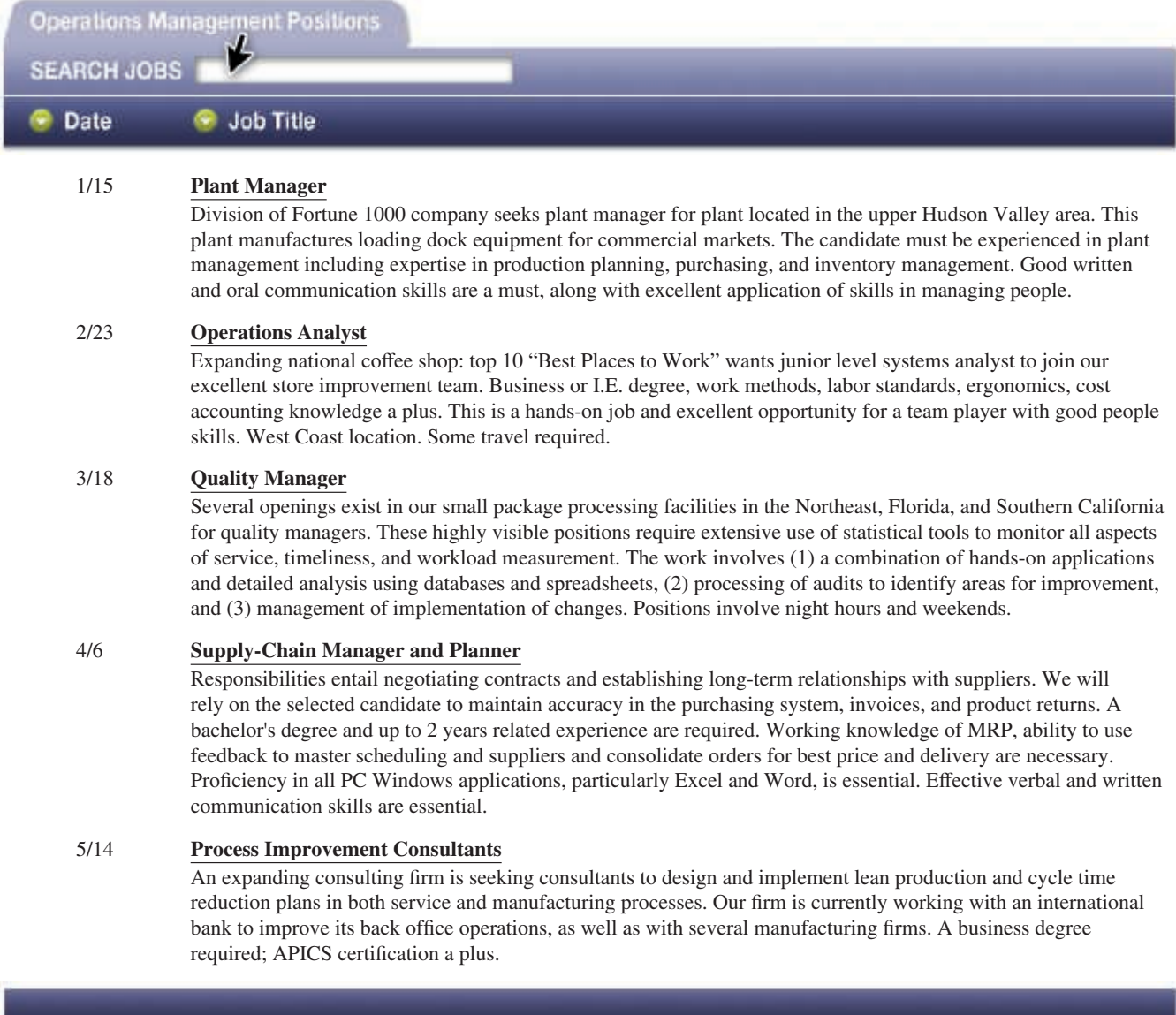
The following professional organizations provide various certifications that may enhance your education and be of help in your career:

- ◆ APICS, the Association for Operations Management ([www.apics.org](http://www.apics.org))
- ◆ American Society for Quality (ASQ) ([www.asq.org](http://www.asq.org))
- ◆ Institute for Supply Management (ISM) ([www.ism.ws](http://www.ism.ws))
- ◆ Project Management Institute (PMI) ([www.pmi.org](http://www.pmi.org))
- ◆ Council of Supply Chain Management Professionals ([www.cscmp.org](http://www.cscmp.org))

Figure 1.3 shows some recent job opportunities.

## The Heritage of Operations Management

The field of OM is relatively young, but its history is rich and interesting. Our lives and the OM discipline have been enhanced by the innovations and contributions of numerous individuals. We now introduce a few of these people, and we provide a summary of significant events in operations management in Figure 1.4.



The screenshot shows a job search interface with a header 'Operations Management Positions' and a 'SEARCH JOBS' button. Below the header is a table with columns for 'Date' and 'Job Title'. The table lists five job openings with their respective dates and descriptions.

Date	Job Title
1/15	<b>Plant Manager</b> Division of Fortune 1000 company seeks plant manager for plant located in the upper Hudson Valley area. This plant manufactures loading dock equipment for commercial markets. The candidate must be experienced in plant management including expertise in production planning, purchasing, and inventory management. Good written and oral communication skills are a must, along with excellent application of skills in managing people.
2/23	<b>Operations Analyst</b> Expanding national coffee shop: top 10 "Best Places to Work" wants junior level systems analyst to join our excellent store improvement team. Business or I.E. degree, work methods, labor standards, ergonomics, cost accounting knowledge a plus. This is a hands-on job and excellent opportunity for a team player with good people skills. West Coast location. Some travel required.
3/18	<b>Quality Manager</b> Several openings exist in our small package processing facilities in the Northeast, Florida, and Southern California for quality managers. These highly visible positions require extensive use of statistical tools to monitor all aspects of service, timeliness, and workload measurement. The work involves (1) a combination of hands-on applications and detailed analysis using databases and spreadsheets, (2) processing of audits to identify areas for improvement, and (3) management of implementation of changes. Positions involve night hours and weekends.
4/6	<b>Supply-Chain Manager and Planner</b> Responsibilities entail negotiating contracts and establishing long-term relationships with suppliers. We will rely on the selected candidate to maintain accuracy in the purchasing system, invoices, and product returns. A bachelor's degree and up to 2 years related experience are required. Working knowledge of MRP, ability to use feedback to master scheduling and suppliers and consolidate orders for best price and delivery are necessary. Proficiency in all PC Windows applications, particularly Excel and Word, is essential. Effective verbal and written communication skills are essential.
5/14	<b>Process Improvement Consultants</b> An expanding consulting firm is seeking consultants to design and implement lean production and cycle time reduction plans in both service and manufacturing processes. Our firm is currently working with an international bank to improve its back office operations, as well as with several manufacturing firms. A business degree required; APICS certification a plus.

Figure 1.3

#### Many Opportunities Exist for Operations Managers

Eli Whitney (1800) is credited for the early popularization of interchangeable parts, which was achieved through standardization and quality control. Through a contract he signed with the U.S. government for 10,000 muskets, he was able to command a premium price because of their interchangeable parts.

Frederick W. Taylor (1881), known as the father of scientific management, contributed to personnel selection, planning and scheduling, motion study, and the now popular field of ergonomics. One of his major contributions was his belief that management should be much more resourceful and aggressive in the improvement of work methods. Taylor and his colleagues, Henry L. Gantt and Frank and Lillian Gilbreth, were among the first to systematically seek the best way to produce.

Another of Taylor's contributions was the belief that management should assume more responsibility for:

1. Matching employees to the right job.
2. Providing the proper training.
3. Providing proper work methods and tools.
4. Establishing legitimate incentives for work to be accomplished.