

|   | <b>Page</b> |
|---|-------------|
| <b>Contents</b>   | <b>iii</b>  |
| <b>List of Tables</b>                                   | <b>xi</b>   |
| <b>List of Figures</b>                                  | <b>xv</b>   |
| <b>1 General</b>  | <b>1</b>    |
| 1.1 Scope . . . . .                                     | 1           |
| 1.2 Normative references . . . . .                      | 1           |
| 1.3 Terms and definitions . . . . .                     | 2           |
| 1.4 Implementation compliance . . . . .                 | 5           |
| 1.5 Structure of this International Standard . . . . .  | 6           |
| 1.6 Syntax notation . . . . .                           | 6           |
| 1.7 The C++ memory model . . . . .                      | 7           |
| 1.8 The C++ object model . . . . .                      | 7           |
| 1.9 Program execution . . . . .                         | 8           |
| 1.10 Multi-threaded executions and data races . . . . . | 12          |
| 1.11 Acknowledgments . . . . .                          | 16          |
| <b>2 Lexical conventions</b>                            | <b>17</b>   |
| 2.1 Separate translation . . . . .                      | 17          |
| 2.2 Phases of translation . . . . .                     | 17          |
| 2.3 Character sets . . . . .                            | 18          |
| 2.4 Trigraph sequences . . . . .                        | 19          |
| 2.5 Preprocessing tokens . . . . .                      | 20          |
| 2.6 Alternative tokens . . . . .                        | 21          |
| 2.7 Tokens . . . . .                                    | 21          |
| 2.8 Comments . . . . .                                  | 21          |
| 2.9 Header names . . . . .                              | 22          |
| 2.10 Preprocessing numbers . . . . .                    | 22          |
| 2.11 Identifiers . . . . .                              | 22          |
| 2.12 Keywords . . . . .                                 | 23          |
| 2.13 Operators and punctuators . . . . .                | 24          |
| 2.14 Literals . . . . .                                 | 24          |
| <b>3 Basic concepts</b>                                 | <b>34</b>   |
| 3.1 Declarations and definitions . . . . .              | 34          |
| 3.2 One definition rule . . . . .                       | 36          |
| 3.3 Scope . . . . .                                     | 38          |
| 3.4 Name lookup . . . . .                               | 45          |
| 3.5 Program and linkage . . . . .                       | 59          |
| 3.6 Start and termination . . . . .                     | 62          |
| 3.7 Storage duration . . . . .                          | 65          |
| 3.8 Object lifetime . . . . .                           | 69          |
| 3.9 Types . . . . .                                     | 72          |
| 3.10 Lvalues and rvalues . . . . .                      | 78          |

|          |  |            |
|----------|--|------------|
| 3.11     | Alignment . . . . .                                    | 80         |
| <b>4</b> | <b>Standard conversions</b>                            | <b>81</b>  |
| 4.1      | Lvalue-to-rvalue conversion . . . . .                  | 82         |
| 4.2      | Array-to-pointer conversion . . . . .                  | 82         |
| 4.3      | Function-to-pointer conversion . . . . .               | 82         |
| 4.4      | Qualification conversions . . . . .                    | 82         |
| 4.5      | Integral promotions . . . . .                          | 83         |
| 4.6      | Floating point promotion . . . . .                     | 84         |
| 4.7      | Integral conversions . . . . .                         | 84         |
| 4.8      | Floating point conversions . . . . .                   | 84         |
| 4.9      | Floating-integral conversions . . . . .                | 85         |
| 4.10     | Pointer conversions . . . . .                          | 85         |
| 4.11     | Pointer to member conversions . . . . .                | 85         |
| 4.12     | Boolean conversions . . . . .                          | 86         |
| 4.13     | Integer conversion rank . . . . .                      | 86         |
| <b>5</b> | <b>Expressions</b>                                     | <b>87</b>  |
| 5.1      | Primary expressions . . . . .                          | 89         |
| 5.2      | Postfix expressions . . . . .                          | 97         |
| 5.3      | Unary expressions . . . . .                            | 109        |
| 5.4      | Explicit type conversion (cast notation) . . . . .     | 117        |
| 5.5      | Pointer-to-member operators . . . . .                  | 118        |
| 5.6      | Multiplicative operators . . . . .                     | 119        |
| 5.7      | Additive operators . . . . .                           | 119        |
| 5.8      | Shift operators . . . . .                              | 121        |
| 5.9      | Relational operators . . . . .                         | 121        |
| 5.10     | Equality operators . . . . .                           | 122        |
| 5.11     | Bitwise AND operator . . . . .                         | 123        |
| 5.12     | Bitwise exclusive OR operator . . . . .                | 123        |
| 5.13     | Bitwise inclusive OR operator . . . . .                | 123        |
| 5.14     | Logical AND operator . . . . .                         | 123        |
| 5.15     | Logical OR operator . . . . .                          | 124        |
| 5.16     | Conditional operator . . . . .                         | 124        |
| 5.17     | Assignment and compound assignment operators . . . . . | 125        |
| 5.18     | Comma operator . . . . .                               | 127        |
| 5.19     | Constant expressions . . . . .                         | 127        |
| <b>6</b> | <b>Statements</b>                                      | <b>130</b> |
| 6.1      | Labeled statement . . . . .                            | 130        |
| 6.2      | Expression statement . . . . .                         | 130        |
| 6.3      | Compound statement or block . . . . .                  | 130        |
| 6.4      | Selection statements . . . . .                         | 131        |
| 6.5      | Iteration statements . . . . .                         | 133        |
| 6.6      | Jump statements . . . . .                              | 136        |
| 6.7      | Declaration statement . . . . .                        | 137        |
| 6.8      | Ambiguity resolution . . . . .                         | 138        |
| <b>7</b> | <b>Declarations</b>                                    | <b>140</b> |
| 7.1      | Specifiers . . . . .                                   | 142        |
| 7.2      | Enumeration declarations . . . . .                     | 157        |

|           |  |            |
|-----------|--|------------|
| 7.3       | Namespaces . . . . .   | 161        |
| 7.4       | The <code>asm</code> declaration . . . . .                     | 173        |
| 7.5       | Linkage specifications . . . . .                               | 174        |
| 7.6       | Attributes . . . . .   | 177        |
| <b>8</b>  | <b>Declarators</b>   | <b>182</b> |
| 8.1       | Type names . . . . .   | 183        |
| 8.2       | Ambiguity resolution . . . . .                                 | 184        |
| 8.3       | Meaning of declarators . . . . .                               | 186        |
| 8.4       | Function definitions . . . . .                                 | 198        |
| 8.5       | Initializers . . . . .   | 202        |
| <b>9</b>  | <b>Classes</b>   | <b>216</b> |
| 9.1       | Class names . . . . .  | 218        |
| 9.2       | Class members . . . . .  | 220        |
| 9.3       | Member functions . . . . .                                     | 222        |
| 9.4       | Static members . . . . .                                       | 225        |
| 9.5       | Unions . . . . .   | 227        |
| 9.6       | Bit-fields . . . . .   | 229        |
| 9.7       | Nested class declarations . . . . .                            | 229        |
| 9.8       | Local class declarations . . . . .                             | 231        |
| 9.9       | Nested type names . . . . .                                    | 231        |
| <b>10</b> | <b>Derived classes</b>   | <b>233</b> |
| 10.1      | Multiple base classes . . . . .                                | 234        |
| 10.2      | Member name lookup . . . . .                                   | 236        |
| 10.3      | Virtual functions . . . . .                                    | 240        |
| 10.4      | Abstract classes . . . . .                                     | 244        |
| <b>11</b> | <b>Member access control</b>                                   | <b>246</b> |
| 11.1      | Access specifiers . . . . .                                    | 248        |
| 11.2      | Accessibility of base classes and base class members . . . . . | 249        |
| 11.3      | Friends . . . . .  | 251        |
| 11.4      | Protected member access . . . . .                              | 254        |
| 11.5      | Access to virtual functions . . . . .                          | 255        |
| 11.6      | Multiple access . . . . .                                      | 256        |
| 11.7      | Nested classes . . . . .                                       | 256        |
| <b>12</b> | <b>Special member functions</b>                                | <b>257</b> |
| 12.1      | Constructors . . . . .   | 257        |
| 12.2      | Temporary objects . . . . .                                    | 260        |
| 12.3      | Conversions . . . . .  | 262        |
| 12.4      | Destructors . . . . .  | 265        |
| 12.5      | Free store . . . . .   | 267        |
| 12.6      | Initialization . . . . .                                       | 269        |
| 12.7      | Construction and destruction . . . . .                         | 275        |
| 12.8      | Copying and moving class objects . . . . .                     | 278        |
| 12.9      | Inheriting constructors . . . . .                              | 286        |
| <b>13</b> | <b>Overloading</b>   | <b>289</b> |
| 13.1      | Overloadable declarations . . . . .                            | 289        |

|           |   |            |
|-----------|---|------------|
| 13.2      | Declaration matching . . . . .                      | 291        |
| 13.3      | Overload resolution . . . . .                       | 292        |
| 13.4      | Address of overloaded function . . . . .            | 311        |
| 13.5      | Overloaded operators . . . . .                      | 313        |
| 13.6      | Built-in operators . . . . .                        | 317        |
| <b>14</b> | <b>Templates</b>                                    | <b>321</b> |
| 14.1      | Template parameters . . . . .                       | 322        |
| 14.2      | Names of template specializations . . . . .         | 325        |
| 14.3      | Template arguments . . . . .                        | 327        |
| 14.4      | Type equivalence . . . . .                          | 333        |
| 14.5      | Template declarations . . . . .                     | 334        |
| 14.6      | Name resolution . . . . .                           | 352        |
| 14.7      | Template instantiation and specialization . . . . . | 366        |
| 14.8      | Function template specializations . . . . .         | 378        |
| <b>15</b> | <b>Exception handling</b>                           | <b>400</b> |
| 15.1      | Throwing an exception . . . . .                     | 401        |
| 15.2      | Constructors and destructors . . . . .              | 403        |
| 15.3      | Handling an exception . . . . .                     | 403        |
| 15.4      | Exception specifications . . . . .                  | 405        |
| 15.5      | Special functions . . . . .                         | 409        |
| <b>16</b> | <b>Preprocessing directives</b>                     | <b>411</b> |
| 16.1      | Conditional inclusion . . . . .                     | 413        |
| 16.2      | Source file inclusion . . . . .                     | 414        |
| 16.3      | Macro replacement . . . . .                         | 415        |
| 16.4      | Line control . . . . .                              | 420        |
| 16.5      | Error directive . . . . .                           | 421        |
| 16.6      | Pragma directive . . . . .                          | 421        |
| 16.7      | Null directive . . . . .                            | 421        |
| 16.8      | Predefined macro names . . . . .                    | 421        |
| 16.9      | Pragma operator . . . . .                           | 423        |
| <b>17</b> | <b>Library introduction</b>                         | <b>424</b> |
| 17.1      | General . . . . .                                   | 424        |
| 17.2      | The C standard library . . . . .                    | 425        |
| 17.3      | Definitions . . . . .                               | 425        |
| 17.4      | Additional definitions . . . . .                    | 428        |
| 17.5      | Method of description (Informative) . . . . .       | 428        |
| 17.6      | Library-wide requirements . . . . .                 | 434        |
| <b>18</b> | <b>Language support library</b>                     | <b>454</b> |
| 18.1      | General . . . . .                                   | 454        |
| 18.2      | Types . . . . .                                     | 454        |
| 18.3      | Implementation properties . . . . .                 | 455        |
| 18.4      | Integer types . . . . .                             | 464        |
| 18.5      | Start and termination . . . . .                     | 465        |
| 18.6      | Dynamic memory management . . . . .                 | 467        |
| 18.7      | Type identification . . . . .                       | 473        |
| 18.8      | Exception handling . . . . .                        | 475        |

|           |  |            |
|-----------|--|------------|
| 18.9      | Initializer lists . . . . .                                    | 480        |
| 18.10     | Other runtime support . . . . .                                | 481        |
| <b>19</b> | <b>Diagnostics library</b>                                     | <b>484</b> |
| 19.1      | General . . . . .  | 484        |
| 19.2      | Exception classes . . . . .                                    | 484        |
| 19.3      | Assertions . . . . .   | 488        |
| 19.4      | Error numbers . . . . .  | 489        |
| 19.5      | System error support . . . . .                                 | 489        |
| <b>20</b> | <b>General utilities library</b>                               | <b>500</b> |
| 20.1      | General . . . . .  | 500        |
| 20.2      | Utility components . . . . .                                   | 500        |
| 20.3      | Pairs . . . . .  | 504        |
| 20.4      | Tuples . . . . .   | 508        |
| 20.5      | Class template <code>bitset</code> . . . . .                   | 518        |
| 20.6      | Memory . . . . .   | 525        |
| 20.7      | Smart pointers . . . . .                                       | 540        |
| 20.8      | Function objects . . . . .                                     | 566        |
| 20.9      | Metaprogramming and type traits . . . . .                      | 585        |
| 20.10     | Compile-time rational arithmetic . . . . .                     | 602        |
| 20.11     | Time utilities . . . . .                                       | 605        |
| 20.12     | Class template <code>scoped_allocator_adaptor</code> . . . . . | 620        |
| 20.13     | Class <code>type_index</code> . . . . .                        | 625        |
| <b>21</b> | <b>Strings library</b>   | <b>628</b> |
| 21.1      | General . . . . .  | 628        |
| 21.2      | Character traits . . . . .                                     | 628        |
| 21.3      | String classes . . . . .                                       | 634        |
| 21.4      | Class template <code>basic_string</code> . . . . .             | 638        |
| 21.5      | Numeric conversions . . . . .                                  | 665        |
| 21.6      | Hash support . . . . .   | 666        |
| 21.7      | Null-terminated sequence utilities . . . . .                   | 667        |
| <b>22</b> | <b>Localization library</b>                                    | <b>671</b> |
| 22.1      | General . . . . .  | 671        |
| 22.2      | Header <code>&lt;locale&gt;</code> synopsis . . . . .          | 671        |
| 22.3      | Locales . . . . .  | 672        |
| 22.4      | Standard <code>locale</code> categories . . . . .              | 684        |
| 22.5      | Standard code conversion facets . . . . .                      | 725        |
| 22.6      | C library locales . . . . .                                    | 726        |
| <b>23</b> | <b>Containers library</b>                                      | <b>728</b> |
| 23.1      | General . . . . .  | 728        |
| 23.2      | Container requirements . . . . .                               | 728        |
| 23.3      | Sequence containers . . . . .                                  | 754        |
| 23.4      | Associative containers . . . . .                               | 786        |
| 23.5      | Unordered associative containers . . . . .                     | 803        |
| 23.6      | Container adaptors . . . . .                                   | 819        |
| <b>24</b> | <b>Iterators library</b>                                       | <b>829</b> |

|           |  |             |
|-----------|--|-------------|
| 24.1      | General . . . . .  | 829         |
| 24.2      | Iterator requirements . . . . .                          | 829         |
| 24.3      | Header <code>&lt;iterator&gt;</code> synopsis . . . . .  | 834         |
| 24.4      | Iterator primitives . . . . .                            | 837         |
| 24.5      | Iterator adaptors . . . . .                              | 841         |
| 24.6      | Stream iterators . . . . .                               | 855         |
| <b>25</b> | <b>Algorithms library</b>                                | <b>863</b>  |
| 25.1      | General . . . . .  | 863         |
| 25.2      | Non-modifying sequence operations . . . . .              | 873         |
| 25.3      | Mutating sequence operations . . . . .                   | 878         |
| 25.4      | Sorting and related operations . . . . .                 | 887         |
| 25.5      | C library algorithms . . . . .                           | 900         |
| <b>26</b> | <b>Numerics library</b>                                  | <b>902</b>  |
| 26.1      | General . . . . .  | 902         |
| 26.2      | Numeric type requirements . . . . .                      | 902         |
| 26.3      | The floating-point environment . . . . .                 | 903         |
| 26.4      | Complex numbers . . . . .                                | 904         |
| 26.5      | Random number generation . . . . .                       | 914         |
| 26.6      | Numeric arrays . . . . .                                 | 959         |
| 26.7      | Generalized numeric operations . . . . .                 | 981         |
| 26.8      | C library . . . . .                                      | 984         |
| <b>27</b> | <b>Input/output library</b>                              | <b>989</b>  |
| 27.1      | General . . . . .  | 989         |
| 27.2      | Iostreams requirements . . . . .                         | 990         |
| 27.3      | Forward declarations . . . . .                           | 990         |
| 27.4      | Standard iostream objects . . . . .                      | 992         |
| 27.5      | Iostreams base classes . . . . .                         | 994         |
| 27.6      | Stream buffers . . . . .                                 | 1013        |
| 27.7      | Formatting and manipulators . . . . .                    | 1023        |
| 27.8      | String-based streams . . . . .                           | 1049        |
| 27.9      | File-based streams . . . . .                             | 1061        |
| <b>28</b> | <b>Regular expressions library</b>                       | <b>1076</b> |
| 28.1      | General . . . . .  | 1076        |
| 28.2      | Definitions . . . . .                                    | 1076        |
| 28.3      | Requirements . . . . .                                   | 1077        |
| 28.4      | Header <code>&lt;regex&gt;</code> synopsis . . . . .     | 1079        |
| 28.5      | Namespace <code>std::regex_constants</code> . . . . .    | 1086        |
| 28.6      | Class <code>regex_error</code> . . . . .                 | 1089        |
| 28.7      | Class template <code>regex_traits</code> . . . . .       | 1089        |
| 28.8      | Class template <code>basic_regex</code> . . . . .        | 1092        |
| 28.9      | Class template <code>sub_match</code> . . . . .          | 1097        |
| 28.10     | Class template <code>match_results</code> . . . . .      | 1103        |
| 28.11     | Regular expression algorithms . . . . .                  | 1108        |
| 28.12     | Regular expression iterators . . . . .                   | 1113        |
| 28.13     | Modified ECMAScript regular expression grammar . . . . . | 1119        |
| <b>29</b> | <b>Atomic operations library</b>                         | <b>1122</b> |

|           |   |             |
|-----------|---|-------------|
| 29.1      | General   | 1122        |
| 29.2      | Header <code>&lt;atomic&gt;</code> synopsis       | 1122        |
| 29.3      | Order and consistency                             | 1125        |
| 29.4      | Lock-free property                                | 1128        |
| 29.5      | Atomic types                                      | 1128        |
| 29.6      | Operations on atomic types                        | 1132        |
| 29.7      | Flag type and operations                          | 1137        |
| 29.8      | Fences  | 1138        |
| <b>30</b> | <b>Thread support library</b>                     | <b>1140</b> |
| 30.1      | General   | 1140        |
| 30.2      | Requirements                                      | 1140        |
| 30.3      | Threads   | 1143        |
| 30.4      | Mutual exclusion                                  | 1149        |
| 30.5      | Condition variables                               | 1162        |
| 30.6      | Futures   | 1170        |
| <b>A</b>  | <b>Grammar summary</b>                            | <b>1187</b> |
| A.1       | Keywords  | 1187        |
| A.2       | Lexical conventions                               | 1187        |
| A.3       | Basic concepts                                    | 1192        |
| A.4       | Expressions                                       | 1192        |
| A.5       | Statements  | 1195        |
| A.6       | Declarations                                      | 1196        |
| A.7       | Declarators                                       | 1200        |
| A.8       | Classes   | 1202        |
| A.9       | Derived classes                                   | 1203        |
| A.10      | Special member functions                          | 1203        |
| A.11      | Overloading                                       | 1204        |
| A.12      | Templates   | 1204        |
| A.13      | Exception handling                                | 1205        |
| A.14      | Preprocessing directives                          | 1205        |
| <b>B</b>  | <b>Implementation quantities</b>                  | <b>1207</b> |
| <b>C</b>  | <b>Compatibility</b>                              | <b>1209</b> |
| C.1       | C++ and ISO C                                     | 1209        |
| C.2       | C++ and ISO C++ 2003                              | 1218        |
| C.3       | C standard library                                | 1225        |
| <b>D</b>  | <b>Compatibility features</b>                     | <b>1229</b> |
| D.1       | Increment operator with <code>bool</code> operand | 1229        |
| D.2       | <code>register</code> keyword                     | 1229        |
| D.3       | Implicit declaration of copy functions            | 1229        |
| D.4       | Dynamic exception specifications                  | 1229        |
| D.5       | C standard library headers                        | 1229        |
| D.6       | Old <code>iostreams</code> members                | 1230        |
| D.7       | <code>char*</code> streams                        | 1231        |
| D.8       | Function objects                                  | 1240        |
| D.9       | Binders   | 1243        |
| D.10      | <code>auto_ptr</code>                             | 1245        |

|          |  |             |
|----------|--|-------------|
| D.11     | Violating <i>exception-specifications</i> . . . . .        | 1247        |
| <b>E</b> | <b>Universal character names for identifier characters</b> | <b>1249</b> |
| E.1      | Ranges of characters allowed . . . . .                     | 1249        |
| E.2      | Ranges of characters disallowed initially . . . . .        | 1249        |
| <b>F</b> | <b>Cross references</b>                                    | <b>1250</b> |
|          | <b>Index</b>   | <b>1268</b> |
|          | <b>Index of grammar productions</b>                        | <b>1297</b> |
|          | <b>Index of library names</b>                              | <b>1300</b> |
|          | <b>Index of implementation-defined behavior</b>            | <b>1336</b> |

# List of Tables

|    |  |     |
|----|--|-----|
| 1  | Trigraph sequences . . . . .   | 19  |
| 2  | Alternative tokens . . . . .   | 21  |
| 3  | Identifiers with special meaning . . . . .   | 23  |
| 4  | Keywords . . . . .   | 23  |
| 5  | Alternative representations . . . . .  | 24  |
| 6  | Types of integer constants . . . . .   | 25  |
| 7  | Escape sequences . . . . .   | 27  |
| 8  | String literal concatenations . . . . .  | 30  |
| 9  | Relations on <code>const</code> and <code>volatile</code> . . . . .                                    | 78  |
| 10 | <i>simple-type-specifiers</i> and the types they specify . . . . .                                     | 154 |
| 11 | Relationship between operator and function call notation . . . . .                                     | 297 |
| 12 | Conversions . . . . .  | 305 |
| 13 | Library categories . . . . .   | 424 |
| 14 | C++ library headers . . . . .  | 435 |
| 15 | C++ headers for C library facilities . . . . .   | 435 |
| 16 | C++ headers for freestanding implementations . . . . .   | 436 |
| 17 | <code>EqualityComparable</code> requirements . . . . .   | 437 |
| 18 | <code>LessThanComparable</code> requirements . . . . .   | 437 |
| 19 | <code>DefaultConstructible</code> requirements . . . . .   | 437 |
| 20 | <code>MoveConstructible</code> requirements . . . . .  | 438 |
| 21 | <code>CopyConstructible</code> requirements (in addition to <code>MoveConstructible</code> ) . . . . . | 438 |
| 22 | <code>MoveAssignable</code> requirements . . . . .   | 438 |
| 23 | <code>CopyAssignable</code> requirements(in addition to <code>MoveAssignable</code> ) . . . . .        | 438 |
| 24 | <code>Destructible</code> requirements . . . . .   | 438 |
| 25 | <code>NullablePointer</code> requirements . . . . .  | 440 |
| 26 | <code>Hash</code> requirements . . . . .   | 441 |
| 27 | Descriptive variable definitions . . . . .   | 441 |
| 28 | Allocator requirements . . . . .   | 442 |
| 29 | Language support library summary . . . . .   | 454 |
| 30 | Header <code>&lt;cstdint&gt;</code> synopsis . . . . .   | 454 |
| 31 | Header <code>&lt;climits&gt;</code> synopsis . . . . .   | 464 |
| 32 | Header <code>&lt;float&gt;</code> synopsis . . . . .   | 464 |
| 33 | Header <code>&lt;stdlib&gt;</code> synopsis . . . . .  | 466 |
| 34 | Header <code>&lt;setjmp&gt;</code> synopsis . . . . .  | 482 |
| 35 | Header <code>&lt;signal&gt;</code> synopsis . . . . .  | 482 |
| 36 | Header <code>&lt;stdalign&gt;</code> synopsis . . . . .  | 482 |
| 37 | Header <code>&lt;stdarg&gt;</code> synopsis . . . . .  | 482 |
| 38 | Header <code>&lt;stdbool&gt;</code> synopsis . . . . .   | 482 |
| 39 | Header <code>&lt;stdlib&gt;</code> synopsis . . . . .  | 482 |
| 40 | Header <code>&lt;time&gt;</code> synopsis . . . . .  | 483 |

|    |  |     |
|----|--|-----|
| 41 | Diagnostics library summary  | 484 |
| 42 | Header <code>&lt;cassert&gt;</code> synopsis   | 488 |
| 43 | Header <code>&lt;cerrno&gt;</code> synopsis  | 489 |
| 44 | General utilities library summary  | 500 |
| 45 | Header <code>&lt;cstdlib&gt;</code> synopsis   | 539 |
| 46 | Header <code>&lt;cstring&gt;</code> synopsis   | 540 |
| 47 | Primary type category predicates   | 589 |
| 48 | Composite type category predicates   | 589 |
| 49 | Type property predicates   | 590 |
| 50 | Type property queries  | 595 |
| 51 | Type relationship predicates   | 596 |
| 52 | Const-volatile modifications   | 597 |
| 53 | Reference modifications  | 598 |
| 54 | Sign modifications   | 598 |
| 55 | Array modifications  | 599 |
| 56 | Pointer modifications  | 599 |
| 57 | Other transformations  | 600 |
| 58 | Expressions used to perform ratio arithmetic   | 604 |
| 59 | Clock requirements   | 608 |
| 60 | Header <code>&lt;ctime&gt;</code> synopsis   | 619 |
| 61 | Strings library summary  | 628 |
| 62 | Character traits requirements  | 629 |
| 63 | <code>basic_string(const Allocator&amp;)</code> effects  | 643 |
| 64 | <code>basic_string(const basic_string&amp;)</code> effects   | 643 |
| 65 | <code>basic_string(const basic_string&amp;, size_type, size_type, const Allocator&amp;)</code> effects   | 643 |
| 66 | <code>basic_string(const charT*, size_type, const Allocator&amp;)</code> effects   | 644 |
| 67 | <code>basic_string(const charT*, const Allocator&amp;)</code> effects  | 644 |
| 68 | <code>basic_string(size_t, charT, const Allocator&amp;)</code> effects   | 644 |
| 69 | <code>basic_string(const basic_string&amp;, const Allocator&amp;)</code> and <code>basic_string(basic_string&amp;&amp;, const Allocator&amp;)</code> effects | 645 |
| 70 | <code>operator=(const basic_string&lt;charT, traits, Allocator&gt;&amp;)</code> effects  | 645 |
| 71 | <code>operator=(const basic_string&lt;charT, traits, Allocator&gt;&amp;&amp;)</code> effects   | 645 |
| 72 | <code>compare()</code> results   | 659 |
| 73 | Potential <code>mbstate_t</code> data races  | 668 |
| 74 | Header <code>&lt;cctype&gt;</code> synopsis  | 668 |
| 75 | Header <code>&lt;cwctype&gt;</code> synopsis   | 669 |
| 76 | Header <code>&lt;cstring&gt;</code> synopsis   | 669 |
| 77 | Header <code>&lt;wchar&gt;</code> synopsis   | 669 |
| 78 | Header <code>&lt;cstdlib&gt;</code> synopsis   | 669 |
| 79 | Header <code>&lt;cuchar&gt;</code> synopsis  | 670 |
| 80 | Localization library summary   | 671 |
| 81 | Locale category facets   | 675 |
| 82 | Required specializations   | 676 |
| 83 | <code>do_in/do_out</code> result values  | 694 |
| 84 | <code>do_unshift</code> result values  | 694 |
| 85 | Integer conversions  | 698 |
| 86 | Length modifier  | 698 |
| 87 | Integer conversions  | 702 |

|     |   |      |
|-----|---|------|
| 88  | Floating-point conversions . . . . .  | 703  |
| 89  | Length modifier . . . . .   | 703  |
| 90  | Numeric conversions . . . . .   | 703  |
| 91  | Fill padding . . . . .  | 704  |
| 92  | <code>do_get_date</code> effects . . . . .  | 711  |
| 93  | Header <code>&lt;locale&gt;</code> synopsis . . . . .                                 | 726  |
| 94  | Potential <code>setlocale</code> data races . . . . .                                 | 727  |
|     |   |      |
| 95  | Containers library summary . . . . .  | 728  |
| 96  | Container requirements . . . . .  | 729  |
| 97  | Reversible container requirements . . . . .   | 731  |
| 98  | Optional container operations . . . . .   | 732  |
| 99  | Allocator-aware container requirements . . . . .                                      | 733  |
| 100 | Sequence container requirements (in addition to container) . . . . .                  | 735  |
| 101 | Optional sequence container operations . . . . .                                      | 737  |
| 102 | Associative container requirements (in addition to container) . . . . .               | 740  |
| 103 | Unordered associative container requirements (in addition to container) . . . . .     | 746  |
|     |   |      |
| 104 | Iterators library summary . . . . .   | 829  |
| 105 | Relations among iterator categories . . . . .   | 829  |
| 106 | Iterator requirements . . . . .   | 831  |
| 107 | Input iterator requirements (in addition to <code>Iterator</code> ) . . . . .         | 831  |
| 108 | Output iterator requirements (in addition to <code>Iterator</code> ) . . . . .        | 832  |
| 109 | Forward iterator requirements (in addition to input iterator) . . . . .               | 833  |
| 110 | Bidirectional iterator requirements (in addition to forward iterator) . . . . .       | 833  |
| 111 | Random access iterator requirements (in addition to bidirectional iterator) . . . . . | 834  |
|     |   |      |
| 112 | Algorithms library summary . . . . .  | 863  |
| 113 | Header <code>&lt;cstdlib&gt;</code> synopsis . . . . .                                | 900  |
|     |   |      |
| 114 | Numerics library summary . . . . .  | 902  |
| 115 | Seed sequence requirements . . . . .  | 915  |
| 116 | Uniform random number generator requirements . . . . .                                | 916  |
| 117 | Random number engine requirements . . . . .   | 917  |
| 118 | Random number distribution requirements . . . . .                                     | 921  |
| 119 | Header <code>&lt;cmath&gt;</code> synopsis . . . . .                                  | 984  |
| 120 | Header <code>&lt;cstdlib&gt;</code> synopsis . . . . .                                | 985  |
|     |   |      |
| 121 | Input/output library summary . . . . .  | 989  |
| 122 | <code>fmtflags</code> effects . . . . .   | 999  |
| 123 | <code>fmtflags</code> constants . . . . .   | 999  |
| 124 | <code>iostate</code> effects . . . . .  | 999  |
| 125 | <code>openmode</code> effects . . . . .   | 1000 |
| 126 | <code>seekdir</code> effects . . . . .  | 1000 |
| 127 | Position type requirements . . . . .  | 1004 |
| 128 | <code>basic_ios::init()</code> effects . . . . .                                      | 1007 |
| 129 | <code>basic_ios::copyfmt()</code> effects . . . . .                                   | 1008 |
| 130 | <code>seekoff</code> positioning . . . . .  | 1054 |
| 131 | <code>newoff</code> values . . . . .  | 1054 |
| 132 | File open modes . . . . .   | 1064 |
| 133 | <code>seekoff</code> effects . . . . .  | 1067 |

|     |   |      |
|-----|---|------|
| 134 | Header <code>&lt;cstdio&gt;</code> synopsis . . . . .   | 1074 |
| 135 | Header <code>&lt;cinttypes&gt;</code> synopsis . . . . .  | 1075 |
| 136 | Regular expressions library summary . . . . .   | 1076 |
| 137 | Regular expression traits class requirements . . . . .  | 1077 |
| 138 | <code>syntax_option_type</code> effects . . . . .   | 1087 |
| 139 | <code>regex_constants::match_flag_type</code> effects when obtaining a match against a character container sequence <code>[first,last)</code> . . . . . | 1087 |
| 140 | <code>error_type</code> values in the C locale . . . . .  | 1088 |
| 141 | <code>match_results</code> assignment operator effects . . . . .  | 1105 |
| 142 | Effects of <code>regex_match</code> algorithm . . . . .   | 1109 |
| 143 | Effects of <code>regex_search</code> algorithm . . . . .  | 1110 |
| 144 | Atomics library summary . . . . .   | 1122 |
| 145 | <code>atomic</code> integral typedefs . . . . .   | 1131 |
| 146 | <code>atomic</code> <code>&lt;inttypes.h&gt;</code> typedefs . . . . .  | 1132 |
| 147 | Atomic arithmetic computations . . . . .  | 1136 |
| 148 | Thread support library summary . . . . .  | 1140 |
| 149 | Standard macros . . . . .   | 1225 |
| 150 | Standard values . . . . .   | 1225 |
| 151 | Standard types . . . . .  | 1226 |
| 152 | Standard structs . . . . .  | 1226 |
| 153 | Standard functions . . . . .  | 1226 |
| 154 | C headers . . . . .   | 1229 |
| 155 | <code>strstreambuf(streamsize)</code> effects . . . . .   | 1233 |
| 156 | <code>strstreambuf(void* (*)(size_t), void (*)(void*))</code> effects . . . . .   | 1233 |
| 157 | <code>strstreambuf(charT*, streamsize, charT*)</code> effects . . . . .   | 1234 |
| 158 | <code>seekoff</code> positioning . . . . .  | 1236 |
| 159 | <code>newoff</code> values . . . . .  | 1236 |

# List of Figures

- 1 Expression category taxonomy . . . . . 78
- 2 Directed acyclic graph . . . . . 234
- 3 Non-virtual base . . . . . 235
- 4 Virtual base . . . . . 236
- 5 Virtual and non-virtual base . . . . . 236
- 6 Name lookup . . . . . 239
- 7 Stream position, offset, and size types [non-normative] . . . . . 989