

# REQUIREMENTS ANALYSIS AND SYSTEM DESIGN

third edition

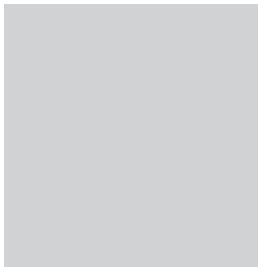
LESZEK A. MACIASZEK



ADDISON-WESLEY

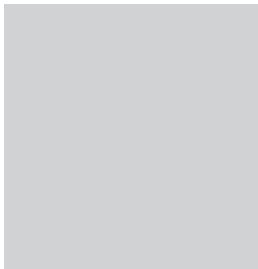
*An imprint of Pearson Education*

Harlow, England • London • New York • Boston • San Francisco • Toronto • Sydney • Singapore • Hong Kong  
Tokyo • Seoul • Taipei • New Delhi • Cape Town • Madrid • Mexico City • Amsterdam • Munich • Paris • Milan



## Brief contents

<i>Contents for case studies</i>	xxi
<i>Preface</i>	xxvii
<i>Guided tour</i>	xxxiv
<i>Publisher's acknowledgements</i>	xxxvi
Chapter 1 The Software Process	1
Chapter 2 Requirements Determination	66
Chapter 3 Fundamentals of Visual Modeling	122
Chapter 4 Requirements Specification	169
Chapter 5 Moving from Analysis to Design	243
Chapter 6 System Architecture and Program Design	304
Chapter 7 Graphical User Interface Design	380
Chapter 8 Persistence and Database Design	441
Chapter 9 Quality and Change Management	490
Chapter 10 Tutorial-style Review and Reinforcement	521
Appendix Fundamentals of Object Technology	565
Bibliography	600
Index	607



# Contents

<i>Contents for case studies</i>	xxi
<i>Preface</i>	xxvii
<i>Guided tour</i>	xxxiv
<i>Publisher's acknowledgements</i>	xxxvi
<b>1 The Software Process</b>	<b>1</b>
<b>Objectives</b>	<b>1</b>
<b>1.1 The nature of software development</b>	<b>2</b>
1.1.1 The software development invariants	2
1.1.2 The software development “accidents”	4
1.1.2.1 Stakeholders	4
1.1.2.2 Process	6
1.1.2.2.1 Iterative and incremental process	6
1.1.2.2.2 Capability maturity model	7
1.1.2.2.3 The ISO 9000 family of quality standards	9
1.1.2.2.4 The ITIL framework	9
1.1.2.2.5 The COBIT framework	11
1.1.2.3 Modeling	12
1.1.2.3.1 Unified modeling language	13
1.1.2.3.2 CASE and process improvement	13
1.1.3 Development or integration?	14
<b>Review quiz 1.1</b>	<b>15</b>
<b>1.2 System planning</b>	<b>15</b>
1.2.1 The SWOT approach	16
1.2.2 The VCM approach	17
1.2.3 The BPR approach	19
1.2.4 The ISA approach	20
<b>Review quiz 1.2</b>	<b>21</b>
<b>1.3 Systems for three management levels</b>	<b>22</b>
1.3.1 Transactional processing systems	23
1.3.2 Analytical processing systems	24
1.3.3 Knowledge processing systems	25
<b>Review quiz 1.3</b>	<b>26</b>

<b>1.4</b>	<b>The software development lifecycle</b>	<b>26</b>
1.4.1	The development approach	27
1.4.1.1	The structured approach	27
1.4.1.2	The object-oriented approach	28
1.4.2	Lifecycle phases	30
1.4.2.1	Business analysis	30
1.4.2.1.1	Requirements determination	31
1.4.2.1.2	Requirements specification	31
1.4.2.2	System design	32
1.4.2.2.1	Architectural design	32
1.4.2.2.2	Detailed design	33
1.4.2.3	Implementation	33
1.4.2.4	Integration and deployment	34
1.4.2.5	Operation and maintenance	34
1.4.3	Activities spanning the lifecycle	35
1.4.3.1	Project planning	36
1.4.3.2	Metrics	37
1.4.3.3	Testing	37
	<b>Review quiz 1.4</b>	<b>39</b>
<b>1.5</b>	<b>Development models and methods</b>	<b>39</b>
1.5.1	The spiral model	40
1.5.2	IBM Rational Unified Process	41
1.5.3	Model-driven architecture	42
1.5.4	Agile software development	42
1.5.5	Aspect-oriented software development	45
	<b>Review quiz 1.5</b>	<b>47</b>
<b>1.6</b>	<b>Problem statements for case studies</b>	<b>47</b>
1.6.1	University enrolment	48
1.6.2	Video store	48
1.6.3	Contact management	49
1.6.4	Telemarketing	50
1.6.5	Advertising expenditure	51
1.6.6	Time logging	51
1.6.7	Currency converter	52
	<b>Summary</b>	<b>53</b>
	<b>Key terms</b>	<b>54</b>
	<b>Multiple-choice test</b>	<b>56</b>
	<b>Questions</b>	<b>58</b>
	<b>Review quiz answers</b>	<b>60</b>
	<b>Multiple-choice test answers</b>	<b>60</b>
	<b>Answers to odd-numbered questions</b>	<b>61</b>
<b>2</b>	<b>Requirements Determination</b>	<b>66</b>
	<b>Objectives</b>	<b>66</b>
<b>2.1</b>	<b>From business processes to solution envisioning</b>	<b>67</b>
2.1.1	Process hierarchy modeling	68

2.1.1.1 Processes and process decompositions	68
2.1.1.2 Process hierarchy diagram	68
2.1.2 Business process modeling	70
2.1.2.1 Flow objects, connecting objects, swimlanes and artifacts	70
2.1.2.2 Business process diagram	72
2.1.3 Solution envisioning	73
2.1.3.1 Solution envisioning process	74
2.1.3.2 Implementation strategies and capability architecture	76
<b>Review quiz 2.1</b>	<b>77</b>
<b>2.2 Requirements elicitation</b>	<b>77</b>
2.2.1 System requirements	79
2.2.1.1 Functional requirements	79
2.2.1.2 Non-functional requirements	80
2.2.2 Traditional methods of requirements elicitation	81
2.2.2.1 Interviewing customers and domain experts	81
2.2.2.2 Questionnaires	83
2.2.2.3 Observation	84
2.2.2.4 Study of documents and software systems	84
2.2.3 Modern methods of requirements elicitation	85
2.2.3.1 Prototyping	85
2.2.3.2 Brainstorming	86
2.2.3.3 Joint application development	87
2.2.3.4 Rapid application development	88
<b>Review quiz 2.2</b>	<b>89</b>
<b>2.3 Requirements negotiation and validation</b>	<b>89</b>
2.3.1 Out-of-scope requirements	89
2.3.2 Requirements dependency matrix	90
2.3.3 Requirements – risks and priorities	90
<b>Review quiz 2.3</b>	<b>91</b>
<b>2.4 Requirements management</b>	<b>91</b>
2.4.1 Requirements identification and classification	92
2.4.2 Requirements hierarchies	93
2.4.3 Change management	93
2.4.4 Requirements traceability	94
<b>Review quiz 2.4</b>	<b>94</b>
<b>2.5 Requirements business model</b>	<b>94</b>
2.5.1 System scope model	95
2.5.2 Business use case model	97
2.5.3 Business glossary	99
2.5.4 Business class model	101
<b>Review quiz 2.5</b>	<b>103</b>
<b>2.6 Requirements document</b>	<b>103</b>
2.6.1 Document templates	103
2.6.2 Project preliminaries	104
2.6.3 System services	105

2.6.4 System constraints	105
2.6.5 Project matters	106
2.6.6 Appendices	107
<b>Review quiz 2.6</b>	<b>107</b>
<b>Summary</b>	<b>107</b>
<b>Key terms</b>	<b>108</b>
Multiple-choice test	110
Questions	111
Exercises: advertising expenditure	112
Exercises: time logging	113
Review quiz answers	113
Multiple-choice test answers	114
Answers to odd-numbered questions	115
Solutions to exercises: AE	117
<b>3 Fundamentals of Visual Modeling</b>	<b>122</b>
<b>Objectives</b>	<b>122</b>
<b>3.1 The use case view</b>	<b>123</b>
3.1.1 Actors	124
3.1.2. Use cases	124
3.1.3 Use case diagrams	126
3.1.4 Documenting use cases	127
<b>Review quiz 3.1</b>	<b>128</b>
<b>3.2 The activity view</b>	<b>128</b>
3.2.1 Actions	130
3.2.2 Activity diagrams	130
<b>Review quiz 3.2</b>	<b>132</b>
<b>3.3 The structure view</b>	<b>133</b>
3.3.1 Classes	133
3.3.2 Attributes	135
3.3.3 Associations	136
3.3.4 Aggregation	137
3.3.5 Generalization	138
3.3.6 Class diagrams	139
<b>Review quiz 3.3</b>	<b>140</b>
<b>3.4 The interaction view</b>	<b>141</b>
3.4.1 Sequence diagrams	141
3.4.2 Communication diagrams	143
3.4.3 Class methods	144
<b>Review quiz 3.4</b>	<b>146</b>
<b>3.5 The state machine view</b>	<b>146</b>
3.5.1 States and transitions	146
3.5.2 State machine diagrams	147
<b>Review quiz 3.5</b>	<b>149</b>

<b>3.6 The implementation view</b>	<b>149</b>
3.6.1 Subsystems and packages	149
3.6.2 Components and component diagrams	150
3.6.3 Nodes and deployment diagrams	152
<b>Review quiz 3.6</b>	<b>153</b>
Summary	154
Key terms	154
Multiple-choice test	156
Questions	157
Exercises	158
Exercises: video store	159
Review quiz answers	161
Multiple-choice test answers	161
Answers to odd-numbered questions	162
Solutions to odd-numbered exercises	163
Solutions to odd-numbered exercises: video store	166
<b>4 Requirements Specification</b>	<b>169</b>
<b>Objectives</b>	<b>169</b>
<b>4.1 Architectural prerogatives</b>	<b>170</b>
4.1.1 Model-View-Controller	171
4.1.2 The Core J2EE architecture	172
4.1.3 Presentation-Controller-Bean-Mediator-Entity-Resource	173
4.1.3.1 The PCBMER layers	175
4.1.3.2 The PCBMER principles	176
<b>Review quiz 4.1</b>	<b>178</b>
<b>4.2 State specifications</b>	<b>178</b>
4.2.1 Modeling classes	178
4.2.1.1 Discovering classes	179
4.2.1.1.1 Noun phrase approach	179
4.2.1.1.2 Common class pattern approach	180
4.2.1.1.3 Use case-driven approach	181
4.2.1.1.4 CRC approach	181
4.2.1.1.5 Mixed approach	182
4.2.1.1.6 Guidelines for discovering classes	182
4.2.1.1.7 Examples of discovering classes	183
4.2.1.2 Specifying classes	186
4.2.1.2.1 Naming classes	186
4.2.1.2.2 Discovering and specifying class attributes	186
4.2.1.2.3 Examples of discovering and specifying class attributes	187
4.2.2 Modeling associations	193
4.2.2.1 Discovering associations	193
4.2.2.2 Specifying associations	195
4.2.2.2.1 Example of specifying associations	195

4.2.3	Modeling aggregation and composition relationships	196
4.2.3.1	Discovering aggregations and composition	198
4.2.3.2	Specifying aggregations and compositions	199
4.2.3.3	Example of aggregation and composition specifications	199
4.2.4	Modeling generalization relationships	200
4.2.4.1	Discovering generalizations	201
4.2.4.2	Specifying generalization	201
4.2.4.3	Examples of generalization specifications	202
4.2.5	Modeling interfaces	202
4.2.5.1	Discovering interfaces	203
4.2.5.2	Specifying interfaces	204
4.2.5.3	Examples of interface specifications	204
4.2.6	Modeling objects	205
4.2.6.1	Specifying objects	205
4.2.6.2	Example of object specifications	205
<b>Review quiz 4.2</b>		<b>206</b>
<b>4.3</b>	<b>Behavior specifications</b>	<b>206</b>
4.3.1	Modeling use cases	207
4.3.1.1	Specifying use cases	208
4.3.1.2	Examples of use case specifications	209
4.3.2	Modeling activities	213
4.3.2.1	Discovering actions	214
4.3.2.2	Specifying actions	214
4.3.2.3	Example of activity specifications	214
4.3.3	Modeling interactions	215
4.3.3.1	Discovering message sequences	216
4.3.3.2	Specifying message sequences	216
4.3.3.3	Examples of sequence specifications	216
4.3.4	Modeling operations	219
4.3.4.1	Discovering class operations	219
4.3.4.2	Specifying class operations	219
4.3.4.3	Examples of operation specifications	220
<b>Review quiz 4.3</b>		<b>221</b>
<b>4.4</b>	<b>State change specifications</b>	<b>221</b>
4.4.1	Modeling object states	222
4.4.1.1	Discovering object states	222
4.4.1.2	Specifying object states	222
4.4.1.3	Example of state machine specifications	223
<b>Review quiz 4.4</b>		<b>223</b>
<b>Summary</b>		<b>224</b>
<b>Key terms</b>		<b>225</b>
<b>Multiple-choice test</b>		<b>226</b>
<b>Questions</b>		<b>228</b>
<b>Exercises: video store</b>		<b>229</b>
<b>Exercises: contact management</b>		<b>230</b>

<b>Exercises: university enrolment</b>	<b>231</b>
<b>Review quiz answers</b>	<b>232</b>
<b>Multiple-choice test answers</b>	<b>232</b>
<b>Answers to odd-numbered questions</b>	<b>233</b>
<b>Solutions to exercises: university enrolment</b>	<b>238</b>
<b>5 <i>Moving from Analysis to Design</i></b>	<b>243</b>
<b>Objectives</b>	<b>243</b>
<b>5.1 Advanced class modeling</b>	<b>244</b>
5.1.1 Extension mechanisms	244
5.1.1.1 Stereotypes	245
5.1.1.2 Comments and constraints	246
5.1.1.3 Tags	248
5.1.2 Visibility and encapsulation	250
5.1.2.1 Protected visibility	250
5.1.2.2 Accessibility of inherited class properties	251
5.1.2.3 Package and friendly visibility	254
5.1.3 Derived information	256
5.1.3.1 Derived attribute	256
5.1.3.2 Derived association	257
5.1.4 Qualified association	257
5.1.5 Association class versus reified class	258
5.1.5.1 Model with association class	259
5.1.5.2 Model with reified class	260
<b>Review quiz 5.1</b>	<b>261</b>
<b>5.2 Advanced generalization and inheritance modeling</b>	<b>261</b>
5.2.1 Generalization and substitutability	261
5.2.2 Inheritance versus encapsulation	262
5.2.3 Interface inheritance	262
5.2.4 Implementation inheritance	264
5.2.4.1 Proper use of implementation inheritance – extension inheritance	264
5.2.4.2 Problematic use of implementation inheritance – restriction inheritance	265
5.2.4.3 Improper use of implementation inheritance – convenience inheritance	266
5.2.4.4 The evils of implementation inheritance	267
5.2.4.4.1 Fragile base class	267
5.2.4.4.2 Overriding, down-calls and up-calls	268
5.2.4.4.3 Multiple implementation inheritance	270
<b>Review quiz 5.2</b>	<b>271</b>
<b>5.3 Advanced aggregation and delegation modeling</b>	<b>271</b>
5.3.1 Putting more semantics into aggregation	272
5.3.1.1 The <i>ExclusiveOwns</i> aggregation	272
5.3.1.2 The <i>Owns</i> aggregation	273

5.3.1.3 The <i>Has</i> aggregation	273
5.3.1.4 The <i>Member</i> aggregation	274
5.3.2 Aggregation as an alternative to generalization	275
5.3.2.1 Delegation and prototypical systems	276
5.3.2.2 Delegation versus inheritance	276
5.3.3 Aggregation and holons – some cerebral ammunition	277
Review quiz 5.3	278
<b>5.4 Advanced interaction modeling</b>	<b>278</b>
5.4.1 Lifelines and messages	279
5.4.1.1 Accounting for basic technology	280
5.4.1.2 Visualizing technology contributions in interaction models	282
5.4.2 Fragments	284
5.4.3 Interaction uses	287
Review quiz 5.4	288
Summary	288
Key terms	289
Multiple-choice test	289
Questions	290
Exercises	291
Exercises: time logging	292
Exercises: advertising expenditure	293
Review quiz answers	295
Multiple-choice test answers	295
Answers to odd-numbered questions	295
Solutions to odd-numbered exercises	299
Solutions to exercises: time logging	300
<b>6 System Architecture and Program Design</b>	<b>304</b>
Objectives	304
<b>6.1 Distributed physical architecture</b>	<b>305</b>
6.1.1 Peer-to-peer architecture	306
6.1.2 Tiered architecture	307
6.1.3 Database-centered architecture	308
Review quiz 6.1	309
<b>6.2 Multilayer logical architecture</b>	<b>310</b>
6.2.1 Architectural complexity	311
6.2.1.1 Spatial cognitive complexity	312
6.2.1.2 Structural complexity	313
6.2.1.2.1 Structural complexity of networks	313
6.2.1.2.2 Structural complexity of hierarchies	314
6.2.2 Architectural patterns	316
6.2.2.1 Façade	317
6.2.2.2 Abstract Factory	318
6.2.2.3 Chain of Responsibility	322
6.2.2.4 Observer	324

6.2.2.5 Mediator	327
<b>Review quiz 6.2</b>	<b>331</b>
<b>6.3 Architectural modeling</b>	<b>331</b>
6.3.1 Packages	331
6.3.2 Components	333
6.3.2.1 Component versus package	334
6.3.2.2 Component versus class and interface	335
6.3.3 Nodes	336
<b>Review quiz 6.3</b>	<b>337</b>
<b>6.4 Principles of program design and reuse</b>	<b>338</b>
6.4.1 Class cohesion and coupling	339
6.4.1.1 Kinds of class coupling	340
6.4.1.2 The Law of Demeter	340
6.4.1.3 Accessor methods and mindless classes	341
6.4.1.4 Dynamic classification and mixed-instance cohesion	344
6.4.2 Reuse strategy	348
6.4.2.1 Toolkit reuse	348
6.4.2.2 Framework reuse	348
6.4.2.3 Pattern reuse	349
<b>Review quiz 6.4</b>	<b>349</b>
<b>6.5 Collaboration modeling</b>	<b>350</b>
6.5.1 Collaboration	350
6.5.2 Composite structure	351
6.5.3 From use case to composite collaboration	353
6.5.4 From collaboration to interaction	357
6.5.5 From interaction to composite structure	362
<b>Review quiz 6.5</b>	<b>362</b>
Summary	362
Key terms	364
Multiple-choice test	366
Questions	367
Exercises: video store	368
Exercises: advertising expenditure	370
Review quiz answers	372
Multiple-choice test answers	372
Answers to odd-numbered questions	373
Solutions to exercises: advertising expenditure	376
<b>7 Graphical User Interface Design</b>	<b>380</b>
Objectives	380
<b>7.1 Principles of GUI design</b>	<b>381</b>
7.1.1 From GUI prototype to implementation	381
7.1.2 Guidelines for good GUI design	384
7.1.2.1 User in control	385
7.1.2.2 Consistency	385

7.1.2.3 Personalization and customization	386
7.1.2.4 Forgiveness	387
7.1.2.5 Feedback	387
7.1.2.6 Aesthetics and usability	387
<b>Review quiz 7.1</b>	<b>388</b>
<b>7.2 Desktop GUI design</b>	<b>388</b>
7.2.1 Primary windows	388
7.2.1.1 Row browsers	390
7.2.1.2 Tree browsers	391
7.2.2 Secondary windows	393
7.2.2.1 Dialog boxes	393
7.2.2.2 Tab folders	395
7.2.2.3 Drop-down lists	395
7.2.2.4 Message boxes	395
7.2.3 Menus and toolbars	396
7.2.4 Buttons and other controls	398
<b>Review quiz 7.2</b>	<b>399</b>
<b>7.3 Web GUI design</b>	<b>400</b>
7.3.1 Enabling technology for Web applications	400
7.3.2 Content design	403
7.3.2.1 Website to Web application continuum	403
7.3.2.2 Forms	404
7.3.3 Navigation design	409
7.3.3.1 Menus and links	409
7.3.3.2 Breadcrumbs and navigation panels	410
7.3.3.3 Buttons	412
7.3.4 Using GUI frameworks to leverage Web design	413
7.3.4.1 The MVC dilemma	413
7.3.4.2 Using Struts technology	415
<b>Review quiz 7.3</b>	<b>418</b>
<b>7.4 Modeling GUI navigation</b>	<b>418</b>
7.4.1 User experience storyboards	420
7.4.2 Modeling UX elements	421
7.4.3 Behavioral UX collaboration	422
7.4.4 Structural UX collaboration	425
<b>Review quiz 7.4</b>	<b>427</b>
<b>Summary</b>	<b>427</b>
<b>Key terms</b>	<b>427</b>
<b>Multiple-choice test</b>	<b>428</b>
<b>Questions</b>	<b>429</b>
<b>Exercises: contact management</b>	<b>430</b>
<b>Exercises: telemarketing</b>	<b>432</b>
<b>Review quiz answers</b>	<b>434</b>
<b>Multiple-choice test answers</b>	<b>434</b>
<b>Answers to odd-numbered questions</b>	<b>434</b>
<b>Solutions to exercises: contact management</b>	<b>436</b>

<b>8 Persistence and Database Design</b>	<b>441</b>
Objectives	441
<b>8.1 Business objects and persistence</b>	<b>442</b>
8.1.1 Database management systems	442
8.1.2 Levels of data models	443
8.1.3 Integrating application and database modeling	444
8.1.4 Underpinnings of object–database mapping	445
<b>Review quiz 8.1</b>	<b>446</b>
<b>8.2 Relational database model</b>	<b>446</b>
8.2.1 Columns, domains and rules	447
8.2.2 Tables	448
8.2.3 Referential integrity	450
8.2.4 Triggers	452
8.2.5 Stored procedures	453
8.2.6 Views	454
8.2.7 Normal forms	455
<b>Review quiz 8.2</b>	<b>456</b>
<b>8.3 Object-relational mapping</b>	<b>456</b>
8.3.1 Mapping entity classes	457
8.3.2 Mapping associations	457
8.3.3 Mapping aggregations	460
8.3.4 Mapping generalizations	461
<b>Review quiz 8.3</b>	<b>464</b>
<b>8.4 Patterns for managing persistent objects</b>	<b>464</b>
8.4.1 Searching for persistent objects	465
8.4.2 Loading persistent objects	467
8.4.3 Unloading persistent objects	468
<b>Review quiz 8.4</b>	<b>468</b>
<b>8.5 Designing database access and transactions</b>	<b>469</b>
8.5.1 Levels of SQL programming	469
8.5.2 Designing business transactions	471
8.5.2.1 Short transactions	471
8.5.2.1.1 Pessimistic concurrency control	471
8.5.2.1.2 Levels of isolation	472
8.5.2.1.3 Automatic recovery	473
8.5.2.1.4 Programmable recovery	474
8.5.2.1.5 Designing stored procedures and triggers	474
8.5.2.2 Long transactions	475
<b>Review quiz 8.5</b>	<b>476</b>
<b>Summary</b>	<b>476</b>
<b>Key terms</b>	<b>477</b>
<b>Multiple-choice tests</b>	<b>479</b>
<b>Questions</b>	<b>480</b>
<b>Exercises: contact management</b>	<b>480</b>
<b>Exercises: telemarketing</b>	<b>481</b>
<b>Review quiz answers</b>	<b>481</b>

Multiple-choice answers	482
Answers to odd-numbered questions	482
Solutions to exercises: Contact management	484
<b>9 Quality and Change Management</b>	<b>490</b>
Objectives	490
<b>9.1 Quality management</b>	<b>491</b>
9.1.1 Quality assurance	492
9.1.1.1 Checklists, reviews and audits	492
9.1.1.2 Test-driven development	494
9.1.2 Quality control	495
9.1.2.1 Test concepts and techniques	496
9.1.2.2 Testing system services	498
9.1.2.3 Testing system constraints	500
9.1.2.3.1 Graphical user interface testing	501
9.1.2.3.2 Database testing	501
9.1.2.3.3 Authorization testing	502
9.1.2.3.4 Testing of other constraints	503
Review quiz 9.1	503
<b>9.2 Change management</b>	<b>504</b>
9.2.1 Instrumenting and managing change requests	505
9.2.1.1 Submitting a change request	506
9.2.1.2 Keeping track of change requests	507
9.2.2 Traceability	508
9.2.2.1 System features to use cases and use case requirements	509
9.2.2.2 Test plans to test cases and test requirements	510
9.2.2.3 UML diagrams to documents and requirements	510
9.2.2.4 Use case requirements to test requirements	511
9.2.2.5 Test requirements to defects	513
9.2.2.6 Use case requirements to enhancements	514
Review quiz 9.2	515
Summary	515
Key terms	515
Multiple-choice test	516
Questions	517
Review quiz answers	518
Multiple-choice test answers	518
Answers to odd-numbered questions	518
<b>10 Tutorial-style Review and Reinforcement</b>	<b>521</b>
Objectives	521
<b>10.1 Use case modeling</b>	<b>522</b>
10.1.1 Actors	522
10.1.2 Use cases	523
10.1.3 Use case diagram	524
10.1.4 Documenting use cases	525

<b>10.2</b>	<b>Activity modeling</b>	<b>526</b>
10.2.1	Actions	526
10.2.2	Activity diagram	528
<b>10.3</b>	<b>Class modeling</b>	<b>529</b>
10.3.1	Classes	529
10.3.2	Attributes	529
10.3.3	Associations	531
10.3.4	Aggregations	532
10.3.5	Generalizations	533
10.3.6	Class diagram	533
<b>10.4</b>	<b>Interaction modeling</b>	<b>534</b>
10.4.1	Sequence diagram	534
10.4.2	Communication diagram	537
<b>10.5</b>	<b>State machine modeling</b>	<b>540</b>
10.5.1	States and transitions	540
10.5.2	State machine diagram	541
<b>10.6</b>	<b>Implementation models</b>	<b>542</b>
10.6.1	Subsystems	542
10.6.2	Packages	543
10.6.3	Components	545
10.6.4	Notes	546
<b>10.7</b>	<b>Object collaboration design</b>	<b>548</b>
10.7.1	Use case design specifications	550
10.7.2	User interface prototyping	552
10.7.3	Sequence diagram	553
10.7.4	Design-level class diagram	555
<b>10.8</b>	<b>Window navigation design</b>	<b>556</b>
10.8.1	User experience (UX) elements	556
10.8.2	Behavioral UX collaboration	556
10.8.3	Structural UX collaboration	558
<b>10.9</b>	<b>Database design</b>	<b>559</b>
10.9.1	Object-relational mapping	559
10.9.2	Referential integrity design	559
	<b>Summary</b>	<b>562</b>
	<b>Exercises: online shopping</b>	<b>562</b>
<b>Appendix:</b>	<b>Fundamentals of Object Technology</b>	<b>565</b>
<b>A.1</b>	<b>Real-life analogy</b>	<b>566</b>
<b>A.2</b>	<b>Instance object</b>	<b>566</b>
A.2.1	Object notation	567
A.2.2	How do objects collaborate?	568
A.2.3	Identity and object communication	569
A.2.3.1	Persistent link	569
A.2.3.2	Transient link	570

A.2.3.3 Message passing	571
<b>A.3 Class</b>	<b>571</b>
A.3.1 Attribute	572
A.3.1.1 Attribute type that designates a class	572
A.3.1.2 Attribute visibility	573
A.3.2 Operation	574
A.3.2.1 Operations objects collaborate	574
A.3.2.2 Operation visibility and scope	575
A.3.3 Class object	575
<b>A.4 Variables, methods and constructors</b>	<b>576</b>
<b>A.5 Association</b>	<b>578</b>
A.5.1 Association degree	579
A.5.2 Association multiplicity	579
A.5.3 Association link and extent	580
A.5.4 Association class	581
<b>A.6 Aggregation and composition</b>	<b>582</b>
A.6.1 Buried reference	583
A.6.2 Inner class	583
A.6.3 Delegation	586
<b>A.7 Generalization and inheritance</b>	<b>587</b>
A.7.1 Polymorphism	588
A.7.2 Overriding versus overloading	589
A.7.3 Multiple inheritance	590
A.7.4 Multiple classification	590
A.7.5 Dynamic classification	591
<b>A.8 Abstract class</b>	<b>592</b>
<b>A.9 Interface</b>	<b>593</b>
A.9.1 Interface versus abstract class	593
A.9.2 Implementing an interface	594
A.9.3 Using an interface	594
<b>Summary</b>	<b>595</b>
<b>Questions</b>	<b>597</b>
<b>Answers to odd-numbered questions</b>	<b>598</b>
<b>Bibliography</b>	<b>600</b>
<b>Index</b>	<b>607</b>