

# A Bibliography of Publications on Floating-Point Arithmetic

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## Introduction

This is a bibliography of material on floating-point arithmetic that I came up with while doing research on a floating-point package of my own. I don't claim it to be anywhere near complete. The material listed is only what I myself possess.

My main interest was in software based, binary floating-point arithmetic on a microprocessor, so you won't find much material about the hardware used in floating-point arithmetic (e.g. adders, carry propagation schemes, higher radix representation for multiplication and division, etc.) in this list. There is also not too much on non-binary floating-point arithmetic.

For most fields covered in this bibliography, the important or historically relevant articles should be included. There is also some material on integer arithmetic in this list as some of the methods used with integer arithmetic contain interesting ideas that may be useful in the realization of a floating-point arithmetic package.

Also, depending on the type of microprocessor used, one may need to implement integer multiplication and division for use in the floating-point package, so articles about this topic are included as well.

As I am German, there is a bit of material in German in this bibliography. However, English translations are provided for all non-English titles.

Thanks to the people who have helped me with previous versions of this document by sending me papers or additional references:

- Steven Sommars ([sesv@research.bell-labs.com](mailto:sesv@research.bell-labs.com)),
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- Nelson H. F. Beebe ([beebe@math.utah.edu](mailto:beebe@math.utah.edu)).

Bibliography entries in the **Books** section are ordered alphabetically by author; ordering is by ascending year in the remaining sections.

**Warning:** it has yet not been possible to bring this citation list up-to-date with the entries in the BIBTE

## Books, hardware oriented

[1722, 282, 1287, 1217, 3119, 3325, 1917, 842, 1165, 1001, 1458, 844, 1344, 7355, 7356, 1558]

## Books, software oriented or theory

[1274, 467, 470, 471, 119, 1421, 2399, 909, 1050, 353, 2960, 2440, 2977, 2276, 321, 528, 7209]

## Books, machine specific

[2179, 3225, 3121, 2442, 1768, 1904, 2295, 1936, 2477]

**Journal Publications, Conference Papers, Technical Reports, Ph.D. Dissertations, Book Contributions, etc.**

## **1 Choice of base, floating point formats**

[499, 751, 753, 731, 728, 894, 1142, 1132, 2037, 2273, 2397, 2550, 2778, 2792]

### **1.1 Precision and Rounding**

[434, 559, 746, 848, 882, 897, 965, 1033, 1042, 1046, 1195, 1297, 1436, 1377, 1539, 1730, 2286, 2462, 2535, 2849, 3166, 3290]

### **1.2 Determination of parameters of floating point arithmetic**

[687, 824, 1637, 2279, 2205]

### **1.3 IEEE standards for floating point arithmetic**

[994, 1198, 1224, 1207, 1235, 1197, 1204, 1341, 1327, 1328, 1281, 1301, 1459, 1386, 1410, 1388, 1726, 1825, 1863, 1864, 1861, 2089, 2176, 2345, 2579, 3061]

### **1.4 Floating point arithmetic, general and implementation issues**

[634, 720, 1015, 1036, 1084, 1096, 1095, 1237, 1239, 1211, 1275, 1267, 1476, 1494, 1993, 2013, 2221, 2222, 2378, 2452, 2355, 2534, 2779, 2780, 2708, 2777, 3019]

### **1.5 Floating point packages**

[1288, 1701, 1680, 1774, 1732, 1885, 1850, 1886, 1968, 2082, 2105, 2208, 2304, 2305, 2306, 2485, 2486, 1353]

### **1.6 Floating point units**

[417, 1154, 1321, 1279, 1331, 1355, 1324, 1350, 1271, 1316, 1325, 1499, 1541, 1498, 1534, 1557, 1663, 1577, 1579, 1580, 1681, 1611, 1608, 1616, 1643, 1717, 1619, 1790, 1777, 1717, 1758, 1787, 1719, 1798, 2009, 1971, 1999, 1965, 2018, 1957, 1950, 1951, 2132, 2084, 2157, 2251, 2280, 2313, 2256, 2282, 2257, 2188, 2217, 2326, 2268, 2218, 2293, 2467, 2413, 2414, 2438, 2328, 2449, 2411, 2408, 2320, 2430, 2469, 2369, 2329, 2450, 2334, 2570, 2505, 2525, 2565, 2520, 2497, 2568, 2551, 2542, 2666, 2775, 2738, 2965, 2878, 2948, 3105, 3055, 3196, 3357]

### 1.7 Test of floating point routines

[501, 1455, 1727, 1871, 1870, 2021, 2022, 1966, 2109, 2475, 2603, 2611, 2680, 2679, 2795, 2774, 2760, 3060]

## 2 Addition and Subtraction

[376, 1514]

### 2.1 Floating-point Summation

[326, 346, 363, 362, 571, 640, 678, 832, 1662, 2281, 2358]

### 2.2 Multiplication

[681, 1247, 1261, 1477, 1544, 1517, 1575, 1602, 1594, 1620, 1677, 1592, 1759]

### 2.3 Division

[209, 238, 223, 323, 349, 439, 1018, 1065, 1312, 1404, 1568, 1646, 1624, 1607, 1771, 1891, 2016, 1995, 2393, 2784, 2729, 2975, 3024, 7377, 2957]

## 3 Elementary functions, general

[385, 399, 587, 651, 616, 1123, 1266, 1628, 1657, 1757, 1720, 1718, 1795, 1841, 7296, 1946, 2053, 2158, 2101, 2283, 7315, 2566, 2603, 2553, 3344, 2555, 2524, 2704, 2857, 2668, 2819, 2820, 2697, 3377, 3345]

### 3.1 Elementary functions, CORDIC and related algorithms

[190, 191, 248, 264, 374, 524, 552, 660, 652, 668, 734, 856, 1069, 1085, 1294, 1452, 1700, 1898, 1709, 1812, 1964, 2163, 2387, 2316, 2547, 2573, 2723, 2817, 3018, 3013, 3136, 3076, 3122]

### 3.2 Elementary functions, function approximation

[240, 241, 482, 624, 769, 768, 984, 1022, 1163, 2001, 2054, 2616, 2692, 2790, 2791]

#### 3.2.1 Polynomial evaluation

[259, 280, 305, 427, 1062, 1229, 2357]

### **3.3 Square root, general**

[1083, 1188, 1482, 1599, 1652, 2571, 2684]

#### **3.3.1 Square root, bit-oriented, iterative, and table methods of computation**

[120, 153, 360, 1023, 1009, 1152, 1354, 1445, 1407, 1373, 1427, 1538, 1826, 1923, 1835, 1888, 1972, 1953, 2036, 1956, 2007, 2048, 2091, 2143, 2183, 2259, 2396, 2583, 2540, 2716, 3046]

#### **3.3.2 Square root, Newton's method**

[158, 281, 303, 375, 348, 344, 384, 452, 428, 514, 519, 533, 597, 586, 580, 582, 703, 1329, 1318, 1398, 1584, 2339, 3026, 2955]

### **3.4 Sine and Cosine**

[180, 1069, 1019, 1024, 1177, 1399, 1545, 1667, 1666, 1766, 1854, 1954, 2124, 2235, 2612, 2969, 2966, 2888, 2988, 3082]

### **3.5 Logarithm**

[154, 271, 332, 691, 999, 1113, 1300, 1530, 2110, 2111, 2613, 2742]

### **3.6 Exponential function**

[141, 410, 1184, 1362, 1519, 1749, 1848, 2476, 2614, 3010]

### **3.7 Arctangent**

[143, 160, 207]

### **3.8 Other transcendental functions**

[500, 614, 161, 1025, 366, 276, 361, 2103, 1158, 2867, 3062]

## **4 Binary-decimal conversion**

[189, 173, 222, 476, 577, 685, 1166, 1292, 1293, 1406, 1655, 1710, 2003, 1976, 2515, 2607, 2531, 2863]

## 5 BCD arithmetic

[675, 727, 778, 779, 780, 781, 782, 783, 784, 1383, 1493, 1706, 1641, 2039, 2652, 2968]

## 6 Multiple precision arithmetic

[293, 331, 411, 429, 633, 617, 954, 1003, 1100, 1099, 1266, 1351, 1431, 1543, 2812, 2796, 3041, 3232]

## 7 Conferences on computer arithmetic

[7235, 7245, 7250, 7259, 7262, 7275, 7293, 7294, 7336, 7366, 7374, 7368, 7400]

## 8 Additional contributions from Nelson H. F. Beebe

[121, 136, 169, 215, 298, 347, 368, 450, 753, 556, 849, 878, 922, 923, 975, 989, 1003, 1008, 1071, 1073, 1100, 1099, 1193, 1164, 1222, 1246, 1265, 1272, 1289, 1389, 1426, 1431, 1460, 1461, 7275, 1715, 1725, 1728, 1742, 1748, 1856, 1862, 1896, 1924, 1980, 2023, 2034, 2063, 2106, 2120, 2128, 2173, 2281, 2282, 2335, 2492, 7348, 2537, 2541, 2554, 2561, 2570, 2611, 2623, 7374, 2747, 2748, 2772, 2776, 2793, 2812, 2865, 2866, 2980, 3060, 3277, 208, 215, 216, 252, 283, 295, 307, 308, 312, 343, 363, 422, 441, 474, 493, 527, 571, 593, 617, 640, 711, 795, 828, 830, 846, 865],[898, 900, 905, 927, 948, 974, 976, 983, 985, 1017, 1064, 1072, 1253, 1284, 1358, 1431, 1438, 1462, 1465, 1560, 1565, 1625, 1639, 1648, 1649, 1704, 1745, 1785, 1789, 1808, 1809, 1814, 1816, 1833, 1844, 1845, 1937, 1969, 2014, 2025, 2100, 2145, 2174, 2190, 2255, 2270, 2285, 2307, 2366, 2377, 2381, 2463, 2487, 2493, 2538, 2585, 2599, 2662, 2673, 2709, 2753, 2804, 2868, 2936, 2942, 2976, 3002, 3010, 3045, 3098, 3106, 3184, 3198, 3201, 3245, 3288, 3335, 7206, 7243, 7251, 7260, 7261, 7286, 7298, 7295, 7341]

## Title word cross-reference

#26 [5508].

$((2^n)^m)$  [3811].  $(10^{31} - 1)/9$  [1977].  $(2^m)$  [4366, 4387, 4571, 4580, 4485].  $(2^n + 1)$  [1082, 4804, 3924].  $(2^n - 1)$  [5023].  $(2^n - 1, 2^{n+p}, 2^n + 1)$  [6311].  $(2^n 2^q 1)$  [6112].  $(2^n \pm 1)$  [5535, 4152].  $(2m)$  [4450].  $(2n + 3)$  [6573].  $(2n - (2p \pm 1))$  [4866].  $(a \cdot x) \cdot x?$  [6853].  $(d, r)$  [790].  $(M, p, k)$  [5829].  $(\mathcal{R})$  [2916].  $(p)$  [4366, 4450].

$(x + y) * (x - y)$  [6721].  $-2$  [744, 183, 206, 950, 802].  $-\infty < n < +\infty$  [141, 160].  $0$  [5656].  $0 < N < 1$  [161].  $0 \div 0$  [700]. **\$1** [3753].  $1$  [5003, 4359, 5168, 5657, 3707, 2169].  $1,000,000$  [619].  $1/\sqrt{x}$  [5800].  $1/t$  [2178].  $10$  [531, 6042].  $116$  [4034].  $128$  [4872].  $15$  [531].  $16$  [2510, 4200, 4087].  $17 \times 69$  [3055].  $2$  [1006, 4317, 2051, 5694, 3237, 4006, 619, 6076, 431, 4359, 5024, 3293, 3471, 1761, 3481, 3148, 3488, 5630, 3503, 531, 322, 3694, 3830, 4466, 3707, 5112, 3371, 4956].  $2,576,980,370,000$  [5658].  $22n + 1$  [2150].  $256$  [4453].  $27$  [434].  $\{2^{(2n+1)} + 1, 2^{(2n+1)}, 2^{(2n+1)} - 1\}$  [6363].  $2^{(n+1)} + 1$  [3983].  $2^{2n+1} - 1$  [6057].  $2^{2n+2} - 1$  [6057].  $2^{2q}$  [6047].  $2^8 - 1$  [2863].  $2^k$  [4498, 5011, 5515, 5052, 5060].  $2^k + 1$  [867].  $2^{k-1}$  [4498].  $2^m$  [4572].  $2^n$  [1569, 6057, 3983].  $2^n + 1$  [3983, 5003, 5740, 4476].  $2^{n+1} - 1$  [6563].  $2^{n+k}$  [6563].  $2^n - (2^{n-2} + 1)$  [5355].  $2^N - 1$  [2995, 4839, 6563, 4229, 3983].  $2^q - 3$  [7072].  $2^q \pm 1$  [6047].  $2^q \pm 3$  [6047].  $2^x p^y \pm 1$  [6278].  $2 \times 2$  [5940].  $3$  [378, 5005, 4194, 431, 4049, 4218, 4054, 5044, 4889, 322, 6247, 4133, 6647, 4953, 4954].  $3 - j$  [299].  $32$  [3999, 4453].  $3 \times 3$  [2499].  $4$  [3983, 4331, 4675, 2527, 2528, 431, 3438, 5745, 5541, 4398, 4731, 2958, 4087, 4089, 2818, 3009, 1933, 3536, 3541]. **\$49.95** [3720].  $5$  [6047, 4816].  $54 \times 54$  [3495].  $6 - j$  [299].  $64 \times 64$  [2284].  $8$  [434, 3451, 4087, 3503].  $84$  [308]. **\$85.00** [4157, 4158].  $88062$  [531].  $8k$  [6892].  $8 \times 8$  [5112].  $9 - j$  [299].  $<$  [6255].  $>$  [6255].  $[0, 1]$  [5168].  $0$  [4372].  $2$  [5758].  $4$  [2803].  $5$  [3911].  $e$  [1160].  $\text{th}$  [1160].  $T^M$  [4642].  $A(N + C)$  [1911].  $a + b$  [3650].  $a + b + c$  [6339].  $AB + CAB + C$  [7006].  $ab + cd$  [6127].  $ab + cd + e$  [7167].  $a \cdot (x \cdot x)$  [6853].  $A \cdot T$  [4080].  $\arctan Z$  [143].  $a \times b + c \times d$  [6339].  $\beta$  [6371, 7117].  $C + AB^2$  [4296].  $c/\sqrt{(a^2 + b^2)}$  [6320].  $\text{CLP}(R)$  [2936].  $\cos^{-1}$  [3136].  $\cos N$  [180].  $\cos x$  [374].  $\cot^{-1} x$  [374].  $d$  [4709, 5518, 3817].  $\Delta_2^0$  [4957].  $e$  [460].  $e^n$  [141].  $e^x$  [410].  $\epsilon$  [3484].  $\eta_T$  [5686].  $\eta T$  [5260].  $\exp(x)$  [1362].  $\exp x$  [374].  $f(x) = 0$  [1223].  $G_\alpha$  [810].  $\text{GF}(2)[x]$  [5886].  $\text{GF}(2^m)$  [4420, 4788, 4403, 6077, 4990, 5446, 4921, 5890].  $\text{GF}(2n)$  [4215].  $\text{GF}(p^m)$  [4667].  $H$  [5185].  $I^2 L$  [3246].  $\infty/\infty$  [5031].  $K$  [5454, 4317, 5942, 2110, 6029, 6371, 5985].  $k < m$  [6371].  $L$  [4359].  $L^2$  [5268].  $L^\infty$  [5267, 7036].  $l_2$  [6087].  $\ln(x)$  [1530].  $\ln x$  [374].  $\log n$  [1229].  $\log Z$  [143].  $LU$  [6841, 6595].  $M$  [4853, 180, 4147, 2632, 2637, 2646, 2926, 5349, 582, 6371].  $M^E \bmod N$  [2783].  $\mathbf{F}_2[X]$  [7116].  $\mathbf{f}_{2^m}$  [4245].  $\mathbf{F}_{5^{5n}}$  [5704].  $\mathbf{F}_{7^{7n}}$  [5704].  $\mathbf{R}^n$  [6958].  $\mathbf{Z}^2$  [4075, 5051].  $\text{GF}(2)$  [5323, 1693].  $\text{GF}(2^4)^2$  [6192].  $\text{GF}(2^{4n})$  [3935].  $\text{GF}(2^8)$  [6192].  $\text{GF}(2^k)$  [4978, 3782, 4936].  $\text{GF}(2^m)$  [5498, 4688, 4996, 3887, 4542, 5157, 3593, 4548, 3898, 5527, 2904, 2905, 3766, 4876, 5323, 5186, 4730, 4401, 5048, 2434, 5447, 4620, 4761, 4922, 5451, 3206, 4296, 4951, 4787, 2314].  $\text{GF}(2^n)$  [5010].  $\text{GF}(p)$  [2083].  $\text{GF}(p^m)$  [3499].  $\text{GF}(p_k)$  [4663].  $\text{GF}(q^n)$  [4711].  $\text{MECIPTI}$  [283].  $\mu$  [1427, 4882, 4924, 2315].  $\mu P$  [1611, 2009].  $N$  [3978, 809, 2339, 2340, 160, 161, 180, 4591, 5084, 4942, 5985, 5706, 4175, 6087, 1295, 3634].  $n^{\text{ième}}$  [1160].  $N'_0 = -N_0^{-1} \bmod W$  [4273].  $N \geq 32$  [5875].  $n \log(n)$  [6511].  $n \times n$  [3147].  $O(1)$  [6409].  $O(n)$  [1196, 3441, 1548].  $O(n^2)$  [2784, 2785].  $O(n \log n)$  [6560, 6712].  $\Omega$  [4938].  $\text{Arccos } x$  [207].  $\text{Arcsin } x$  [207].  $\text{Arctan } x$  [207].  $\text{mod } p$  [1916].  $P$  [6551, 4652, 2061, 1131, 895, 1045, 1636, 7117, 4289, 4638, 3359].  $p^k$  [6729].  $\pi$  [1631, 2239, 2240, 4617, 268, 5658, 1694, 460].  $p \times p$  [4596, 4740].  $q$  [5802].  $q * m - n$  [1629].  $QR$  [6152].  $R$  [3614, 3069, 1606, 1614, 6452, 5875].

$r = m^k$  [1439].  $r^a$  [4961].  $r^b - 1$  [4961].  $r^c + 1$  [4961].  $\{r^n - 2, r^n - 1, r^n\}$  [5314].  $r \geq 8$  [5875].  $s$  [4893].  $\sin(\mathbf{BIG})$  [5249].  $\sin^{-1}$  [3136].  $\sin N$  [180].  $\sin x$  [374].  $\sqrt{(a^2 + b^2)}$  [6320].  $\sqrt{x}$  [1482].  $\sqrt{(x/d)}$  [3859].  $\sqrt{2}$  [7040].  $\sqrt{x}$  [1308, 452].  $\sqrt{x^2 + y^2}$  [5694].  $T$  [6611].  $\tan^{-1} x$  [374].  $\theta(\log N)$  [2360].  $\times$  [4080, 3929, 4146].  $w$  [4748].  $X$  [1543, 2901].  $x^2 + ny^2$  [3720].  $x^n$  [6009, 3317].  $x \star (1/x) \neq 1$  [3254].  $y$  [4429].  $Z$  [5346].

**-2** [1005]. **-adic** [1131, 1045, 1636, 2061, 895]. **-Approximations** [7036, 5267, 5268]. **-ary** [2926, 4147]. **-b** [3495]. **-Bit** [3999, 6892, 308, 5985, 5084]. **-body** [4591, 4942]. **-circulant** [6452]. **-Coordinate** [4429]. **-count** [6611]. **-CSRmesh** [6497]. **-D** [5694, 4194, 4218, 3293, 6247, 4133, 5112, 3371, 2169]. **-Depth** [3441]. **-Digit** [434]. **-Dimensional** [5518, 2051, 4709]. **-Fold** [5454]. **-Friendly** [5829]. **-function** [5185]. **-gram** [5706]. **-Matrix** [4853]. **-Moduli** [6047, 3983, 4675, 4816]. **-Norms** [6087]. **-Order** [3614]. **-Partition** [6029]. **-Real** [4957]. **-select** [4175]. **-sets** [3069]. **-spaces** [4893]. **-th** [5942, 3817, 5802, 2340]. **-transform** [5346]. **-Vectors** [6087].

**.NET** [6462, 5087].

**/m** [4882]. **/spl** [4882].

**0.18-CMOS** [5796]. **0.4.1rc** [6463]. **0.80pJ** [6599]. **0.80pJ/flop** [6599]. **'00** [7476, 7481, 2546]. **'01** [7490]. **'03** [7519]. **'04** [7528, 7536]. **'07** [7571, 7577, 7579, 7584]. **'08** [7588, 3040, 5394].

**1** [217, 3559, 6685, 3422, 2884, 228, 63, 65, 67, 564, 3285, 6719, 4080, 4423, 1164, 5796, 7122, 1934, 3879]. **1-GHz** [6685, 4423, 5796]. **1-Output** [5360]. **1.0** [3880]. **1.24Tflop** [6599]. **1.24Tflop/sW** [6599]. **1.5** [5674]. **10** [5758]. **10-kA** [5758]. **10-kA/cm** [5758]. **10/20** [959]. **100** [2897, 2898]. **100-MFLOPS** [2897, 2898]. **1014** [6796]. **1057** [1982]. **10858** [1747]. **10967** [4377, 5174]. **10967-1** [3285]. **10967-2** [4377]. **10967-3** [5174]. **10th** [7286, 7620, 7368, 7497, 7510, 27, 7267, 2770]. **'11** [7615, 1111, 1392, 1508, 1409, 1313]. **11-bit** [4924]. **11/780** [2037, 1570, 1571, 1804, 1020]. **116** [270]. **1164/WTL** [2034]. **11i** [4939]. **11th** [7488, 7381, 7399, 7400, 3191]. **120B** [1121]. **128-bit** [6361, 4131]. **12th** [7531, 7597, 7242, 7423, 3466, 7583]. **13** [4336, 2092]. **132-Bit** [343]. **13th** [7516, 7258, 7442, 7412, 7570, 3858, 3786, 7640]. **14-Port** [3929]. **144** [2038]. **14th** [7403, 7487, 7518, 7569, 7481, 7467]. **15** [2773]. **15-b** [4468]. **15-bit** [4136]. **15C** [1630]. **15th** [7306, 7577, 7242, 7585, 7489, 7535]. **16-19** [7206]. **16-b** [6500]. **16-Bit** [4547, 6727, 6744, 7132, 6892, 3031, 1261, 1602, 5008, 3084, 1760, 6360, 5980, 1477]. **16-bit-** [1611]. **16-bit-Multiplikation** [1477]. **16-by-8-bit** [1646]. **16-Digit** [5380]. **160-ns** [2842]. **160-Word** [3929]. **1620** [255]. **164** [1816]. **167** [3503, 3541]. **16BST** [1818, 1734, 1735, 1737, 1741, 1751, 1764, 1773, 1690]. **16F/400** [918]. **16th**



[7560, 7551, 4664, 7515, 7557]. **17** [288, 839]. **17-Bit** [649, 648]. **1788** [6587]. **1788-2015** [6101]. **17th** [7622, 7562, 7478, 7552, 7555]. **'18** [7633, 563]. **18-21** [7568]. **18.Mai** [1485]. **18th** [7587, 7576, 7582, 5488]. **18th-Century** [5488]. **1945** [61]. **1947** [7198]. **196** [5702, 5713]. **1962** [7206]. **1965** [7210, 7212]. **1967** [7217, 7219]. **1968** [7222]. **1969** [7220, 7221, 588]. **1971** [7232]. **1972** [7230, 4061]. **1973** [4138, 4139]. **1975** [7239]. **1976** [7240, 7242]. **1977** [7243, 7268, 1653]. **1979** [7248, 7251]. **1980** [7252, 7258, 1526, 7263, 7260]. **1981** [7265, 7270]. **1983** [7286]. **1984** [7295]. **1985** [7312]. **1987** [2089]. **1988** [7315, 7326]. **1989** [7339, 2585]. **1989-01** [2391]. **1989/Taipei** [7339]. **1991** [2641, 7361, 2770]. **1992** [2862, 7424]. **1993** [7392, 7435, 3191]. **1994** [7413]. **1994-12** [3285]. **1995** [7414, 7426, 3466]. **1998** [7452, 7454, 3906]. **1998-12** [3905]. **1999** [7464, 7465, 7470, 7472]. **19th** [7595, 7565]. **1st** [7449].

**2** [2180, 6512, 2523, 1735, 64, 66, 68, 4377, 4050, 4589, 6471, 3932, 4907, 529, 2015, 7123, 3525, 4131, 4780, 2828, 3021]. **2-D** [3525]. **2-Digit** [4188]. **2-dimensional** [2996]. **2.0** [3630]. **2.44** [4049, 4218]. **20** [2672, 2405]. **20-MFLOPS** [2406, 2405]. **200-ns** [1486]. **'2000** [7475, 7474, 7475, 7481]. **2001** [7486, 7487, 7489, 4841, 7491, 7497, 7498]. **2002** [7500, 7501, 7503, 7504, 7505, 7512]. **2003** [7515, 7516, 7519, 7520]. **2004** [7527, 7528, 7530, 7536, 7537, 4899]. **2005** [7544, 7545, 7547, 7550, 7556]. **2006** [7559, 7560, 7563, 7567]. **2006Petrozavodsk** [7617]. **2007** [7571, 7573, 7574, 7576, 7579, 7581, 7591, 7586]. **2008** [7587, 7588, 5500, 7590, 6572, 5948, 5949, 6739, 5552, 5779, 5575]. **2009** [7593, 7597, 7600, 7601, 5533]. **2010** [7610, 7611, 7613]. **2011** [7616]. **2013** [7621]. **2015** [7624, 7625]. **2016** [7629]. **2017** [7630]. **2018** [6484]. **2019** [6538, 7635, 7636]. **2020** [6667, 6665, 6666, 6668, 6669, 6671, 6692, 7637, 6718]. **2020s** [6781]. **2021** [6781, 6782, 6783, 6784, 6792, 7641, 6838, 6857]. **2022** [6897, 6898, 6899, 7643, 6926, 6927]. **2023** [7645]. **20th** [7599, 7639, 7618, 7580]. **21-23** [7597]. **2100** [2564]. **21064** [3351]. **210uW** [6433]. **210uW/MHz** [6433]. **21164** [3396]. **21st** [7605, 7533, 7477, 7621, 7594]. **22** [338]. **22-nm** [6685]. **22nd** [7625]. **22nm** [6599]. **23-28** [7564]. **23nd** [7629]. **23rd** [7351, 7608, 7611]. **24** [1128]. **24-26** [7517]. **24-bit** [2370]. **24.und** [7268]. **24732** [5176]. **248GOPS** [6870]. **248GOPS/W** [6870]. **24b** [2467]. **24th** [7630, 7450, 7453, 7507, 7613, 7268]. **25-28** [7476]. **256** [6317]. **25th** [7347, 7463, 7268, 7578, 7634]. **26-28** [7528]. **26th** [7613, 7636]. **27th** [7637, 7610]. **281** [3063]. **286** [3649]. **28nm** [6870]. **28th** [7641, 7458]. **29.95** [3720]. **29th** [7466, 7643]. **2B** [646]. **2DFFT** [1884]. **2nd** [7609, 4593, 7231]. **2Sum** [6168, 6277].

**3** [3101, 5174, 6446, 2776, 6141]. **3-ps** [5796]. **30** [2038]. **30-bit** [2427]. **30-MFLOP** [2251]. **30-ns** [3481]. **300** [4218, 1230]. **300-MHz** [4218]. **300MHz** [4049]. **30th** [7645]. **312** [433]. **3171** [2505]. **31st** [7320]. **32** [5130, 2063]. **32-** [6967]. **32-Bit** [3728, 2318, 2187, 2331, 5492, 4819, 3422, 1404, 5020, 1624, 2741, 2412, 2413, 2414, 2415, 6847, 2563, 1997, 2437, 3319, 2575, 3195, 3965, 2490, 3210]. **320** [3104]. **320-MFLOPS** [3105, 3104]. **320C25** [3297]. **32b**

[2251]. **33** [2217]. **33rd** [7431, 7482, 7375]. **34** [513]. **34-MFLOP** [2490]. **360** [418, 419, 505, 384, 392, 393, 682, 440, 481, 1442, 6480, 538]. **3600** [303]. **36th** [7395]. **370** [1946, 2037, 2484]. **37th** [7581]. **390** [4091, 3825, 3826, 4117, 4118]. **39th** [7571, 7588]. **3CT** [3391]. **3DNow** [3932, 4050]. **3DTV** [5785]. **3m** [6386]. **3rd** [7447, 7235, 7553]. **3X** [5452].

**4** [3401, 4805]. **4-2** [1168]. **4-bit** [6760]. **4-Input** [5360]. **4-Input/1-Output** [5360]. **4.4ns** [3495]. **40** [2414]. **40-MFLOPS** [2412, 2414]. **40-ns** [649]. **400** [918]. **4000** [498]. **400MHz** [3929]. **400th** [7424]. **4096-Core** [6885, 6768]. **40ns** [648]. **41** [444]. **432** [1857]. **44th** [7567]. **45th** [3773]. **48th** [7550]. **4d** [4686]. **4m** [6386]. **4th** [7245, 7476, 7370, 7498, 7644].

**5** [3551, 4160, 6987]. **50** [2329]. **50-Megacycle** [149]. **50-MHz** [2329]. **501** [3790, 3640]. **50th** [7407]. **512** [6395, 7048]. **512-bit** [6912]. **528** [1119, 4032]. **53\*53** [3271]. **53nd** [7606]. **54** [339]. **54-b** [2842]. **55-b** [3481]. **5th** [7514, 7596, 7262, 7565, 7421].

**6.7-MFLOPS** [2448, 2450]. **60** [606, 579, 411]. **600** [3998]. **600-MHz** [3998]. **6000** [3391, 2541, 637, 2566, 2570, 1243, 3373, 718]. **6000/7000** [1037, 1243]. **600MHz** [4091]. **601** [3351]. **603e** [3623]. **60M** [2640]. **60M-flops** [2640]. **64** [4793, 4005, 4180, 4040, 4206, 4207, 6558, 4252, 4127]. **64-active-instruction** [3537]. **64-b** [3649, 2965, 3537]. **64-Bit** [2438, 3929, 7112, 2326, 2329, 5401, 5143, 5002, 3077, 3439, 5168, 2718, 3455, 2405, 2406, 2551, 2410, 2932, 6967, 2775, 2265, 3333, 4940, 2034]. **64-bit-Universal-Floating-Point-ISA-Compute-Engine** [6558]. **6400** [1695]. **64b** [2328]. **65** [625]. **65-nm** [7112]. **65/6600** [625]. **650** [2091]. **651** [2050]. **65nm** [6433]. **6600** [732, 555, 625, 592, 1346]. **6600/7600** [732]. **665** [2205]. **68000** [1885]. **68000-Einplatinenrechner** [2082]. **693** [2812]. **6th** [7561, 4849, 7526, 7275, 7465, 7580, 7443, 7556, 7530].

**7-9** [7599]. **70** [5698]. **7000** [1243]. **7094** [398, 473]. **7094-II** [473]. **70th** [5610]. **714** [3060]. **715** [3062, 3677]. **719** [3041]. **722** [3061]. **7289** [7040]. **73** [1030]. **754** [3852, 5584, 2864, 4319, 3404, 6063, 3989, 4525, 5500, 6538, 6925, 3880, 4341, 6815, 4838, 6821, 6822, 1410, 6569, 6835, 6200, 1862, 6572, 2095, 3461, 3626, 5610, 5956, 5337, 4247, 5059, 5195, 6963, 6608, 7105, 7106, 2277, 6484, 6368, 7117, 1680, 4767, 3950, 5651, 2017, 1459, 6761, 7182, 3360, 5570, 5575, 5807, 7140]. **754-1985** [1861, 1862]. **754-2008** [5437, 5500, 6572, 5575]. **754-2019** [6571, 6538]. **754-Posit** [6963]. **754r** [5428, 5133, 5146, 5278, 5501, 5179, 5232, 5178, 5191, 5380]. **7600** [732]. **77** [1191, 4032, 1332]. **780** [2037, 1570, 1571, 1804]. **786** [3954]. **'79** [7248, 7251]. **7th** [7252, 7254, 7559, 7293, 7323, 7564].

**8** [1296]. **8-Bit** [3819, 6882, 7019, 1968, 7070, 7094, 6973, 7111, 6495]. **8-to-64** [6599]. **80** [1484]. **80\*87** [3022]. **80-bit** [1929]. **80-FLOPS** [2965].

**8000** [3455]. **80287** [1904]. **8080/8085** [1584, 1134, 1220]. **8080A** [1488]. **8085A** [2392]. **8086/80286** [1936]. **8087** [1630, 1316, 1904]. **8087/80287** [1936, 1904]. **8087/80287/80387** [2295]. **8088/8087** [1734]. **80960** [2247]. **80960KB** [2248]. **80b** [2449]. **80h** [1296]. **80's** [7257]. **814** [4456]. **8231A** [4156]. **826** [6433]. **'83** [7278]. **83S87** [2518]. **'84** [7287]. **842** [5013]. **'85** [7292, 481]. **854** [3411, 3412, 2089, 3485]. **854-1987** [2041, 2089]. **'86** [7299, 7300]. **86<sup>TM</sup>** [3928]. **871** [5457]. **'88** [7321, 7322, 7325, 2311]. **881** [5516]. **'89** [7333, 7340]. **89/TI** [4469, 4470]. **8s** [766]. **8th** [7345, 7545, 7454, 7307, 5640].

**9** [517, 696]. **9-11** [7573]. **9.4** [6870]. **'90** [7343, 7352, 7367, 4312, 3395, 4973, 4974, 2682, 3493, 4456, 3844]. **908** [5670]. **90nm** [4805]. **'91** [7364, 7367, 417, 396]. **'92** [7373, 7376, 7379, 7387, 4469, 4470]. **'93** [7390]. **'94** [7402, 7403, 7412]. **'95** [7419, 3857, 4452, 4764]. **954** [6079]. **'96** [7433, 7437]. **96-bit** [2261]. **97** [3721]. **'98** [7450, 7458, 3975, 7448]. **980A** [1016]. **'99** [7463, 7464, 7465]. **9th** [7336, 7611, 7568, 7270, 2362].

= [2806, 2807, 3353, 7232].

**Imaginary\_I** [5570].

**A-Priori** [2103]. **A.K** [4681]. **a.k.a** [5547]. **A/D** [3896, 906, 3353, 4136, 4468, 802]. **A/D-konverter** [3353]. **A1** [1099, 1193]. **Aarhus** [7275, 7275]. **Abacus** [202, 1027, 5551]. **Abbreviating** [7]. **abc}** [4823]. **ABE** [547]. **ABI** [6893]. **Abnormal** [6777, 6051]. **Abotec** [3185]. **Absolute** [3398, 3399, 2766, 2255, 433]. **Abstract** [5592, 4553, 5626, 526, 5343, 5870, 6381, 4850, 2916, 2114, 5871, 4902, 4914, 2990]. **abstraction** [5487, 5848, 1330]. **abstraction-based** [5487]. **Abstracts** [7391, 7482]. **Abu** [408]. **Acadiana** [7454]. **ACBAM** [6985]. **ACBAM-Accuracy-Configurable** [6985]. **Accelerate** [6619, 6310, 4591]. **Accelerated** [6820, 5026, 5499, 5710, 6465, 7007, 7131]. **Accelerating** [5477, 6056, 4811, 3875, 5720, 6936, 6819, 6191, 7065, 7088, 4246, 6736, 6351, 4738, 6356, 5788]. **Acceleration** [6707, 6841, 6217, 6834, 6455]. **Accelerator** [6058, 6793, 6518, 5702, 5714, 7047, 5739, 7068, 6328, 6953, 6347, 2256, 6471, 6740, 7104, 6031, 6982, 4922, 7130, 7000, 7195, 6645, 6410, 2269, 7120]. **Accelerators** [6940, 7056, 6581, 7075, 6846, 7096, 6475, 7138, 4783, 7011, 5290, 3509]. **Acceptance** [3493]. **Access** [2146, 5121, 3404, 4594, 4648, 7007]. **Accessibility** [7543]. **Accessible** [6935]. **Account** [3, 5570]. **Accumulate** [6533, 4997, 6432, 6837, 6451, 6746, 6990, 5978, 3833, 6658, 6771, 4517, 6598, 3678]. **Accumulated** [1368, 575, 977]. **Accumulation** [6281, 2057, 1959, 179, 5944, 6208, 5319, 6107, 5558, 4439, 77, 454, 1072, 3715, 5827, 3741, 3766, 5765, 574, 5555, 2769, 95, 5460]. **accumulations** [4246]. **Accumulator** [3869, 4776, 6254, 380, 2699, 1032, 3319, 5797, 5885, 4778]. **Accumulators** [6526, 6349, 371, 1073]. **accuracies** [2605]. **Accuracy** [4656, 217, 6258, 7024, 6907, 1715, 5482, 861, 1015, 4809, 5401, 7154, 6804, 6805, 2680, 5915, 6069, 3243, 5922, 6179, 5286, 5154, 6186, 1841, 227, 228, 7160, 7161,

7190, 434, 390, 1290, 1852, 3616, 4562, 4374, 2383, 6442, 1746, 1981, 2545, 1621, 7071, 1984, 5939, 6324, 1628, 2403, 7076, 3122, 753, 5189, 6734, 832, 5194, 3801, 6985, 5794, 3168, 6243, 3685, 165, 6990, 1685, 2021, 2022, 6761, 411, 3533, 6880, 7002, 494, 6772, 6773, 5392, 7013, 5897, 5681, 5826, 1813, 4670, 5913, 6290, 6812, 6074, 6943, 3765, 3098, 1745, 6721, 2549, 2100, 1994, 5188, 5859, 5190, 6464]. **accuracy** [3794, 1756, 5352, 6134, 7113, 1679, 107, 2463, 1689, 1922, 1785, 6379, 2302, 3198, 6494, 3849, 545, 5126, 2053, 1211, 3654, 651, 1353, 2573]. **accuracy-adjustable** [7113]. **accuracy-guaranteed** [5352]. **Accurate** [5586, 5130, 1805, 2651, 2654, 2871, 7153, 1385, 4351, 4537, 4538, 4539, 4691, 4833, 4834, 3746, 4355, 6003, 6181, 6295, 4017, 5291, 2697, 6079, 4706, 4846, 4848, 5297, 2704, 5416, 5523, 5529, 4371, 6570, 6100, 5938, 5609, 5757, 5942, 5943, 3290, 5944, 6208, 230, 2553, 2242, 6954, 6591, 3304, 905, 571, 3476, 640, 5777, 6607, 7296, 4905, 4906, 5077, 6032, 2981, 1536, 5085, 5453, 5454, 5455, 5561, 5641, 5970, 5971, 3687, 3822, 3824, 4933, 5101, 4126, 2611, 6041, 6877, 3024, 598, 5986, 4497, 1795, 5816, 3053, 5264, 3244, 3425, 4692, 4185, 2367, 5522, 6302, 4212, 5937, 1868, 5940, 2737, 3126, 758]. **accurate** [759, 2956, 4745, 2964, 4747, 6132, 4261, 2149, 4460, 5227, 3011, 2844, 5470, 5246, 1095]. **Accurately** [3567, 6531, 2515, 5755, 5045, 2607, 4932, 6532, 6285, 4820, 4821, 5623, 5648]. **ACE** [946, 5118]. **achieved** [3028]. **Achieving** [6050, 5401, 5700, 6298, 1841, 4751, 5878]. **ACL2** [7500, 4278]. **ACL2-2002** [7500]. **ACM** [7315, 7402, 7527, 7528, 7543, 7544, 7558, 7571, 7587, 7588, 7563, 7490, 7506, 2092, 7512, 7529, 2349, 7420, 7367]. **ACM/IEEE** [7558]. **ACM/SIGDA** [7527, 7544]. **ACM/SIGPLAN** [7529]. **Acoustics** [7299, 7365, 7519, 7536]. **Acousto** [1907]. **Acousto-Optic** [1907]. **acquisition** [2504, 2672]. **ACRITH** [1981, 1813, 2545, 1984, 1870, 2105]. **ACRITH-XSC** [2545]. **across** [5337]. **ACSSC** [7591]. **ACT8837** [2341]. **ACTION** [6956]. **Activation** [6691]. **Activations** [6332]. **active** [5785, 3537]. **Activity** [5895]. **Actual** [5330, 6522]. **acyclic** [3213]. **Ada** [7402, 7345, 7381, 1873, 7402, 2324, 2647, 2648, 2873, 2874, 3233, 2508, 2665, 3428, 2355, 2075, 6081, 2529, 7381, 1526, 1750, 2106, 1757, 3646, 2771, 2141, 2815, 1702, 2843, 1484]. **Ada-Europe** [7381]. **Ada83** [3044]. **adaptable** [4343]. **Adaptation** [2877, 4413, 6865]. **adapted** [6013]. **Adapting** [2936, 4032]. **Adaptive** [5839, 6576, 4233, 3117, 1634, 2926, 6733, 6844, 6224, 2451, 1770, 3692, 3693, 3827, 1463, 1550, 7000, 2177, 1948, 1583, 1721, 4818, 4989, 6438, 5169, 2395, 3788, 3920, 1756, 2431, 6122, 2967, 3152, 5793, 3704, 5659]. **ADC** [4367, 2456, 4146, 4960]. **ADCOM** [7577]. **Add** [6515, 5485, 3055, 4673, 4987, 6281, 4334, 5497, 7046, 6182, 5165, 2542, 6715, 5315, 3456, 6448, 3907, 4395, 5333, 5334, 5335, 3128, 5774, 5559, 5638, 5444, 5445, 5084, 6986, 4768, 7133, 6247, 6390, 6657, 6541, 4498, 2333, 4813, 5697, 3059, 3591, 5018, 4038, 5025, 6196, 4567, 5029, 4581, 4883, 4079, 6020, 5062, 4747, 3156, 5647, 4775, 4947, 1705, 4650, 4790]. **add/sub** [3591]. **Addendum** [1231, 763]. **Adder** [6057, 3728, 3981, 4318, 4819, 5496, 4993, 1103, 5280, 2893, 336, 6939, 1125, 5751, 6446, 5758, 754, 3796, 6612, 5963, 6030, 3805, 3667, 6613, 5355, 5356, 4438, 4278, 4928, 5651, 6994, 5980, 534, 590, 937, 5376, 5575, 6879, 6492, 6389,

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[51]. **Firmware** [3802, 1837, 1633, 918]. **Firmware-Oriented** [3802]. **First** [7280, 195, 5285, 7406, 7441, 3901, 7241, 7408, 7464, 567, 7084, 1146, 7632, 3490, 237, 1909, 2595, 73, 19, 22, 56, 3203, 957, 7501, 249, 6943, 7361, 3762, 3771, 7591, 1052, 369, 1159, 4441, 7437, 3194, 2157, 3841, 3017, 7617, 588]. **first-**[3841]. **first-in** [3194]. **first-order** [3017]. **first-out** [3194]. **Fischler** [2481]. **Fisherman** [7521]. **Fists** [170]. **Fitting** [373]. **Five** [5066, 1714, 3440]. **five-moduli** [1714]. **fix** [6398, 6556]. **fixe** [2763]. **Fixed** [2636, 4499, 5674, 3547, 5895, 2042, 1371, 7149, 6678, 2670, 1821, 3058, 6415, 3996, 4822, 960, 7156, 2075, 6827, 3895, 390, 6309, 4208, 3902, 6318, 741, 5752, 5753, 3297, 1139, 3917, 6332, 6460, 4072, 4405, 6018, 911, 1148, 6471, 5794, 7127, 189, 6641, 491, 5572, 6765, 7002, 5666, 7143, 5918, 6071, 6813, 5392, 1263, 1810, 4814, 2669, 5911, 736, 4851, 968, 2713, 5936, 6714, 3275, 3276, 2724, 3279, 5317, 3619, 2395, 1986, 521, 4238, 6216, 684, 981, 2763, 6739, 3146, 3803, 2446, 5435, 2967, 5352, 2274, 3339, 4923, 6240, 5976, 4629, 4931, 3350, 4778, 4134, 147, 1797, 541, 542]. **fixed** [2307, 2628, 6070]. **Fixed-**[2670, 5752, 5753, 5666, 2763]. **Fixed-Integer** [741]. **Fixed-Point** [4499, 5895, 6415, 3895, 6309, 3902, 6318, 3297, 3917, 6460, 4405, 6471, 5794, 7127, 6641, 491, 6765, 6071, 2636, 2042, 7149, 3058, 7156, 2075, 6332, 7143, 5918, 5392, 1810, 5911, 736, 4851, 968, 2713, 5936, 6714, 3275, 3276, 1986, 4238, 6216, 684, 6739, 3146, 2446, 5435, 2967, 3339, 4923, 5976, 4629, 4931, 3350, 4778, 4134, 2628, 6070]. **Fixed-Point-Arithmetic** [6678]. **Fixed-Posit** [6827]. **fixed-precision** [2307]. **Fixed-Rate** [6018]. **Fixed-Size** [1821, 4072]. **Fixed-Slash** [1139, 911, 1148]. **Fixed-Width** [5572, 3803]. **Fixed-Word-Length** [390]. **fixing** [6253]. **flag** [5462]. **flagged** [4988]. **flags** [5223]. **Flap** [5565]. **flash** [5208]. **Flaw** [3419, 3453, 3506, 3392, 3349]. **FLECKmarks** [3583]. **flerformat** [1740]. **Flex** [2063]. **Flex/32** [2063]. **FlexBlock** [7104]. **flexibility** [3204]. **Flexible** [5516, 6551, 6825, 6826, 5844, 6318, 4575, 1886, 7104, 698, 4769, 2839, 6771, 4541]. **flexiblen** [1886]. **Flexpoint** [6479]. **Fließkomma** [2304, 2305, 2306, 2485, 2486, 1476]. **Fließkomma-Arithmetik** [2304, 2305, 2306, 2485, 2486, 1476]. **Fließkommapakets** [2305]. **Flight** [3790, 3640]. **flip** [5957]. **Float** [2115, 2455, 5812, 6391, 5163, 5025, 6044, 6556, 3336]. **Float-Fix** [6556]. **float-float** [5163]. **float-point** [6044]. **float-Precision** [3336]. **float-to-string** [6391]. **float.h** [2794, 2587]. **Float16** [7020]. **Float8** [7020]. **FLOATing** [5634, 2041, 4505, 7021, 3970, 2635, 5813, 7015, 2037, 6500, 4653, 4964, 5252, 5814, 6048, 6154, 6664, 5584, 4500, 4654, 3854, 7017, 7188, 2174, 2175, 4502, 4965, 217, 417, 3974, 5674, 6257, 6502, 7018, 6777, 6258, 1485, 2859, 2860, 2861, 3032, 3033, 3034, 3035, 3036, 3219, 3220, 3221, 3223, 3550, 4659, 5131, 5133, 6053, 6397, 6399, 6670, 7019, 5676, 5677, 5820, 5821, 1948, 169, 1804, 5900, 6788, 4313, 2322, 4975, 1368, 1809, 3397, 5992, 1013, 3398, 3399, 3981, 4163, 4164, 4165, 1950, 4513, 2328, 4320, 1951, 4800, 6791, 1577, 2505, 2189, 3730, 6516, 5688, 861]. **Floating** [1015, 1095, 2049, 2332, 2655, 2871, 4520, 4521, 5263, 5483, 5690, 5905, 6060, 6061, 6062, 6404, 6794, 7030, 3405, 3406, 7031, 1579, 1580, 3407, 2052, 1719, 6063, 2507, 2053, 728, 2334, 5268, 5908, 6169, 105, 1267, 1268, 1377, 6523, 4329, 4813, 4987, 6408, 6681, 7039, 3567, 6526, 2509, 5489, 247, 6410, 865, 5702, 171,

3235, 3412, 1498, 1499, 5403, 5143, 6685, 2666, 1584, 5592, 2670, 3573, 4334, 5492, 5831, 6914, 1271, 2673, 2674, 2675, 5995, 6065, 6284, 3059, 3996, 1725, 2515, 731, 1197, 1386, 1502, 1503, 1726, 1825, 2206, 2345, 3061, 3999, 6173, 4001, 1198, 1199, 1275, 1388, 1727]. **Floating** [5914, 3877, 4005, 5146, 5278, 5500, 5501, 2877, 4337, 4822, 3420, 3421, 3582, 2063, 2064, 3423, 3740, 6180, 6176, 3583, 3879, 3881, 4342, 6810, 2350, 2519, 2520, 6694, 4011, 4012, 4344, 2208, 4831, 617, 2352, 2887, 3250, 4351, 4537, 4539, 4691, 4834, 5920, 5921, 6072, 6815, 6179, 1965, 5284, 4695, 6933, 5286, 5154, 6543, 3746, 4355, 6935, 6818, 1966, 2067, 502, 6182, 3889, 1733, 1833, 2891, 2893, 1968, 5413, 505, 1395, 1834, 6429, 6700, 4543, 5294, 5512, 3431, 3750, 4022, 4189, 3257, 5513, 1838, 4704, 6185, 2215, 1279, 6821, 6822, 963, 1512, 3432, 1204, 6548, 1514, 4705, 6186, 5603]. **Floating** [4195, 7053, 822, 2217, 6549, 6701, 7055, 7159, 5012, 5839, 1280, 2218, 2897, 6299, 4545, 2704, 5723, 2530, 3260, 3753, 227, 228, 1608, 1971, 5518, 824, 878, 4034, 5843, 881, 1285, 6827, 1741, 2374, 2707, 2708, 4713, 966, 5415, 5933, 6300, 6704, 967, 1033, 1403, 1610, 6705, 4364, 4553, 5523, 307, 1611, 308, 678, 2221, 2222, 2378, 1849, 1850, 4201, 7060, 5732, 5733, 2714, 6193, 6304, 6305, 6306, 6829, 7162, 4862, 3759, 970, 392, 393, 3442, 3764, 4041, 4204, 4205, 5166, 5306, 3899, 6558, 3265, 2540, 1036, 1037, 3611, 3093, 6831, 5607, 1616]. **Floating** [1976, 1297, 436, 6713, 4373, 971, 6566, 3450, 5532, 2542, 5739, 1299, 2544, 2719, 2910, 6197, 6715, 6316, 1301, 1410, 5315, 5849, 3902, 1132, 6200, 1619, 5171, 3905, 6571, 1861, 1862, 1863, 2088, 2089, 6572, 7069, 7070, 4223, 5176, 5748, 6718, 3104, 3105, 4218, 3283, 343, 1865, 4222, 5173, 5608, 6102, 2915, 5938, 3106, 3107, 5751, 6319, 5537, 5754, 5756, 5939, 5941, 6320, 6450, 4054, 4380, 3907, 5538, 1304, 1627, 1222, 2397, 6207, 6324, 6724, 255, 6326, 1628, 5944, 6208, 627, 345, 1224, 1308, 1417, 1987, 2236, 2921, 3774, 3908, 3909, 4227, 4381, 4570, 4870, 4871, 5032, 5422, 5851, 4384, 3776, 743]. **Floating** [746, 3293, 7074, 5319, 3294, 1871, 5760, 2551, 6581, 1751, 891, 1042, 258, 2552, 3297, 5541, 828, 4235, 3467, 2413, 2928, 2929, 1139, 5324, 5325, 5855, 4393, 3783, 751, 752, 894, 1988, 4576, 896, 1046, 753, 6107, 5857, 5948, 3301, 6588, 6589, 6730, 6954, 6955, 6332, 6333, 4581, 4883, 6731, 6111, 6211, 6336, 6338, 5189, 1637, 6114, 5047, 2106, 350, 2423, 2747, 2749, 2937, 6213, 4584, 4885, 5050, 6214, 6341, 6591, 5769, 5770, 6846, 1529, 441, 5333, 5334, 7083, 7085, 6218, 1142, 6465, 2108, 5193, 6018, 6466, 832, 905, 1431, 571, 5771, 6219, 3305, 2942, 2943, 2251, 2430, 6349, 6597, 2753]. **Floating** [1890, 4899, 2561, 94, 6599, 1760, 640, 687, 2563, 5959, 3651, 980, 6469, 1641, 2760, 7091, 1643, 6221, 3135, 5867, 6851, 4595, 526, 577, 911, 1148, 3798, 5778, 403, 2568, 1149, 4415, 6964, 6355, 1999, 6356, 3483, 3144, 5628, 4416, 7095, 7173, 983, 2259, 5552, 5343, 3801, 450, 6023, 6024, 6359, 6360, 6361, 6608, 6609, 363, 2438, 5554, 1532, 1764, 6224, 642, 1896, 2120, 2262, 2442, 2443, 3149, 5068, 5632, 6226, 6473, 1438, 3929, 1152, 2121, 2772, 7105, 4423, 2449, 2450, 6475, 6612, 6744, 5962, 916, 5075, 5963, 6030, 3805, 5202, 5351, 7104, 3493, 2781, 4093, 3663]. **Floating** [3665, 3667, 3808, 3809, 4092, 5078, 2575, 2970, 2576, 5965, 4430, 2784, 2785, 5437, 7107, 2004, 645, 1059, 1325, 2579, 2268, 4269, 6232, 646, 6750, 1157, 1235, 1327, 5967, 6031, 5636, 2131, 7112, 702, 4272, 4438, 6032, 2272, 2792, 2793, 3160,

2008, 6617, 5559, 838, 2796, 2981, 1773, 6138, 2588, 3163, 4916, 5638, 5444, 5445, 2009, 6480, 6481, 2278, 992, 2984, 7193, 2279, 1239, 3681, 922, 923, 6236, 2280, 994, 3166, 2281, 4621, 5639, 2282, 6238, 2804, 5085, 5453, 5454, 5641, 5972, 4278, 6753, 6486, 1541, 6374, 1680, 454, 1681, 6375, 3945, 3946, 5087, 1544, 4109, 2600, 1455, 1776, 4927, 5089]. **Floating** [5361, 2288, 4117, 4284, 4454, 4768, 5090, 5795, 7122, 4628, 5092, 2991, 1686, 7127, 1777, 5651, 5884, 2601, 3693, 4931, 2467, 269, 212, 2151, 2992, 2018, 5798, 1547, 2469, 788, 1687, 2812, 2998, 3186, 3187, 3188, 3352, 3698, 3699, 2293, 5977, 6246, 6994, 7133, 3353, 6143, 6144, 6629, 2021, 2022, 1690, 1691, 3003, 5978, 2607, 4932, 5220, 5221, 5222, 5223, 5458, 5459, 5460, 5461, 5462, 2816, 3004, 844, 1339, 1459, 1460, 1786, 5565, 3956, 3957, 5103, 1341, 2297, 4128, 2026, 5887, 4287, 6247, 3959, 1787, 5567, 2476, 2613, 2614, 3010, 5106, 5107, 1466, 5568, 6761, 1790, 5230, 5374, 3529]. **Floating** [4939, 6146, 6642, 4136, 593, 3357, 4471, 6381, 7136, 6041, 7137, 6491, 1073, 5375, 2028, 3841, 849, 5376, 5569, 2829, 3198, 3530, 2831, 6763, 3360, 6382, 2833, 2834, 1350, 5110, 1076, 5571, 5889, 3708, 1351, 3844, 3201, 6252, 6492, 6493, 2305, 3963, 215, 6390, 1470, 1702, 2623, 1703, 5116, 5239, 5383, 5384, 5578, 5579, 5663, 5666, 6495, 1557, 1355, 1472, 1473, 1474, 1475, 3967, 2034, 7194, 5807, 7140, 2035, 3019, 3020, 5983, 216, 3209, 2308, 6254, 2843, 4297, 6151, 134, 1798, 5242, 7184, 5984, 2631, 800, 1358, 3027, 1707, 3541, 5390, 5810, 4151, 949, 1942, 6768, 6885, 6886, 5986]. **Floating** [6657, 5123, 5582, 5670, 5124, 5391, 5248, 6659, 5598, 5717, 5917, 4640, 6385, 4295, 1938, 2176, 3385, 5392, 663, 2858, 1944, 1945, 6498, 3972, 1565, 5673, 6256, 3031, 3719, 3856, 5472, 5473, 6051, 6156, 6052, 721, 297, 1486, 2498, 2640, 3037, 3222, 3390, 3391, 3392, 3393, 4504, 6398, 6507, 6508, 7020, 2499, 1086, 1011, 5678, 1801, 2318, 1802, 1803, 1363, 2320, 1570, 1571, 2043, 2321, 4798, 6160, 4161, 1488, 2502, 2868, 3045, 5588, 5903, 2045, 1369, 1808, 2184, 2503, 2185, 5904, 4316, 2047, 2325, 7025, 2649, 3229, 3047, 2326, 4319, 5258, 5259, 1092, 2186]. **floating** [1371, 2329, 5826, 4803, 2504, 1191, 5139, 3866, 2330, 6273, 2331, 2190, 2652, 2653, 3053, 1814, 4324, 4519, 4669, 4806, 4807, 4808, 5140, 5262, 5993, 6275, 3731, 1717, 300, 2191, 667, 5265, 5590, 4327, 3867, 1016, 4811, 5400, 5591, 7033, 7034, 7151, 2192, 1017, 1194, 6407, 5830, 6682, 3234, 4988, 3568, 1816, 2194, 2662, 7153, 6409, 1955, 6527, 1378, 6528, 3411, 6282, 1379, 4818, 4989, 2668, 3236, 380, 1586, 6411, 3870, 4992, 1819, 2058, 2672, 3737, 3872, 5911, 1381, 1723, 2204, 2341, 4525, 5497, 3994, 3995, 5996, 4820, 4821, 3998, 1590, 5499, 5710, 6174, 4178, 2681, 1105]. **floating** [1962, 4004, 4687, 4532, 422, 5502, 3422, 5712, 7189, 2348, 2878, 2879, 2880, 3880, 4010, 3245, 6292, 2686, 6293, 5409, 5410, 960, 1277, 2688, 6421, 5999, 5718, 3067, 2886, 3249, 3426, 4538, 4692, 4833, 6178, 6074, 4013, 3069, 249, 4837, 5153, 5283, 4352, 962, 4541, 5599, 6697, 5155, 2522, 5288, 2523, 5002, 2354, 4185, 2890, 5289, 2209, 503, 1734, 1735, 2892, 6005, 4016, 1203, 5291, 5156, 5510, 735, 1117, 5008, 4190, 4191, 6941, 4702, 4703, 5602, 1513, 1969, 2366, 1737, 1970, 820, 509, 3751, 1205, 5298, 1030, 6298, 2898, 2370, 4851, 6702, 4709, 5842, 4710, 283, 3084]. **floating** [3261, 4712, 4854, 3085, 2532, 622, 880, 1031, 1209, 1284, 1740, 3438, 2900, 3086, 1032, 2709, 1844, 5520, 1845, 2536, 1846, 5727, 2376, 4857, 4858, 1847, 5416, 6009, 6088, 6553, 1288, 2377,



252, 178, 3896, 2381, 1851, 4367, 4861, 3897, 2538, 6945, 4037, 6709, 6710, 3088, 4038, 5020, 3605, 5848, 7062, 4039, 4556, 4716, 6557, 2902, 2903, 3607, 6438, 3091, 3444, 3608, 1292, 1408, 1214, 1975, 3610, 2223, 3445, 1409, 1298, 3270, 3098, 4045, 2224, 4564, 2908, 2541, 3099, 2718, 5311, 5312, 1745, 2911, 6443, 6570, 6716, 5741, 2086, 5742, 517, 827, 1216, 2389, 5744, 682, 2391, 1219, 1864]. **floating** [1747, 3285, 3620, 5174, 5175, 5177, 5533, 2227, 2228, 4049, 4567, 7191, 3619, 1134, 1220, 1867, 2392, 4723, 5937, 2914, 4569, 5752, 5753, 1625, 3288, 6011, 6205, 6321, 6322, 6449, 201, 2090, 3623, 6012, 6453, 2231, 2919, 3110, 3289, 6013, 2233, 2401, 2402, 2234, 3111, 2094, 2095, 3461, 3626, 3627, 4226, 4228, 5610, 5758, 4725, 2923, 3291, 3463, 3629, 3292, 6105, 629, 474, 745, 2405, 2406, 2407, 2408, 747, 748, 1225, 2241, 2100, 1633, 312, 521, 4877, 4878, 6329, 2741, 1226, 1227, 2412, 2414, 2415, 1752, 1875, 1528, 1753, 5617, 6841, 3635, 3915, 4394, 3123, 3300, 4881]. **floating** [5619, 2932, 3468, 5326, 830, 898, 974, 1994, 4238, 5949, 6109, 4882, 2557, 3302, 900, 976, 2934, 7080, 2247, 2248, 5951, 6458, 6335, 3918, 3919, 5859, 5190, 7169, 6216, 756, 2748, 2936, 3125, 4583, 5862, 6115, 6016, 5955, 4886, 3791, 4408, 4589, 352, 4591, 3922, 6847, 4887, 525, 572, 5623, 1758, 5337, 3642, 5624, 5957, 1639, 5339, 5340, 4246, 6020, 4889, 6598, 2253, 7192, 1051, 1996, 1314, 2949, 3649, 574, 641, 758, 759, 402, 689, 690, 575, 6021, 2255, 4891, 1997, 1998, 981, 910, 3134, 1435, 2567, 4596, 4740, 6122, 3137, 2257, 2117, 2763, 5062, 2258, 5342, 3143, 6738, 7094, 1647]. **floating** [1648, 1649, 696, 2569, 5779, 5870, 3485, 5344, 4898, 5064, 5346, 5347, 5348, 5432, 5553, 6967, 2570, 2000, 3928, 5067, 5434, 320, 1895, 2261, 2441, 2444, 2769, 3659, 6026, 2962, 2963, 918, 7101, 2447, 2448, 985, 4259, 3319, 4747, 2265, 3152, 6229, 3320, 3321, 3934, 2452, 3810, 4907, 6978, 3326, 581, 4908, 5352, 5876, 6231, 481, 4261, 3154, 3155, 5353, 5557, 6134, 5877, 986, 4264, 4098, 4267, 5785, 766, 987, 3813, 4099, 7110, 4753, 3333, 6136, 4911, 1328, 2005, 5786, 7111, 2269, 208, 701, 990, 2270, 2976, 2271, 3815, 7113, 2273, 2585, 3335, 527, 7114, 3504, 2274, 7197]. **floating** [2589, 2798, 2983, 4917, 2277, 3338, 4102, 5789, 6234, 2457, 2592, 2802, 2593, 2594, 1774, 2139, 1333, 5082, 6865, 993, 529, 1241, 1242, 1334, 707, 1063, 2985, 1064, 3339, 1678, 484, 4923, 3508, 774, 5969, 5643, 5644, 5879, 6241, 5792, 3942, 3943, 4106, 1337, 4924, 4623, 1914, 3167, 107, 5793, 5647, 6487, 998, 2986, 2463, 3944, 5648, 3684, 3342, 777, 2014, 2285, 2599, 2145, 7121, 4925, 6038, 710, 711, 3178, 3825, 4118, 4767, 5562, 2465, 3947, 4455, 4929, 4930, 5796, 3949, 3690, 2806, 2807, 2989, 2990, 2808, 3349, 3183, 2290, 3692, 3827, 4629, 927, 3184, 3517, 2017]. **floating** [3518, 1066, 3951, 5216, 4125, 4456, 6756, 3828, 2472, 1689, 1922, 3002, 4631, 2294, 1170, 2473, 2474, 4457, 4458, 4633, 5097, 5098, 5099, 5224, 5225, 5366, 5367, 5368, 5369, 1785, 1461, 293, 1462, 2025, 4775, 3702, 4131, 376, 324, 4777, 846, 2824, 2825, 3194, 3195, 5105, 1929, 3703, 147, 1465, 1788, 1931, 2300, 1935, 1789, 3011, 5229, 6379, 3012, 1697, 847, 3356, 4468, 4940, 1072, 3358, 1347, 4137, 4293, 7182, 1792, 3705, 1793, 1698, 1937, 4140, 4294, 2030, 942, 6383, 4943, 4944, 716, 795, 3706, 1794, 2621, 2482, 2484, 4474, 4475, 2032, 5237, 1352, 2836, 2164, 493, 3204]. **floating** [2487, 850, 3965, 2490, 3015, 4784, 4949, 5238, 5385, 5806, 6253, 2491, 1796, 1704, 1356, 1797, 541, 542, 543, 2166, 2307, 5117, 796, 2492, 2493, 1256,

295, 1705, 2167, 3210, 3375, 1939, 1560, 2310, 2494, 1357, 2627, 4144, 1799, 1561, 4952, 5244, 5581, 5808, 948, 2630, 4146, 4298, 4953, 4954, 5809, 599, 798, 2848, 7007, 194, 2850, 2313, 2495, 2852, 2853, 3213, 3851, 7185, 5246, 4959, 4960, 5125, 5127, 4650, 4790, 4791, 2315, 6774, 7012, 5149, 2351, 2689, 1253, 6518, 1732, 3906, 4884, 1885, 3656, 3196, 2304, 2305, 2306, 2485, 2486, 1476, 5597, 996]. **floating-** [5392, 5911]. **Floating-Decimal** [134]. **Floating-Point** [2041, 7021, 3970, 2635, 4653, 4964, 5252, 5814, 5584, 4654, 7017, 7188, 4965, 3974, 6502, 7018, 6258, 4659, 5133, 6397, 6399, 6670, 7019, 5676, 5677, 5820, 5821, 5900, 6788, 4975, 3398, 3981, 4163, 4164, 4165, 1950, 4513, 2328, 4800, 6791, 2505, 3730, 5688, 861, 1015, 1095, 2049, 2655, 2871, 5263, 5483, 5690, 5905, 6060, 6061, 6062, 6404, 6794, 3406, 3407, 2052, 6063, 2507, 2053, 728, 2334, 5908, 6169, 1267, 1268, 1377, 4329, 6408, 6681, 7039, 3567, 6526, 5489, 247, 865, 5702, 3235, 3412, 5143, 6685, 2666, 1584, 5592, 2670, 3573, 4334, 5492, 5831, 6914, 1271, 6284]. **Floating-Point** [731, 1386, 1503, 1726, 2345, 3061, 3999, 6173, 4001, 1199, 1275, 1727, 5914, 3877, 4005, 5146, 5278, 5500, 5501, 2877, 4337, 3420, 3421, 3582, 2063, 6180, 6176, 4342, 6810, 2519, 2520, 6694, 4344, 4831, 617, 5920, 5921, 6072, 6815, 6933, 5286, 5154, 6543, 4355, 6935, 1966, 2067, 6182, 3889, 1733, 2891, 2893, 5413, 505, 6700, 4543, 5294, 5512, 3431, 4022, 4189, 1838, 6185, 2215, 1279, 6821, 6822, 1512, 6186, 4195, 7053, 2217, 6549, 5012, 5839, 1280, 2218, 2897, 6299, 4545, 5723, 3753, 1971, 5518, 878, 4034, 881, 1285, 6827, 2707, 2708, 4713, 5415, 5933, 6300, 6704]. **Floating-Point** [1403, 1610, 6705, 4364, 4553, 5523, 307, 2221, 2222, 2378, 1850, 4201, 7060, 5733, 6829, 4862, 970, 392, 393, 5306, 3899, 2540, 6831, 5607, 1976, 971, 6566, 2544, 2719, 2910, 6197, 6316, 1301, 5315, 5849, 3902, 1132, 6200, 1619, 6571, 1861, 1862, 1863, 2088, 2089, 6572, 7069, 5176, 5748, 6718, 3104, 3105, 4218, 343, 5608, 6102, 5938, 5537, 5754, 5756, 5939, 5941, 6320, 6450, 4380, 3907, 5538, 1222, 6207, 6324, 6724, 1628, 5944, 6208, 345, 1224, 1308, 1417, 1987, 2921, 3774, 3908, 3909, 4227, 4381, 4570, 4870, 4871, 5032, 5422, 5851, 4384, 3776, 743, 746, 7074, 5319, 1871, 2551, 6581]. **Floating-Point** [891, 1042, 3297, 5541, 828, 2413, 2929, 5324, 5325, 5855, 3783, 751, 752, 894, 1046, 5948, 3301, 6588, 6589, 6730, 6954, 6955, 6333, 6211, 6338, 6114, 5047, 2749, 6213, 4885, 5050, 6214, 6341, 6591, 5769, 5770, 1529, 441, 5333, 5334, 7083, 7085, 2108, 5193, 6018, 832, 905, 1431, 571, 5771, 6219, 3305, 2942, 2943, 2251, 2430, 6349, 2753, 4899, 2561, 6599, 640, 687, 2563, 5959, 6469, 1641, 2760, 7091, 5867, 6851, 4595, 526, 577, 1149, 3483, 5628, 4416, 7095, 7173, 983, 5552, 5343, 2438, 5554, 1764, 6224, 642, 1896, 2120, 2262, 2442, 2443, 3149, 5068, 5632, 6226, 6473]. **Floating-Point** [1152, 2772, 2449, 2450, 6475, 6612, 6744, 916, 5075, 5202, 5351, 2781, 4093, 3665, 3667, 3808, 2970, 5965, 2784, 2785, 5437, 7107, 2004, 645, 1325, 2579, 2268, 6750, 6031, 7112, 702, 4272, 6032, 2792, 2793, 3160, 6617, 5559, 4916, 5638, 5444, 5445, 6481, 2278, 2279, 1239, 3681, 922, 923, 6236, 2280, 994, 3166, 2281, 4621, 2282, 2804, 5085, 5453, 5454, 5641, 5972, 6753, 6486, 1681, 6375, 3946, 1544, 4109, 1455, 1776, 4927, 5089, 5361, 4454, 4768, 5090, 5795, 7122, 5092, 2991, 7127, 5651, 5884, 3693, 2467, 212, 2992, 2812, 2998, 3186, 3187, 3352, 3698, 3699, 2293, 5977, 6246, 6994, 7133]. **Floating-Point** [6143, 6144, 6629, 2021, 3003, 2607, 4932, 1459, 1460, 1786,

5565, 5103, 1341, 5887, 1787, 5567, 2476, 2613, 2614, 3010, 1466, 5568, 6761, 1790, 3529, 4939, 6146, 6642, 4136, 593, 3357, 6381, 6041, 7137, 5375, 2028, 849, 5569, 2829, 3530, 2831, 6763, 3360, 6382, 5889, 3844, 3201, 6252, 6493, 2305, 215, 1470, 1702, 2623, 5116, 5239, 5383, 5384, 5578, 5579, 5666, 1355, 2034, 7194, 3020, 216, 3209, 2308, 6254, 5242, 7184, 2631, 800, 3027, 1707, 5390, 4151, 6885, 6886, 6657, 5123, 5582, 5670, 5124, 5391, 5248, 6659, 5717, 5917, 4640, 6385, 4505, 7015, 4500, 2174, 2175, 417, 3223, 1948]. **Floating-point** [4313, 6516, 2332, 7030, 7031, 1579, 1580, 1719, 5268, 6523, 4813, 4987, 2509, 6410, 2673, 2674, 2675, 5995, 6065, 1502, 1825, 2206, 2064, 3740, 5284, 4695, 1395, 4704, 2530, 2374, 308, 3759, 5166, 1297, 5532, 1299, 3905, 7070, 4223, 4222, 4054, 3293, 258, 2928, 4576, 896, 6107, 6332, 4581, 4883, 6731, 2423, 6846, 6465, 1760, 3651, 980, 3135, 6964, 6355, 2259, 3929, 2121, 2576, 5636, 2008, 2009, 6238, 3945, 4284, 4931, 2151, 2469, 2297, 2026, 4287, 6247, 7136, 3841, 5376, 3198, 2833, 2834, 1076, 3708, 1351, 6492, 1472, 1473, 1474, 1475, 5984, 6768, 5598, 1938, 2176, 3385, 2858, 3972]. **floating-point** [1565, 6256, 5473, 6156, 721, 1486, 2640, 3037, 3390, 3391, 3392, 4504, 6398, 6507, 2499, 1086, 5678, 1801, 2318, 1802, 1803, 6160, 4161, 2868, 3045, 5588, 5903, 5904, 2325, 7025, 2649, 2326, 4319, 5258, 5259, 2186, 2329, 5826, 4803, 5139, 2331, 2190, 2652, 3053, 1814, 4324, 4806, 4807, 5140, 5993, 6275, 3731, 2191, 5265, 5590, 4327, 1016, 4811, 5400, 5591, 7033, 7034, 2192, 1017, 1194, 6407, 5830, 6682, 3234, 4988, 2194, 7153, 6527, 1378, 3411, 4989, 1586, 6411, 4992, 2058, 2672, 3872, 4525, 3995, 3998, 1590, 5499, 5710, 6174, 1962, 4004, 4687, 5502, 7189, 2348]. **floating-point** [2878, 2879, 2880, 4010, 6293, 5409, 5410, 2688, 6421, 5718, 3067, 4538, 4013, 3069, 249, 4837, 5153, 5283, 4352, 962, 4541, 5155, 5002, 2354, 4185, 2890, 5289, 503, 1734, 1735, 6005, 5291, 735, 1117, 4191, 6941, 1969, 1737, 1970, 820, 509, 5298, 1030, 6298, 2898, 2370, 4851, 6702, 4709, 4712, 4854, 3085, 622, 880, 1031, 1209, 1284, 1740, 3438, 2900, 3086, 1844, 5520, 1845, 2536, 1846, 5727, 4857, 4858, 6009, 6088, 6553, 1288, 252, 178, 1851, 4367, 4861, 6945, 6709, 6710, 5020, 3605, 5848, 4039, 4556, 4716, 2902, 2903, 3444, 3608, 1408, 1214, 1975, 3445, 3270, 4564]. **floating-point** [2541, 5311, 5312, 1745, 6443, 6570, 6716, 5741, 2086, 5742, 1216, 5744, 2391, 1219, 1864, 1747, 3620, 5175, 5177, 5533, 2227, 2228, 4049, 7191, 1134, 1220, 1867, 4723, 5937, 2914, 5752, 5753, 1625, 6011, 6205, 6321, 6322, 6449, 6012, 2233, 2401, 2402, 3111, 2094, 2095, 3461, 3626, 3627, 4226, 4228, 5610, 5758, 4725, 2923, 3291, 3463, 3292, 629, 474, 745, 2405, 2406, 2407, 2408, 4877, 6329, 2741, 2412, 2414, 2415, 1528, 1753, 5617, 6841, 3635, 3915, 4881, 5619, 3468, 830, 898, 974, 4238, 5949, 6109, 4882, 2557, 3302, 7080, 2247, 2248, 5951, 6458, 6335, 3918, 3919, 5859, 6216]. **floating-point** [756, 2748, 2936, 3125, 4583, 6115, 6016, 5955, 4886, 4408, 4589, 4591, 3922, 4887, 525, 572, 5623, 1758, 5337, 5624, 5957, 1639, 4246, 6020, 4889, 6598, 7192, 1051, 1996, 574, 641, 758, 759, 402, 689, 575, 6021, 4891, 1997, 1998, 1435, 6122, 2257, 2117, 2763, 5062, 5342, 1648, 1649, 696, 2569, 5779, 5870, 3485, 5344, 4898, 5064, 5346, 5347, 5348, 5432, 5553, 6967, 2570, 2000, 3928, 5067, 5434, 1895, 2261, 2441, 2444, 2769, 3659, 6026, 2962, 2963, 7101, 2447, 2448, 985, 4259, 4747, 2265, 3152, 6229, 3321, 3934, 6978, 4908,

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**Normalization** [2061, 967, 1033, 439, 2012, 1941, 2171, 1586, 1833, 4036, 1612, 3706]. **Normalized** [6704, 178, 1235, 1457, 3413, 312, 4576, 477]. **Normalizing** [6300, 3088, 5774]. **Norms** [5694, 5495, 6087]. **normwise** [5926]. **Northcon** [7380]. **Northcon/92** [7380]. **Northeast** [7277, 7301]. **Northeast-83** [7277]. **Northeast-86** [7301]. **Northeast/83** [7277]. **Northern** [7488, 7604]. **Norwegian** [1740]. **Notation** [4689, 6138, 1336, 312, 5551]. **notations** [4808]. **notch** [2967]. **Note** [1006, 3978, 275, 223, 278, 125, 175, 158, 969, 513, 342, 561, 82, 343, 744, 202, 362, 8, 919, 1670, 3817, 708, 712, 1924, 2023, 3019, 2309, 5469, 6151, 4489, 950, 7186, 4327, 116, 2886, 4557, 1975, 1625, 1228, 6732, 6843, 3645, 757, 1669, 3197, 78, 1253]. **Notes** [195, 669, 52, 36, 26, 344, 2394, 4052, 3774, 30, 207, 1670, 742, 3626, 5332, 7174]. **Nothing** [2093, 4062, 6975]. **notice** [6261, 6667, 6779, 6632]. **Notwendigkeit** [405]. **Nov** [7526]. **Novel** [804, 4317, 6691, 6818, 876, 6708, 6945, 3276, 2729, 6837, 2108, 6362, 4096, 4263, 2801, 3678, 6751, 4621, 5231, 5232, 5380, 6879, 6045, 4657, 6078, 2945, 5631, 5974, 4775, 4951]. **November** [7333, 7474, 7558, 7210, 7220, 7475, 7622, 7244, 7317, 7335, 7346, 7441, 7319, 7235, 7241, 7322, 7364, 7420, 7506, 7638, 7258, 7289, 7455, 7325, 7456, 7480, 7496, 7509, 7523, 7591, 7603, 7632, 7263, 7278, 7425, 7437, 7303, 7331, 7359, 4899]. **NPB** [6687]. **NPL** [946]. **NPU** [7003]. **ns** [1486, 3271, 3481, 649, 2841, 2842]. **NS16000** [1643]. **NS16081** [1643]. **NS32000** [1953]. **NS32081** [1971, 2017]. **NS32381** [1951]. **NS32532** [2186, 2227]. **NS32532-NS32580** [2186]. **NS32580** [2186]. **NSA** [1645]. **NSW** [7323]. **NTRU** [4751]. **NTT** [6793, 6953, 6770]. **NTT-Based** [6953, 6770, 6793]. **NTT-Uncoupled** [6770]. **NTTU** [6770]. **NU** [1363]. **Nuclear** [7372]. **Null** [391]. **Nullstellensätze** [4069]. **Number** [5672, 6047, 6892, 7146, 3548, 3722, 1487, 3723, 4508, 4661, 4971, 4972, 5476, 5679, 5680, 6509, 6675, 6904, 219, 855, 3863, 4314, 4977, 6790, 497, 666, 804, 857, 725, 806, 1091, 1576, 7027, 6166, 6061, 5692, 728, 6913, 6529, 1958, 3869, 4991, 612, 220, 1276, 1596, 5833, 5503, 672, 7156, 6542, 3584, 3744, 4014, 4354, 6424, 3889, 1202, 3430, 6296, 3080, 5515, 433, 177, 337, 338, 6943, 6084, 885, 1743, 253, 2078, 5023, 5736, 561, 1213, 1293, 7589, 6440, 5314, 1618, 6200, 6450, 1626, 1135, 1136, 1306, 3776, 202, 347, 1419, 1632, 3464, 5181, 750, 828, 6727, 6952]. **Number** [203, 6454, 1138, 1424, 1876, 5618, 5946, 753, 5858, 5950, 25, 1048, 1231, 4732, 288, 6845, 4076, 5053, 906, 685, 6596, 6849, 7089, 5341, 5196, 4595, 692, 1148, 1889, 4598, 3141, 6965, 2953, 318, 1650, 3489, 5072, 915, 3931, 1153, 919, 3494, 2782, 1440, 3498, 3327, 3328, 4431, 4607, 2580, 4100, 4270, 988, 1156, 767, 1907, 3334, 3162, 3501, 1674, 6862, 1912, 6864, 1540, 5881, 709, 455, 485, 6243, 3344, 1917, 532, 786, 2150, 7132, 1169, 6757, 4632, 4635, 2609, 938, 1248, 5372, 3959, 2475, 2299, 5888, 939, 2029, 1251, 6644, 2834, 2161, 6389, 5663, 3536, 3024, 5121, 797]. **Number** [4649, 598, 3027, 7232, 2634, 3214, 3386, 3387, 4961, 4962, 4498, 1711, 4304, 4657, 3547, 2642, 2319, 3861, 4662, 5899, 4795, 6271, 3561, 6401, 2181, 1089, 1262, 1489, 2045, 2047, 2325, 1264, 3228, 3229, 1811, 1949, 3048, 3049, 1714, 4167, 3865, 5590, 6280, 3988, 3733, 4674, 4675, 4816, 2196, 2200, 4170, 4522, 956, 2057, 4677, 5271, 2338, 2512, 2673, 2674, 2675, 2676, 2513, 3239, 3240, 3575, 3576, 3577, 3993, 4680,

3739, 4528, 6068, 1827, 4182, 5715, 1109, 1110, 4350, 2353, 2889, 3072, 3252, 3253, 3585, 3743, 3886, 3747, 3888, 1278, 4026, 4356, 2700, 2701, 4029, 4196]. **number** [2371, 2705, 2899, 2372, 3894, 3597, 226, 2373, 2375, 2710, 252, 1035, 1210, 2379, 2380, 1292, 5025, 7564, 3446, 3447, 3448, 3449, 2384, 4565, 626, 5169, 5741, 1411, 2724, 3903, 6447, 4379, 1039, 1221, 1303, 1415, 1416, 1523, 1524, 1869, 2230, 1985, 2919, 3110, 2234, 1040, 257, 888, 4233, 2734, 3113, 3114, 3115, 3116, 312, 231, 2417, 2930, 3124, 1877, 1989, 1990, 1991, 1992, 2245, 2246, 2418, 2419, 2931, 2745, 2933, 2421, 2746, 2422, 1230, 3788, 3920, 4078, 4243, 5192, 1755, 2752, 2945, 4248, 4249, 4250, 4411, 4412, 4413, 4594, 4890, 4081, 4251, 5866, 2431, 2114, 575, 5776, 5626]. **number** [1763, 3926, 5071, 5556, 6743, 5073, 7100, 236, 4425, 4746, 2451, 3322, 3323, 2971, 2972, 4096, 4262, 4263, 3157, 3329, 3330, 406, 3331, 3332, 3499, 1770, 1908, 5209, 6233, 4434, 4435, 4755, 2978, 2979, 3502, 3676, 527, 7114, 4275, 2456, 2591, 4276, 1537, 1910, 2010, 2458, 1450, 4442, 529, 4622, 2463, 3944, 5796, 5093, 3690, 1918, 3183, 2149, 5799, 2470, 2811, 2996, 3952, 4122, 4123, 4124, 1000, 1067, 1068, 1688, 1782, 1783, 2019, 2020, 5094, 2999, 3000, 4630, 3006, 188, 2608, 3007, 324, 1463, 1550, 3527, 3704, 1931, 2300, 2027, 5233, 2827, 3840, 1176, 5108]. **number** [3198, 4140, 4294, 2833, 3706, 2031, 3363, 3364, 3365, 5382, 148, 4481, 2839, 2844, 3211, 3212, 3378, 3379, 4147, 4148, 4149, 4487, 4488, 4646, 4647, 4648, 2846, 2847, 2848, 4955, 545, 801, 3028, 2855, 2856, 6890, 4817]. **Number-Theoretic** [4100, 4270]. **Numbers** [7514, 7559, 665, 1013, 4166, 39, 5137, 1493, 1095, 6404, 2507, 551, 5908, 6169, 3567, 6531, 6532, 7447, 4523, 1383, 2515, 6689, 332, 1389, 1108, 1829, 1830, 4344, 156, 6818, 4840, 6546, 673, 1207, 4849, 7526, 55, 878, 1516, 3755, 6705, 54, 3758, 6194, 7061, 2715, 559, 560, 41, 1212, 2540, 6831, 1976, 2544, 2719, 2910, 6198, 6200, 4219, 343, 5938, 6209, 6327, 4574, 7078, 1636, 6107, 260, 1529, 5547, 639, 686, 5867, 6602, 447, 2953, 4416, 2259, 3486, 6023, 115, 6027, 7098, 1152, 2784, 2785, 368, 4614, 1449, 3817, 1239, 6867, 185, 3945, 4926, 2150]. **Numbers** [6627, 2607, 4932, 5371, 3834, 3530, 1699, 3366, 6495, 6766, 1471, 1257, 661, 5985, 949, 1079, 4957, 6813, 5251, 3972, 6156, 3391, 4980, 2330, 3568, 4815, 6409, 5705, 5144, 2673, 2674, 2675, 5913, 4820, 4821, 2347, 5599, 2889, 5288, 3745, 2693, 2694, 2703, 2371, 137, 1404, 2377, 308, 2382, 1615, 6093, 4556, 4716, 5417, 1215, 1296, 138, 6196, 3278, 682, 1624, 256, 2100, 2740, 2926, 4879, 5041, 3468, 5326, 1994, 2934, 6335, 4074, 5623, 6598, 2255, 6221, 3135, 1435, 2952, 1319, 3654, 3487, 3310, 364, 5631, 2769, 3659, 8, 4754, 4271, 4437, 4914, 1333, 1064, 2598]. **numbers** [2145, 654, 711, 4119, 4766, 2805, 4455, 5653, 3189, 6995, 3005, 846, 5464, 5465, 6147, 3961, 850, 4950, 2307, 3375, 5246]. **numeral** [5551]. **Numerals** [877, 5551, 961]. **numerare** [2]. **Numeration** [7016, 1605, 512, 623, 1400, 96, 6996, 2703]. **numeri** [137, 138]. **Numeric** [2645, 1581, 6684, 3437, 893, 1044, 577, 1316, 2954, 2778, 1324, 1326, 1534, 2459, 929, 1687, 1936, 2477, 2508, 5711, 2368, 3762, 3444, 3608, 2751, 1321, 6364, 1663]. **Numerical** [7246, 2173, 5813, 7253, 7426, 4656, 4794, 496, 7499, 6055, 7417, 2868, 3045, 6163, 6907, 3729, 7440, 5484, 5691, 5907, 6276, 1716, 6683, 6530, 5592, 5594, 731, 1197, 6066, 7391, 7240, 1390, 817, 6069, 7044, 3251, 4351, 5922, 5837, 3586, 1601,

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2354, 4185, 2890, 5289, 2209, 503, 1734, 1735, 1833, 2892, 6005, 4016, 1203, 1395, 5291, 5156, 5510, 735, 1117, 5008, 4190, 4191, 6941, 4702, 4703, 5602]. **point** [4704, 1513, 1969, 2366, 1737, 4705, 1970, 736, 820, 509, 822, 3751, 6701, 7055, 7159, 1205, 5298, 1030, 2075, 6298, 2898, 2370, 4851, 2530, 6702, 4709, 5842, 4710, 283, 3084, 3261, 4712, 4854, 5843, 3085, 2532, 622, 880, 1031, 1209, 1284, 1740, 3438, 2374, 2900, 3086, 1032, 2709, 1844, 5520, 968, 1845, 2536, 1846, 5727, 2376, 4857, 4858, 1847, 5416, 6009, 6088, 6553, 1288, 1611, 2377, 252, 178, 308, 2713, 3896, 2381, 1851, 4367, 4861, 3897, 2538, 6945, 4037, 6709, 6710, 3088, 4038, 3759, 5020, 3605, 5848, 7062, 4039, 4556, 4716, 6557, 3764, 5166, 2902, 2903]. **point** [3265, 3607, 4208, 6438, 1037, 3091, 3444, 3608, 1292, 1408, 5025, 1214, 1975, 3610, 2223, 3445, 1409, 1297, 3270, 3098, 5936, 4045, 2224, 3450, 5532, 4564, 2908, 2541, 3099, 1299, 2718, 5311, 5312, 1745, 6714, 2911, 6443, 6570, 6716, 5741, 3275, 3276, 2086, 5742, 517, 2724, 827, 1216, 2389, 5744, 682, 2391, 3905, 1219, 1864, 7070, 1747, 3285, 3620, 4223, 5174, 5175, 5177, 5533, 2227, 2228, 4049, 4567, 5317, 7191, 3619, 1134, 4222, 1220, 1867, 2392, 4723, 5937, 2914, 4569, 5752, 5753, 1625, 3288, 6011, 6205, 6321, 6322, 6449, 2395, 201, 2090, 4054, 3623, 6012, 6453, 2231, 2919, 3110, 3289]. **point** [6013, 2233, 2401, 2402, 2234, 3111, 1986, 627, 2094, 2095, 3461, 3626, 3627, 4226, 4228, 5610, 5758, 4725, 2923, 3291, 3463, 3629, 3292, 6105, 629, 474, 745, 2405, 2406, 3293, 3294, 2407, 2408, 747, 748, 1225, 258, 5037, 2552, 2241, 2100, 1633, 312, 521, 4877, 4878, 6329, 2741, 1226, 1227, 2412, 2414, 2415, 2928, 1752, 1875, 1528, 1753, 5617, 6841, 3635, 3915, 4394, 3123, 3300, 1988, 4881, 5619, 4576, 896, 2932, 3468, 5326, 830, 898, 974, 1994, 6107, 4238, 5949, 6109, 4882, 2557, 3302, 900, 976, 2934, 7080, 2247, 2248, 6332, 5951, 6458, 4581, 4883, 6335, 6731, 3918, 3919]. **point** [5859, 5190, 7169, 6216, 350, 756, 2423, 2748, 2936, 3125, 4583, 5862, 6115, 6016, 5955, 6846, 4886, 3791, 4408, 4589, 352, 6465, 4591, 3922, 6847, 4887, 525, 572, 684, 5623, 1758, 5337, 3642, 5624, 5957, 1639, 5339, 5340, 4246, 6020, 4889, 6598, 2253, 1890, 7192, 1051, 1996, 1314, 1760, 2949, 3649, 574, 641, 758, 759, 402, 3651, 689, 690, 980, 575, 6021, 2255, 4891, 1997, 1998, 981, 910, 3134, 6221, 3135, 1435, 2567, 4596, 4740, 5778, 6122, 3137, 2257, 2117, 6964, 6355, 2763, 5062, 2258, 5342, 3143, 6738, 7094, 1647, 6739, 3146, 1648, 1649, 696, 2569, 2259, 5779, 5870, 3485, 5344]. **point** [4898, 5064, 5346, 5347, 5348, 5432, 5553, 6967, 2570, 2000, 3928, 5067, 5434, 320, 1895, 2261, 2441, 2444, 2446, 2769, 3659, 6026, 1438, 3929, 2121, 2962, 2963, 918, 5634, 7101, 5435, 2447, 2448, 985, 4259, 3319, 4747, 2967, 2265, 3152, 6229, 3320, 3321, 3934, 4092, 2452, 3810, 4907, 6978, 2576, 3326, 581, 4908, 5352, 5876, 6231, 481, 4261, 3154, 3155, 5353, 5557, 6134, 5877, 986, 4264, 4098, 4267, 5785, 766, 987, 3813, 4099, 7110, 4753, 3333, 6136, 4911, 646, 1328, 2005, 5786, 5636, 7111, 2269, 208, 701, 990, 2270, 2976, 2271, 3815, 7113, 2272, 2273, 2585, 3335, 2008, 527]. **point** [7114, 3504, 2274, 838, 7197, 2589, 2798, 2983, 4917, 2009, 2277, 3338, 4102, 5789, 6234, 2457, 2592, 2802, 2984, 2593, 2594, 1774, 2139, 1333, 5082, 6865, 993, 529, 1241, 1242, 1334, 707, 1063, 2985, 1064, 3339, 1678, 484, 4923, 3508, 774, 5969, 6238, 5643, 5644, 5879, 6241, 5792, 3942, 3943, 4106, 1337, 4924, 4623, 1914, 3167, 107, 5793, 5647, 6487, 998, 2986, 2463,

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1. Table 5 (page 124):

- insert `k <-- 0` after assertion, and also delete `k <-- 0` from Table 6.
2. Table 9 (page 125):
 

```
for          -1:USER!("");
substitute   -1:USER!("0");
```

 and delete the comment.
  3. Table 10 (page 125):
 

```
for          fill(-k, "0")
substitute   fill(-k-1, "0")
```
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- branch and bound algorithms for global optimization,
- constraint propagation,
- solution sets of linear systems,
- hardware and software systems for interval computations, and
- fuzzy logic.

Actual applications described in the book include:

- economic input-output models,
- quality control in manufacturing design,
- a computer-assisted proof in quantum mechanics,
- medical expert systems,
- and others.

A realistic view of interval computations is taken: the articles indicate when and how overestimation and other challenges can be overcome. An introductory chapter explains the content of the papers in terminology accessible to mathematically literate graduate students. The style of the individual, refereed contributions has been made uniform and understandable, and there is an extensive book-wide index. Audience: Valuable to students and researchers interested in automatic result verification. Detailed information, including contents, contributors, and an order form can be found:

- on Kluwer homepage <http://www.wkap.nl>, or
- on the Interval Computations homepage <http://cs.utep.edu/interval-comp/main.html>, in the “Books” section.

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Industry immediately started to investigate the failure.” From the report: “The internal SRI software exception was caused during execution of a data conversion from 64-bit floating point to 16-bit signed integer value. The floating point number which was converted had a value greater than what could be represented by a 16-bit signed integer. This resulted in an Operand Error. The data conversion instructions (in Ada code) were not protected from causing an Operand Error, although other conversions of comparable variables in the same place in the code were protected.”.

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result. Interval arithmetic is an improvement on this, but still not an ideal solution because if the final interval is larger than desired, there is no simple way to restart the computation at higher precision. By contrast, in XR no precision level is set in advance, and no computation takes place until a final request takes place for some output. Despite this, programming with XR is no different from MPFP, except for the declaration of critical variables as type ‘XR’.

The main aim is to produce a usable efficient implementation, which can be easily interfaced with existing C++ code. This contrasts with previous implementations in functional languages (Haskell, Miranda etc.), which, although theoretically important, seem to be rather too slow for real use.

This code is designed as an add-on to Victor Shoup’s arbitrary-precision arithmetic package NTL, and implements a new type XR, to complement NTL’s ZZ and RR integer and real types.

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- branch and bound algorithms for global optimization,
- constraint propagation,
- solution sets of linear systems,
- hardware and software systems for interval computations, and
- fuzzy logic.

Actual applications described in the book include:

- economic input-output models,
- quality control in manufacturing design,
- a computer-assisted proof in quantum mechanics,
- medical expert systems,
- and others.

A realistic view of interval computations is taken: the articles indicate when and how overestimation and other challenges can be overcome. An introductory chapter explains the content of the papers in terminology accessible to mathematically literate graduate students. The style of

the individual, refereed contributions has been made uniform and understandable, and there is an extensive book-wide index. Audience: Valuable to students and researchers interested in automatic result verification. Detailed information, including contents, contributors, and an order form can be found:

- on Kluwer homepage <http://www.wkap.nl>, or
- on the Interval Computations homepage <http://cs.utep.edu/interval-comp/main.html>, in the “Books” section.

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