

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

Informationsteknologi – Databasesprog – GQL

Information technology – Database languages – GQL

DANSK STANDARD
Danish Standards Association

Göteborg Plads 1
DK-2150 Nordhavn

Tel: +45 39 96 61 01
dansk.standard@ds.dk
www.ds.dk

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

DS projekt: M376243
ICS: 35.060

Første del af denne publikations betegnelse er:
DS/ISO/IEC, hvilket betyder, at det er en international standard, der har status som dansk standard.

Denne publikations overensstemmelse er:
IDT med: ISO/IEC 39075:2024

DS-publikationen er på engelsk.

I tilfælde af redaktionelle fejl i DS-publikationen kan der skrives til:
editorial-mistakes@ds.dk

ADVARSEL: DS-publikationer revideres over tid. Derudover kan sådanne publikationer ændres ved rettelserblade og/eller tillæg. Der kan også udgives rettelserblade, der udelukkende angår oversættelsen af en publikation. Det er derfor vigtigt at sikre sig, at man benytter en gældende udgave, medmindre fx lovgivning kræver andet. Den enkelte publikations status fremgår af <https://webshop.ds.dk/>. Her kan man desuden tilmelde sig en gratis notifikationservice og følge en udgivet DS-publikations udvikling ved at klikke på "Følg standarden".

En oversigt over forskellige DS-publikationstyper og -betegnelser findes her:
<https://www.ds.dk/publikationstyper>.

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

ISO/IEC 39075**Information technology — Database languages — GQL**

Technologies de l'information — Langages de base de données — GQL

**First edition
2024-04**



COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents	Page
Foreword.....	xiv
Introduction.....	xv
1 Scope.....	1
2 Normative references.....	2
3 Terms and definitions.....	3
3.1 General terms and definitions.....	3
3.2 GQL-environment terms and definitions.....	4
3.3 GQL-catalog terms and definitions.....	6
3.4 Graph terms and definitions.....	7
3.5 Procedure and command terms and definitions.....	9
3.6 General syntax terms and definitions.....	12
3.7 Graph pattern terms and definitions.....	14
3.8 Value terms and definitions.....	15
3.9 Type terms and definitions.....	17
3.10 Temporal terms and definitions.....	19
4 Concepts.....	21
4.1 Use of terms.....	21
4.2 GQL-environments and their components.....	21
4.2.1 General description of GQL-environments.....	21
4.2.2 GQL-agents.....	22
4.2.3 GQL-implementations.....	22
4.2.3.1 Introduction to GQL-implementations.....	22
4.2.3.2 GQL-clients.....	23
4.2.3.3 GQL-servers.....	23
4.2.4 Basic security model.....	24
4.2.4.1 Principals.....	24
4.2.4.2 Authorization identifiers and privileges.....	24
4.2.5 GQL-catalog.....	24
4.2.5.1 General description of the GQL-catalog.....	24
4.2.5.2 GQL-directories.....	25
4.2.5.3 GQL-schemas.....	26
4.2.6 GQL-data.....	27
4.3 GQL-objects.....	27
4.3.1 General introduction to GQL-objects.....	27
4.3.2 References to GQL-schemas and GQL-objects.....	27
4.3.3 Primary objects and secondary objects.....	28
4.3.4 Properties and supported property value types.....	28
4.3.5 Graphs.....	29

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

4.3.5.1	Introduction to graphs.	29
4.3.5.2	Graph descriptors.	30
4.3.6	Binding tables.	30
4.4	Values.	32
4.4.1	General information about values.	32
4.4.2	Comparable values.	32
4.4.3	Properties of distinct values.	32
4.4.4	Reference values.	33
4.4.5	Material values and the null value.	33
4.5	GQL-sessions.	33
4.5.1	General description of GQL-sessions.	33
4.5.2	Session contexts.	34
4.5.2.1	Introduction to session contexts.	34
4.5.2.2	Session context creation.	35
4.5.2.3	Session context modification.	35
4.6	GQL-transactions.	35
4.6.1	General description of GQL-transactions.	35
4.6.2	Transaction demarcation.	36
4.6.3	Transaction isolation.	37
4.6.4	Encompassing transaction belonging to an external agent.	37
4.7	GQL-requests and GQL-programs.	38
4.7.1	General description of GQL-requests and GQL-programs.	38
4.7.2	GQL-request contexts.	38
4.7.2.1	Introduction to GQL-request contexts.	38
4.7.2.2	GQL-request context creation.	38
4.7.2.3	GQL-request context modification.	39
4.7.3	Execution of GQL-requests.	39
4.7.4	Working schema references.	40
4.7.5	Working graph site.	41
4.7.6	Execution stack.	41
4.7.7	Operations.	41
4.8	Execution contexts.	42
4.8.1	General description of execution contexts.	42
4.8.2	Execution context creation and initialization.	44
4.8.3	Execution context modification.	45
4.8.4	Execution outcomes.	45
4.9	Diagnostic information.	46
4.9.1	Introduction to diagnostic information.	46
4.9.2	GQL-status objects.	46
4.9.3	Conditions.	47
4.10	Procedures and commands.	49
4.10.1	General description of procedures and commands.	49
4.10.2	Procedures.	49
4.10.2.1	General description of procedures.	49
4.10.2.2	Named procedure descriptors.	50
4.10.2.3	Procedure execution.	50
4.10.2.4	Procedures classified by kind of side effects.	50

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

4.10.3	Commands.	51
4.10.4	GQL-procedures.	51
4.10.4.1	Introduction to GQL-procedures.	51
4.10.4.2	Binding variables and general parameters.	51
4.10.4.3	Statements.	52
4.10.4.4	Statements classified by use of working graph sites.	52
4.10.4.5	Statements classified by function.	52
4.11	Graph pattern matching.	53
4.11.1	Summary of graph pattern matching.	53
4.11.2	Paths.	53
4.11.3	Path patterns.	54
4.11.4	Graph pattern variables.	55
4.11.5	References to graph pattern variables.	56
4.11.6	Path pattern matching.	57
4.11.7	Path modes.	58
4.11.8	Selective path search prefixes.	59
4.11.9	Match modes.	59
4.12	Data types.	59
4.12.1	General introduction to data types and base types.	59
4.12.2	Major classes of data types.	60
4.12.3	Data type descriptors.	62
4.12.4	Naming of data types and base types.	62
4.12.5	Material, nullable, and immaterial data types.	63
4.12.6	Most specific static value type and static base type.	63
4.12.7	Open and closed data types.	63
4.12.8	Additional terminology related to data types.	64
4.13	GQL-object types.	64
4.13.1	Introduction to GQL-object types and related base types.	64
4.13.2	Graph types and graph element types.	65
4.13.2.1	Introduction to graph types and graph element types.	65
4.13.2.2	Graph type descriptors.	65
4.13.2.3	Node types.	66
4.13.2.4	Edge types.	67
4.13.2.5	Property types.	68
4.13.2.6	Key label sets.	69
4.13.2.7	Structural consistency of element types.	69
4.13.3	Binding table types.	70
4.14	Dynamic union types.	71
4.14.1	Introduction to dynamic union types and the dynamic base type.	71
4.14.2	Dynamic union data type descriptors.	71
4.14.3	Characteristics of dynamic union types.	71
4.14.4	Dynamic generation of type tests and casts.	72
4.14.4.1	Introduction to dynamic generation of type tests and casts for <value expression>s.	72
4.14.4.2	Dynamic generation of type tests and strict casts for a <value expression> without operands.	72
4.14.4.3	Dynamic generation of type tests and strict casts for a <value expression> with operands.	73
4.14.4.4	Dynamic generation of additional type tests and lax casts for a <value expression>.	75
4.15	Constructed value types.	75

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

4.15.1	Introduction to constructed value types and related base types.	75
4.15.2	Path value types.	76
4.15.3	List value types.	76
4.15.4	Record types.	77
4.16	Predefined value types.	79
4.16.1	Introduction to predefined value types and related base types.	79
4.16.2	Boolean types.	81
4.16.3	Character string types.	82
4.16.3.1	Introduction to character strings.	82
4.16.3.2	Collations.	83
4.16.4	Byte string types.	84
4.16.5	Numeric types.	85
4.16.5.1	Introduction to numbers.	85
4.16.5.2	Characteristics of numbers.	85
4.16.5.3	Binary exact numeric types.	87
4.16.5.4	Decimal exact numeric types.	88
4.16.5.5	Approximate numeric types.	89
4.16.6	Temporal types.	90
4.16.6.1	Introduction to temporal data.	90
4.16.6.2	Temporal instant types.	90
4.16.6.3	Temporal duration types.	91
4.16.6.4	Operators involving values of temporal types.	92
4.16.7	Reference value types.	93
4.16.8	Immaterial value types: null type and empty type.	94
4.17	Sites.	94
4.17.1	General description of sites.	94
4.17.2	Static and dynamic sites.	95
4.17.3	Assignment and store assignment.	95
4.17.4	Nullability.	95
4.17.4.1	Introduction to nullability.	95
4.17.4.2	Nullability requirements.	96
4.17.4.3	Nullability inference.	96
5	Notation and conventions.	97
5.1	Notation taken from The Unicode® Standard	97
5.2	Notation.	97
5.3	Conventions.	98
5.3.1	Specification of syntactic elements.	98
5.3.2	Use of terms.	99
5.3.2.1	Syntactic containment.	99
5.3.2.2	Keywords and <keyword>s.	100
5.3.2.3	Terms denoting rule requirements.	100
5.3.2.4	Rule evaluation order.	100
5.3.2.5	Conditional rules.	101
5.3.2.6	Syntactic substitution.	102
5.3.3	Descriptors.	102
5.3.4	Subclauses used as subroutines.	103
5.3.5	Document typography.	103

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

5.3.6	Index typography.....	103
5.3.7	Feature ID and Feature Name.....	104
6	<GQL-program>.....	105
7	Session management.....	107
7.1	<session set command>.....	107
7.2	<session reset command>.....	111
7.3	<session close command>.....	113
7.4	<session parameter specification>.....	114
8	Transaction management.....	115
8.1	<start transaction command>.....	115
8.2	<transaction characteristics>.....	116
8.3	<rollback command>.....	117
8.4	<commit command>.....	118
9	Procedure specification.....	119
9.1	<procedure specification>.....	119
9.2	<procedure body>.....	121
10	Variable definitions.....	125
10.1	<graph variable definition>.....	125
10.2	<binding table variable definition>.....	127
10.3	<value variable definition>.....	129
11	Object expressions.....	131
11.1	<graph expression>.....	131
11.2	<binding table expression>.....	133
11.3	<object expression primary>.....	135
12	Catalog-modifying statements.....	136
12.1	<linear catalog-modifying statement>.....	136
12.2	<create schema statement>.....	137
12.3	<drop schema statement>.....	138
12.4	<create graph statement>.....	139
12.5	<drop graph statement>.....	142
12.6	<create graph type statement>.....	143
12.7	<drop graph type statement>.....	145
12.8	<call catalog-modifying procedure statement>.....	146
13	Data-modifying statements.....	147
13.1	<linear data-modifying statement>.....	147
13.2	<insert statement>.....	149
13.3	<set statement>.....	154
13.4	<remove statement>.....	158
13.5	<delete statement>.....	160
13.6	<call data-modifying procedure statement>.....	162
14	Query statements.....	163
14.1	<composite query statement>.....	163
14.2	<composite query expression>.....	164
14.3	<linear query statement> and <simple query statement>.....	168
14.4	<match statement>.....	170

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

14.5	<call query statement>.....	173
14.6	<filter statement>.....	174
14.7	<let statement>.....	175
14.8	<for statement>.....	177
14.9	<order by and page statement>.....	180
14.10	<primitive result statement>.....	182
14.11	<return statement>.....	185
14.12	<select statement>.....	190
15	Procedure calling.....	199
15.1	<call procedure statement> and <procedure call>.....	199
15.2	<inline procedure call>.....	201
15.3	<named procedure call>.....	203
16	Common elements.....	205
16.1	<at schema clause>.....	205
16.2	<use graph clause>.....	206
16.3	<graph pattern binding table>.....	208
16.4	<graph pattern>.....	213
16.5	<insert graph pattern>.....	219
16.6	<path pattern prefix>.....	222
16.7	<path pattern expression>.....	226
16.8	<label expression>.....	236
16.9	<path variable reference>.....	238
16.10	<element variable reference>.....	239
16.11	<graph pattern quantifier>.....	240
16.12	<simplified path pattern expression>.....	242
16.13	<where clause>.....	247
16.14	<yield clause>.....	248
16.15	<group by clause>.....	250
16.16	<order by clause>.....	252
16.17	<sort specification list>.....	253
16.18	<limit clause>.....	256
16.19	<offset clause>.....	257
17	Object references.....	258
17.1	<schema reference> and <catalog schema parent and name>.....	258
17.2	<graph reference> and <catalog graph parent and name>.....	261
17.3	<graph type reference> and <catalog graph type parent and name>.....	263
17.4	<binding table reference> and <catalog binding table parent and name>.....	264
17.5	<procedure reference> and <catalog procedure parent and name>.....	266
17.6	<catalog object parent reference>.....	267
17.7	<reference parameter specification>.....	269
17.8	<external object reference>.....	271
18	Type elements.....	272
18.1	<nested graph type specification>.....	272
18.2	<node type specification>.....	277
18.3	<edge type specification>.....	281
18.4	<label set phrase> and <label set specification>.....	289

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

18.5	<property types specification>.....	290
18.6	<property type>.....	291
18.7	<property value type>.....	292
18.8	<binding table type>.....	293
18.9	<value type>.....	294
18.10	<field type>.....	318
19	Predicates.....	319
19.1	<search condition>.....	319
19.2	<predicate>.....	320
19.3	<comparison predicate>.....	321
19.4	<exists predicate>.....	326
19.5	<null predicate>.....	327
19.6	<value type predicate>.....	328
19.7	<normalized predicate>.....	329
19.8	<directed predicate>.....	330
19.9	<labeled predicate>.....	331
19.10	<source/destination predicate>.....	332
19.11	<all_different predicate>.....	334
19.12	<same predicate>.....	335
19.13	<property_exists predicate>.....	336
20	Value expressions and specifications.....	337
20.1	<value expression>.....	337
20.2	<value expression primary>.....	339
20.3	<value specification>.....	340
20.4	<dynamic parameter specification>.....	342
20.5	<let value expression>.....	343
20.6	<value query expression>.....	344
20.7	<case expression>.....	346
20.8	<cast specification>.....	349
20.9	<aggregate function>.....	363
20.10	<element_id function>.....	369
20.11	<property reference>.....	370
20.12	<binding variable reference>.....	372
20.13	<path value expression>.....	375
20.14	<path value constructor>.....	377
20.15	<list value expression>.....	378
20.16	<list value function>.....	379
20.17	<list value constructor>.....	381
20.18	<record constructor>.....	383
20.19	<field>.....	385
20.20	<boolean value expression>.....	386
20.21	<numeric value expression>.....	388
20.22	<numeric value function>.....	390
20.23	<string value expression>.....	397
20.24	<character string function>.....	400
20.25	<byte string function>.....	405
20.26	<datetime value expression>.....	407

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

20.27	<datetime value function>.....	408
20.28	<duration value expression>.....	414
20.29	<duration value function>.....	418
21	Lexical elements.....	422
21.1	Names and variables.....	422
21.2	<literal>.....	425
21.3	<token>, <separator>, and <identifier>.....	438
21.4	<GQL terminal character>.....	448
22	Additional common rules.....	452
22.1	Annotation of a <GQL-program>.....	452
22.2	Machinery for graph pattern matching.....	455
22.3	Evaluation of a <path pattern expression>.....	460
22.4	Evaluation of a selective <path pattern>.....	465
22.5	Satisfaction of a <label expression> by a label set.....	469
22.6	Application of bindings to evaluate an expression.....	471
22.7	Evaluation of an expression on a group variable.....	475
22.8	Application of bindings to generate a record.....	476
22.9	Resolution of a <simple directory path> from a start directory.....	478
22.10	Store assignment.....	479
22.11	Determination of identical values.....	485
22.12	Determination of distinct values.....	487
22.13	Equality operations.....	489
22.14	Ordering operations.....	490
22.15	Grouping operations.....	491
22.16	Determination of collation.....	492
22.17	Graph-type specific combination of property value types.....	493
22.18	General combination of value types.....	494
22.19	Static combination of value types.....	497
22.20	Determination of value type precedence.....	500
23	GQLSTATUS and diagnostic records.....	505
23.1	GQLSTATUS.....	505
23.2	Diagnostic records.....	510
24	Conformance.....	513
24.1	Introduction to conformance.....	513
24.2	Minimum conformance.....	513
24.3	Conformance to features.....	513
24.4	Requirements for GQL-programs.....	515
24.4.1	Introduction to requirements for GQL-programs.....	515
24.4.2	Claims of conformance for GQL-programs.....	515
24.5	Requirements for GQL-implementations.....	516
24.5.1	Introduction to requirements for GQL-implementations.....	516
24.5.2	Claims of conformance for GQL-implementations.....	516
24.5.3	Extensions and options.....	516
24.6	GQL Flagger.....	516
24.7	Implied feature relationships.....	517
Annex A	(informative) GQL conformance summary.....	522

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

Annex B (informative) Implementation-defined elements	555
Annex C (informative) Implementation-dependent elements	574
Annex D (informative) GQL optional feature taxonomy	577
Annex E (informative) Maintenance and interpretation of GQL	587
Bibliography	588
Index	589

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

Tables

Table	Page
1 Valid operators involving values of temporal types.	92
2 Symbols used in BNF.	97
3 Conversion of simplified syntax delimiters to default edge delimiters.	244
4 Valid combinations of source and target and types.	350
5 Truth table for the AND Boolean operator.	387
6 Truth table for the OR Boolean operator.	387
7 Truth table for the IS Boolean operator.	387
8 GQLSTATUS class and subclass codes.	505
9 Operation codes.	510
10 Implied feature relationships.	517
D.1 Feature taxonomy for optional features.	577

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

Figures

Figure		Page
1	Components of a GQL-environment.	21
2	Components of a GQL-catalog.	25
3	Major classes of data types.	61

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see <https://www.iso.org/directives> or https://www.iec.ch/members_experts/refdocs).

ISO and IEC draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO and IEC take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO and IEC had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://www.iso.org/patents> and <https://patents.iec.ch>. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see <https://www.iso.org/iso/foreword.html>. In the IEC, see <https://www.iec.ch/understanding-standards>.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

Any feedback or questions on this document should be directed to the user's national standards body. <https://www.iso.org/members.html> and <https://www.iec.ch/national-committees>.

Introduction

This document defines GQL, a database language for modeling structured data as a graph, and for storing, querying, and modifying that data in a graph database or other graph store. There are two major graph data models in current use: the Resource Description Framework (RDF) model and the Property Graph model. The RDF model has been standardized by W3C in a number of specifications. GQL addresses the Property Graph model.

Property graphs organize data as entities called nodes (or, alternatively, vertices) and edges (or, alternatively, relationships). Each graph element (a node or an edge) can have associated labels and properties. The flexibility and intuitiveness of the data model and its emphasis on interconnections between graph elements make property graphs suitable for storing complex knowledge and for analytical tasks such as entity resolution, fraud detection, cyber security, and forecasting.

GQL is declarative and transactional, taking inspiration from SQL and from leading independently-developed property graph languages. Property graphs select data primarily through path pattern matching. Defining path pattern searches in a graph is often simpler or more flexible than defining the equivalent joins in SQL. The flexible data model, the availability of path pattern matching, and the efficiency of traversing edges compared to joining tables have led to increasing interest in property graph databases.

Various graph data models have been around for many decades, but it is only since the early 21st century that the demand has driven the rise of commercial graph database and graph analytical systems for property graphs.

GQL provides a standard yet flexible common language for this growing market. GQL supports the same graph pattern matching syntax as SQL Property Graph Queries, ISO/IEC 9075-16, Information technology — Database languages SQL— Part 16: Property Graph Queries (SQL/PGQ). While SQL/PGQ provides the property graph data model and graph pattern matching on top of a relational SQL database, GQL is intended for pure property graphs that provide graph data management independent from SQL.

This is a preview of DS/ISO/IEC 39075:2024. [Click here to purchase the full version from the ANSI store.](#)

Information technology — Database languages — GQL

1 Scope

This document defines data structures and basic operations on property graphs. It provides capabilities for creating, accessing, querying, maintaining, and controlling property graphs and the data they comprise.

This document specifies the syntax and semantics of a data management language for specifying and modifying the structure of property graphs and collections thereof. This document provides a vehicle for portability of data definitions and manipulation among GQL-implementations.

Implementations of this document can exist in environments that also support application programming languages, end-user query facilities, and various tools for database design, data administration, and performance optimization.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601-1:2019, *Date and time — Representations for information interchange — Part 1: Basic rules*

ISO 8601-2:2019, *Date and time — Representations for information interchange — Part 2: Extensions*

ISO/IEC 9075-2:2023, *Information technology — Database languages — SQL — Part 2: Foundation (SQL/Foundation)*

ISO/IEC 14651:2020, *Information technology — International string ordering and comparison — Method for comparing character strings and description of the common template tailorable ordering*

IEEE Std 754:2019, *IEEE Standard for Floating-Point Arithmetic*

Internet Engineering Task Force (IETF) RFC 3986, *Uniform Resource Identifier (URI): Generic Syntax*. Edited by: Berners-Lee, T., Fielding, R., Masinter, L. January 2005
Available at: <https://www.ietf.org/rfc/rfc3986.txt>

Kuhn, Markus. *Coordinated Universal Time with Smoothed Leap Seconds (UTC-SLS)* [online]. University of Cambridge: IETF, January 2006. Available at <https://tools.ietf.org/html/draft-kuhn-leapsecond-00>

The Unicode Consortium. *The Unicode Standard (Information about the latest version of the Unicode standard can be found by using the “Latest Version” link on the “Enumerated Versions of The Unicode Standard” page.)* [online]. Mountain View, California, USA: The Unicode Consortium, Available at <https://www.unicode.org/versions/enumeratedversions.html>

The Unicode Consortium. *Unicode Collation Algorithm* [online]. Mountain View, California, USA: The Unicode Consortium, Available at <https://www.unicode.org/reports/tr10/>

The Unicode Consortium. *Unicode Normalization Forms* [online]. Mountain View, California, USA: The Unicode Consortium, Available at <https://www.unicode.org/reports/tr15/>

The Unicode Consortium. *Unicode Identifier and Pattern Syntax* [online]. Mountain View, California, USA: The Unicode Consortium, Available at <https://www.unicode.org/reports/tr31/>

van Kesteren, A. *URL Living Standard* [online]. [Place of publication unknown]: WHATWG, Available at <https://url.spec.whatwg.org>