

# ISO/IEC 10967-3:2006-05 (E)

## Information technology - Language independent arithmetic - Part 3: Complex integer and floating point arithmetic and complex elementary numerical functions

---

<b>Contents</b>		<b>Page</b>
Foreword	vii	
Introduction	viii	
1 Scope	1	
1.1 Inclusions	1	1
1.2 Exclusions	2	2
2 Conformity	3	
3 Normative references	4	
4 Symbols and definitions	4	
4.1 Symbols	4	4
4.1.1 Sets and intervals	4	4
4.1.2 Operators and relations	4	4
4.1.3 Mathematical functions	5	5
4.1.4 Exceptional values	6	6
4.1.5 Datatypes and special values	6	6
4.1.6 Complex value constructors and complex datatype constructors	8	8
4.2 Definitions of terms	9	9
5 Specifications for imaginary and complex datatypes and operations	14	
5.1 Imaginary and complex integer datatypes and operations	14	14
5.1.1 The complex integer result helper function	15	15
5.1.2 Imaginary and complex integer operations	15	15
5.1.2.1 Complex integer comparisons	15	15
5.1.2.2 Multiplication by the imaginary unit	17	17
5.1.2.3 The real and imaginary parts of a complex value	17	17
5.1.2.4 Formation of a complex integer from two real valued integers	18	18
5.1.2.5 Basic complex integer arithmetic	18	18
5.1.2.6 Absolute value and signum of integers and imaginary integers	21	21
5.1.2.7 Divisibility interrogation	21	21
5.1.2.8 Integer division and remainder extended to imaginary and complex integers	22	22
5.1.2.9 Maximum and minimum	27	27
5.2 Imaginary and complex floating point datatypes and operations	28	28
5.2.1 Maximum error requirements	28	28
5.2.2 Sign requirements	29	29
5.2.3 Monotonicity requirements	30	30
5.2.4 The complex floating point result helper functions	30	30
5.2.5 Basic arithmetic for complex floating point	31	31
5.2.5.1 Complex floating point comparisons	31	31
5.2.5.2 Multiplication by the imaginary unit	33	33
5.2.5.3 The real and imaginary parts of a complex value	34	34
5.2.5.4 Formation of a complex floating point from two floating point values	34	34
5.2.5.5 Fundamental complex floating point arithmetic	34	34
5.2.5.6 Absolute value, phase and signum of complex floating point values	38	38
5.2.5.7 Floor, round, and ceiling	39	39
5.2.5.8 Maximum and minimum	39	39
5.2.6 Complex sign, multiplication, and division	40	40
5.2.6.1 Complex signum	41	41
5.2.6.2 Complex multiplication	41	41
5.2.6.3 Complex division	42	42
5.2.7 Operations for conversion from polar to Cartesian	43	43
5.3 Elementary transcendental imaginary and complex floating point operations	44	44
5.3.1 Operations for exponentiations and logarithms	44	44
5.3.1.1 Exponentiation of imaginary base to integer power	44	44
5.3.1.2 Natural exponentiation	45	45
5.3.1.3 Complex exponentiation of argument base	45	45

5.3.1.4	Complex square root .....	46
5.3.1.5	Natural logarithm .....	47
5.3.2	Operations for radian trigonometric elementary functions .....	49
5.3.2.1	Radian angle normalisation .....	49
5.3.2.2	Radian sine .....	49
5.3.2.3	Radian cosine .....	50
5.3.2.4	Radian tangent .....	50
5.3.2.5	Radian cotangent .....	51
5.3.2.6	Radian secant .....	52
5.3.2.7	Radian cosecant .....	52
5.3.2.8	Radian arc sine .....	53
5.3.2.9	Radian arc cosine .....	54
5.3.2.10	Radian arc tangent .....	56
5.3.2.11	Radian arc cotangent .....	57
5.3.2.12	Radian arc secant .....	58
5.3.2.13	Radian arc cosecant .....	59
5.3.3	Operations for hyperbolic elementary functions .....	60
5.3.3.1	Hyperbolic normalisation .....	61
5.3.3.2	Hyperbolic sine .....	61
5.3.3.3	Hyperbolic cosine .....	61
5.3.3.4	Hyperbolic tangent .....	61
5.3.3.5	Hyperbolic cotangent .....	62
5.3.3.6	Hyperbolic secant .....	62
5.3.3.7	Hyperbolic cosecant .....	62
5.3.3.8	Inverse hyperbolic sine .....	62
5.3.3.9	Inverse hyperbolic cosine .....	63
5.3.3.10	Inverse hyperbolic tangent .....	63
5.3.3.11	Inverse hyperbolic cotangent .....	64
5.3.3.12	Inverse hyperbolic secant .....	64
5.3.3.13	Inverse hyperbolic cosecant .....	65
5.4	Operations for conversion between imaginary and complex numeric datatypes .....	65
5.4.1	Integer to complex integer conversions .....	65
5.4.2	Floating point to complex floating point conversions .....	66
5.5	Support for imaginary and complex numerals .....	67
6	Notification 68 6.1 Continuation values .....	68
7	Relationship with language standards 68 8 Documentation requirements 69 Annex A (normative) Partial conformity 71 A.1 Maximum error relaxation .....	71
A.2	Extra accuracy requirements relaxation .....	71
A.3	Relationships to other operations relaxation .....	72
A.4	Part 1 and part 2 requirements relaxation .....	72
Annex B (informative) Rationale 73 B.1 Scope .....		73
B.1.1	Inclusions .....	73
B.1.2	Exclusions .....	73
B.2	Conformity .....	73
B.3	Normative references .....	74
B.4	Symbols and definitions .....	74
B.4.1	Symbols .....	74
B.4.1.1	Sets and intervals .....	74
B.4.1.2	Operators and relations .....	74
B.4.1.3	Mathematical functions .....	74
B.4.1.4	Exceptional values .....	75
B.4.1.5	Datatypes and special values .....	75
B.4.1.6	Complex value constructors and complex datatype constructors . 75 B.4.2 Definitions of terms .....	75
B.5	Specifications for the imaginary and complex datatypes and operations .....	76
B.5.1	Imaginary and complex integer datatypes and operations .....	76
B.5.2	Imaginary and complex floating point datatypes and operations .....	76

B.5.2.1	Maximum error requirements .....	76
B.5.2.2	Sign requirements .....	76
B.5.2.3	Maximum error requirements .....	76
B.5.2.4	Basic arithmetic for complex floating point .....	77
B.5.3	Elementary transcendental imaginary and complex floating point operations 78 B.5.3.1	
	Operations for exponentiations and logarithms .....	78
B.5.3.2	Operations for radian trigonometric elementary functions .....	78
B.5.3.2.1	Radian angle normalisation .....	78
B.5.3.2.2	Radian sine .....	79
B.5.3.2.3	Radian cosine .....	79
B.5.3.2.4	Radian tangent .....	79
B.5.3.2.5	Radian cotangent .....	80
B.5.3.2.6	Radian secant .....	80
B.5.3.2.7	Radian cosecant .....	80
B.5.3.2.8	Radian arc sine .....	80
B.5.3.2.9	Radian arc cosine .....	81
B.5.3.2.10	Radian arc tangent .....	81
B.5.3.2.11	Radian arc cotangent .....	81
B.5.3.2.12	Radian arc secant .....	81
B.5.3.2.13	Radian arc cosecant .....	81
B.5.3.3	Operations for hyperbolic elementary functions .....	82
B.5.3.3.1	Hyperbolic normalisation .....	82
B.5.3.3.2	Hyperbolic sine .....	82
B.5.3.3.3	Hyperbolic cosine .....	82
B.5.3.3.4	Hyperbolic tangent .....	82
B.5.3.3.5	Hyperbolic cotangent .....	83
B.5.3.3.6	Hyperbolic secant .....	83
B.5.3.3.7	Hyperbolic cosecant .....	83
B.5.3.3.8	Inverse hyperbolic sine .....	83
B.5.3.3.9	Inverse hyperbolic cosine .....	83
B.5.3.3.10	Inverse hyperbolic tangent .....	84
B.5.3.3.11	Inverse hyperbolic cotangent .....	84
B.5.3.3.12	Inverse hyperbolic secant .....	84
B.5.3.3.13	Inverse hyperbolic cosecant .....	84
B.5.4	Operations for conversion between imaginary and complex numeric datatypes 84 B.5.5	
	Support for imaginary and complex numerals .....	84
B.6	Notification .....	84
B.6.1	Continuation values .....	84
B.7	Relationship with language standards .....	84
B.8	Documentation requirements .....	84
Annex C (informative) Example bindings for specific languages 85 C.1 Ada .....		86
C.2	C .....	96
C.3	C++ .....	105
C.4	Fortran .....	113
C.5	Common Lisp .....	122