Assignment 4

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CSE 13S – Winter 24

Purpose

Audience for this section: Pretend that you are working in industry, and write this paragraph for your boss. You are answering the basic question, "What does this thing do?". This section can be short. A single paragraph is okay.

Do not just copy the assignment PDF to complete this section, use your own words.

Questions

Please answer the following questions before you start coding. They will help guide you through the assignment. To make the grader's life easier, please do not remove the questions, and simply put your answers below the text of each question.

- Are there any cases where our sin or cosine formulae can't be used? How can we avoid this?

  ANS

  Our user-defined Sin and Cos functions should be able to be used for any angle, perhaps besides extremely large or small angles, however all input angles should be normalized to between 0 and 2 pi. Then, the Sin and Cos formulae will work at all inputs.

- What ways (other than changing epsilon) can we use to make our results more accurate?

  ANS

  Reducing angle range, allowing Taylor Series to converge more rapidly, will make results more accurate. Using a data type larger than double will also help.

- What does it mean to normalize input? What would happen if you didn't?

  ANS

  We normalize input between 0 and 2 pi radians. If we didn't normalize input it would take much longer for the Taylor series to converge and our results may be less accurate if not impossible to calculate given sufficiently large or small input.

- How would you handle the expression 321+? What should the output be? How can we make this a more understandable RPN expression?

ANS

The expression should simplify the [3,2,1,+] stack to [3,3]. The expression may be more understandable if the RPN is visualized in stack notation or if more operators are provided so the stack reduces to a one-number result.

- Does RPN need parenthesis? Why or why not?

ANS

RPN doesn't need parenthesis because operators are placed directly after their operands and apply to said operands.

Testing

List what you will do to test your code. Make sure this is comprehensive. Be sure to test inputs with delays and a wide range of files/characters.

ANS

I will test a large number of inputs to the stack, functionality of all user-defined math functions, invalid inputs, and basic regular functionality of the calculator.

How to Use the Program

./calc will be used on the command line followed by a .txt file input or input characters. The program will then run down the RPN stack from the input provided.

Program Design

A stack, doubles, user defined types and functions, and pointers to functions are used to create our calculator. The math functions can be maintained in mathlib.c, the calculator is controlled by calc.c, our stack is defined in stack.c, and several function operators are defined in operators.c. All 4 files work together in calc.c to give us a working calculator.

Pseudocode

```
FUNCTION main(argc, argv):
   DECLARE a AS INTEGER
   DECLARE save, token AS STRING
   DECLARE buffer[1024] AS STRING
   DECLARE e AS BOOLEAN
   DECLARE dtoken AS DOUBLE

   WHILE (a = getopt(argc, argv, "mh")) != -1:
       SWITCH a:
           CASE 'm': BREAK
           CASE 'h': PRINT USAGE(argv[0]); RETURN 0
           CASE '?': PRINT USAGE(argv[0]); RETURN 1

   WHILE (NOT feof(stdin)):
       PRINT "> "
       READ buffer FROM stdin
       token = strtok_r(buffer, " ", save)
       e = false
```

```
        WHILE (token IS NOT NULL AND NOT e):
            FOR i FROM 0 TO LENGTH(token):
                IF token[i] = '\n' THEN
                    token[i] = '\0'
                END IF
            END FOR

            IF parse_double(token, dtoken) THEN
                IF stack_push(dtoken) = false THEN
                    PRINT ERROR_NO_SPACE(dtoken)
                    e = true
                END IF
            ELSE IF token EQUALS "+" OR token EQUALS "-" OR token EQUALS "*" OR token EQUALS "/" OR
                 token EQUALS "%" THEN
                IF apply_binary_operator(binary_operators[token[0]]) = false THEN
                    PRINT ERROR_BINARY_OPERATOR
                    e = true
                END IF
            ELSE IF token EQUALS "s" OR token EQUALS "c" OR token EQUALS "t" OR token EQUALS "a" OR
                 token EQUALS "r" THEN
                IF apply_unary_operator(my_unary_operators[token[0]]) = false THEN
                    PRINT ERROR_UNARY_OPERATOR
                    e = true
                END IF
            ELSE:
                IF LENGTH(token) = 1 THEN
                    PRINT ERROR_BAD_CHAR(token[0])
                    e = true
                ELSE:
                    PRINT ERROR_BAD_STRING(token)
                    e = true
                END IF
            END IF

            token = strtok_r(NULL, " ", save)
        END WHILE

        IF (e = false AND NOT feof(stdin)) THEN
            stack_print()
            PRINT "\n"
        END IF

        stack_clear()

    RETURN 0
END FUNCTION
```

Function Descriptions

Sin(x), Cos(x), and Tan(x) all take in a double x, convert it to between 0 and 2 pi radians, and calulate the sin, cos, or tan of that angle respectively. Abs(x) takes in a double x, and if it is negative it returns -x, otherwise it returns x. Sqrt(x) takes a double x and returns its square root. stack_push(x) takes a double x, and adds it to the stack, incrementing stack size, and returns true or false depending if the push was successful. stack_pop(x) takes in a double x reduces stack size, and returns t/f depending if the pop was successful, and x is changed to the value popped off. stack_peek(x) takes in a double x, and returns t/f depending if the peek was successful, and x is changed to the value popped off. stack_clear() has no input or output and just changes stack size to 0. stack_print() has no input or output, but prints all items of the

stack to the screen. parse_double(s, d) takes a string s and double d and checks if the double d is in string s, returning t/f depending if it is. operator_add/sub/mul/div(lhs, rhs) takes in a left hand side double and right hand side double, and performs either +/-/*/ or / respectively with the doubles. They return the result. apply_binary_operator(op) takes a user-defined type of binary_operator_fn and applies it to the stack, returning t/f depending if the operation was successful or not. apply_unary_operator(op) takes a user-defined type of unary_operator_fn and applies it to the stack, returning t/f depending if the operation was successful or not.

Results

```
#include <stdio.h>
#include <math.h>
#define EPSILON 1e-14

double Abs(double x) {
    if (x < 0.0)
        return -x;
    return x;
}

double Sqrt(double x) {
    if (x < 0)
        return nan("nan");
    double old = 0.0, new = 1.0;
    while (Abs(old - new) > EPSILON) {
        old = new;
        new = 0.5 * (old + (x / old));
    }
    return new;
}

double Sin(double x) {
    x = fmod(x, 2 * M_PI);
    double sinval = 0.0, term = x, n=2.0;
    while (fabs(term) > EPSILON) {
        sinval += term;
        term *= (-1.0*x*x)/(n*(n+1.0));
        n += 2.0;
    }
    return sinval;
}

double Cos(double x) {
    x = fmod(x, 2 * M_PI);
    double cosval = 0.0, term = 1.0, n = 1.0;
    while (fabs(term) > EPSILON) {
        cosval += term;
        term *= (-1.0*x*x)/(n*(n+1.0));
        n+=2.0;
    }
    return cosval;
}

double Tan(double x) {
    return (Sin(x) / Cos(x));
}
```

```
int main(void) {
  for( double input = -2*M_PI; input <= 2*M_PI; input += M_PI/16.0 ){
  printf("USER: Abs = %f\tSqrt = %f\tSin = %f\tCos = %f\tTan = %f\n", Abs(input), Sqrt(input), Sin(
      input), Cos(input), Tan(input));
  printf("REAL: Abs = %f\tSqrt = %f\tSin = %f\tCos = %f\tTan = %f\n", fabs(input), sqrt(input), sin
      (input), cos(input), tan(input));
  printf("DIFF: Abs = %f\tSqrt = %f\tSin = %f\tCos = %f\tTan = %f\n", Abs(input) - fabs(input),
      Sqrt(input) - sqrt(input), Sin(input) - sin(input), Cos(input) - cos(input), Tan(input) - tan
      (input));
    };
  return 0;
}
```

OUTPUT:

```
USER: Abs = 6.283185  Sqrt = nan Sin = 0.000000 Cos = 1.000000 Tan = 0.000000
REAL: Abs = 6.283185  Sqrt = -nan Sin = 0.000000 Cos = 1.000000 Tan = 0.000000
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 6.086836  Sqrt = nan Sin = 0.195090 Cos = 0.980785 Tan = 0.198912
REAL: Abs = 6.086836  Sqrt = -nan Sin = 0.195090 Cos = 0.980785 Tan = 0.198912
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 5.890486  Sqrt = nan Sin = 0.382683 Cos = 0.923880 Tan = 0.414214
REAL: Abs = 5.890486  Sqrt = -nan Sin = 0.382683 Cos = 0.923880 Tan = 0.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 5.694137  Sqrt = nan Sin = 0.555570 Cos = 0.831470 Tan = 0.668179
REAL: Abs = 5.694137  Sqrt = -nan Sin = 0.555570 Cos = 0.831470 Tan = 0.668179
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = -0.000000  Tan = 0.000000
USER: Abs = 5.497787  Sqrt = nan Sin = 0.707107 Cos = 0.707107 Tan = 1.000000
REAL: Abs = 5.497787  Sqrt = -nan Sin = 0.707107 Cos = 0.707107 Tan = 1.000000
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 5.301438  Sqrt = nan Sin = 0.831470 Cos = 0.555570 Tan = 1.496606
REAL: Abs = 5.301438  Sqrt = -nan Sin = 0.831470 Cos = 0.555570 Tan = 1.496606
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = -0.000000 Tan = 0.000000
USER: Abs = 5.105088  Sqrt = nan Sin = 0.923880 Cos = 0.382683 Tan = 2.414214
REAL: Abs = 5.105088  Sqrt = -nan Sin = 0.923880 Cos = 0.382683 Tan = 2.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 4.908739  Sqrt = nan Sin = 0.980785 Cos = 0.195090 Tan = 5.027339
REAL: Abs = 4.908739  Sqrt = -nan Sin = 0.980785 Cos = 0.195090 Tan = 5.027339
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 4.712389  Sqrt = nan Sin = 1.000000 Cos = -0.000000  Tan = -526507330395186.375000
REAL: Abs = 4.712389  Sqrt = -nan Sin = 1.000000 Cos = -0.000000 Tan = -510190062007397.125000
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = -16317268387789.250000
USER: Abs = 4.516039  Sqrt = nan Sin = 0.980785 Cos = -0.195090  Tan = -5.027339
REAL: Abs = 4.516039  Sqrt = -nan Sin = 0.980785 Cos = -0.195090 Tan = -5.027339
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = -0.000000  Tan = 0.000000
USER: Abs = 4.319690  Sqrt = nan Sin = 0.923880 Cos = -0.382683  Tan = -2.414214
REAL: Abs = 4.319690  Sqrt = -nan Sin = 0.923880 Cos = -0.382683 Tan = -2.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = -0.000000 Tan = 0.000000
USER: Abs = 4.123340  Sqrt = nan Sin = 0.831470 Cos = -0.555570  Tan = -1.496606
REAL: Abs = 4.123340  Sqrt = -nan Sin = 0.831470 Cos = -0.555570 Tan = -1.496606
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 3.926991  Sqrt = nan Sin = 0.707107 Cos = -0.707107  Tan = -1.000000
REAL: Abs = 3.926991  Sqrt = -nan Sin = 0.707107 Cos = -0.707107 Tan = -1.000000
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 3.730641  Sqrt = nan Sin = 0.555570 Cos = -0.831470  Tan = -0.668179
REAL: Abs = 3.730641  Sqrt = -nan Sin = 0.555570 Cos = -0.831470 Tan = -0.668179
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 3.534292  Sqrt = nan Sin = 0.382683 Cos = -0.923880  Tan = -0.414214
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REAL: Abs = 3.534292  Sqrt = -nan Sin = 0.382683 Cos = -0.923880 Tan = -0.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = -0.000000  Tan = 0.000000
USER: Abs = 3.337942  Sqrt = nan Sin = 0.195090 Cos = -0.980785  Tan = -0.198912
REAL: Abs = 3.337942  Sqrt = -nan Sin = 0.195090 Cos = -0.980785 Tan = -0.198912
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = -0.000000 Tan = 0.000000
USER: Abs = 3.141593  Sqrt = nan Sin = -0.000000 Cos = -1.000000 Tan = 0.000000
REAL: Abs = 3.141593  Sqrt = -nan Sin = -0.000000 Cos = -1.000000 Tan = 0.000000
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = -0.000000 Tan = 0.000000
USER: Abs = 2.945243  Sqrt = nan Sin = -0.195090 Cos = -0.980785 Tan = 0.198912
REAL: Abs = 2.945243  Sqrt = -nan Sin = -0.195090 Cos = -0.980785 Tan = 0.198912
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 2.748894  Sqrt = nan Sin = -0.382683 Cos = -0.923880 Tan = 0.414214
REAL: Abs = 2.748894  Sqrt = -nan Sin = -0.382683 Cos = -0.923880 Tan = 0.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 2.552544  Sqrt = nan Sin = -0.555570 Cos = -0.831470 Tan = 0.668179
REAL: Abs = 2.552544  Sqrt = -nan Sin = -0.555570 Cos = -0.831470 Tan = 0.668179
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = -0.000000  Tan = -0.000000
USER: Abs = 2.356194  Sqrt = nan Sin = -0.707107 Cos = -0.707107 Tan = 1.000000
REAL: Abs = 2.356194  Sqrt = -nan Sin = -0.707107 Cos = -0.707107 Tan = 1.000000
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = -0.000000  Tan = -0.000000
USER: Abs = 2.159845  Sqrt = nan Sin = -0.831470 Cos = -0.555570 Tan = 1.496606
REAL: Abs = 2.159845  Sqrt = -nan Sin = -0.831470 Cos = -0.555570 Tan = 1.496606
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 1.963495  Sqrt = nan Sin = -0.923880 Cos = -0.382683 Tan = 2.414214
REAL: Abs = 1.963495  Sqrt = -nan Sin = -0.923880 Cos = -0.382683 Tan = 2.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 1.767146  Sqrt = nan Sin = -0.980785 Cos = -0.195090 Tan = 5.027339
REAL: Abs = 1.767146  Sqrt = -nan Sin = -0.980785 Cos = -0.195090 Tan = 5.027339
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 1.570796  Sqrt = nan Sin = -1.000000 Cos = 0.000000 Tan = -767391639233967.375000
REAL: Abs = 1.570796  Sqrt = -nan Sin = -1.000000 Cos = 0.000000 Tan = -211677438046097.062500
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = -0.000000  Tan = -555714201187870.312500
USER: Abs = 1.374447  Sqrt = nan Sin = -0.980785 Cos = 0.195090 Tan = -5.027339
REAL: Abs = 1.374447  Sqrt = -nan Sin = -0.980785 Cos = 0.195090 Tan = -5.027339
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = -0.000000 Tan = -0.000000
USER: Abs = 1.178097  Sqrt = nan Sin = -0.923880 Cos = 0.382683 Tan = -2.414214
REAL: Abs = 1.178097  Sqrt = -nan Sin = -0.923880 Cos = 0.382683 Tan = -2.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 0.981748  Sqrt = nan Sin = -0.831470 Cos = 0.555570 Tan = -1.496606
REAL: Abs = 0.981748  Sqrt = -nan Sin = -0.831470 Cos = 0.555570 Tan = -1.496606
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 0.785398  Sqrt = nan Sin = -0.707107 Cos = 0.707107 Tan = -1.000000
REAL: Abs = 0.785398  Sqrt = -nan Sin = -0.707107 Cos = 0.707107 Tan = -1.000000
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = -0.000000  Tan = -0.000000
USER: Abs = 0.589049  Sqrt = nan Sin = -0.555570 Cos = 0.831470 Tan = -0.668179
REAL: Abs = 0.589049  Sqrt = -nan Sin = -0.555570 Cos = 0.831470 Tan = -0.668179
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 0.392699  Sqrt = nan Sin = -0.382683 Cos = 0.923880 Tan = -0.414214
REAL: Abs = 0.392699  Sqrt = -nan Sin = -0.382683 Cos = 0.923880 Tan = -0.414214
DIFF: Abs = 0.000000  Sqrt = nan Sin = 0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 0.196350  Sqrt = nan Sin = -0.195090 Cos = 0.980785 Tan = -0.198912
REAL: Abs = 0.196350  Sqrt = -nan Sin = -0.195090 Cos = 0.980785 Tan = -0.198912
DIFF: Abs = 0.000000  Sqrt = nan Sin = -0.000000 Cos = 0.000000 Tan = -0.000000
USER: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 1.000000 Tan = 0.000000
REAL: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 1.000000 Tan = 0.000000
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 0.196350  Sqrt = 0.443113 Sin = 0.195090Cos = 0.980785 Tan = 0.198912
REAL: Abs = 0.196350  Sqrt = 0.443113 Sin = 0.195090Cos = 0.980785 Tan = 0.198912
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 0.000000 Tan = 0.000000
```

```
USER: Abs = 0.392699  Sqrt = 0.626657 Sin = 0.382683Cos = 0.923880 Tan = 0.414214
REAL: Abs = 0.392699  Sqrt = 0.626657 Sin = 0.382683Cos = 0.923880 Tan = 0.414214
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 0.589049  Sqrt = 0.767495 Sin = 0.555570Cos = 0.831470 Tan = 0.668179
REAL: Abs = 0.589049  Sqrt = 0.767495 Sin = 0.555570Cos = 0.831470 Tan = 0.668179
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 0.785398  Sqrt = 0.886227 Sin = 0.707107Cos = 0.707107 Tan = 1.000000
REAL: Abs = 0.785398  Sqrt = 0.886227 Sin = 0.707107Cos = 0.707107 Tan = 1.000000
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = -0.000000 Tan = 0.000000
USER: Abs = 0.981748  Sqrt = 0.990832 Sin = 0.831470Cos = 0.555570 Tan = 1.496606
REAL: Abs = 0.981748  Sqrt = 0.990832 Sin = 0.831470Cos = 0.555570 Tan = 1.496606
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 1.178097  Sqrt = 1.085402 Sin = 0.923880Cos = 0.382683 Tan = 2.414214
REAL: Abs = 1.178097  Sqrt = 1.085402 Sin = 0.923880Cos = 0.382683 Tan = 2.414214
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 1.374447  Sqrt = 1.172368 Sin = 0.980785Cos = 0.195090 Tan = 5.027339
REAL: Abs = 1.374447  Sqrt = 1.172368 Sin = 0.980785Cos = 0.195090 Tan = 5.027339
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = -0.000000 Tan = 0.000000
USER: Abs = 1.570796  Sqrt = 1.253314 Sin = 1.000000Cos = -0.000000 Tan = -124928193894467.562500
REAL: Abs = 1.570796  Sqrt = 1.253314 Sin = 1.000000Cos = -0.000000 Tan = -217310787702646.593750
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = -0.000000 Tan = 92382593808179.031250
USER: Abs = 1.767146  Sqrt = 1.329340 Sin = 0.980785Cos = -0.195090 Tan = -5.027339
REAL: Abs = 1.767146  Sqrt = 1.329340 Sin = 0.980785Cos = -0.195090 Tan = -5.027339
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = 0.000000
USER: Abs = 1.963495  Sqrt = 1.401248 Sin = 0.923880Cos = -0.382683 Tan = -2.414214
REAL: Abs = 1.963495  Sqrt = 1.401248 Sin = 0.923880Cos = -0.382683 Tan = -2.414214
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 2.159845  Sqrt = 1.469641 Sin = 0.831470Cos = -0.555570 Tan = -1.496606
REAL: Abs = 2.159845  Sqrt = 1.469641 Sin = 0.831470Cos = -0.555570 Tan = -1.496606
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 2.356194  Sqrt = 1.534990 Sin = 0.707107Cos = -0.707107 Tan = -1.000000
REAL: Abs = 2.356194  Sqrt = 1.534990 Sin = 0.707107Cos = -0.707107 Tan = -1.000000
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = -0.000000 Tan = 0.000000
USER: Abs = 2.552544  Sqrt = 1.597668 Sin = 0.555570Cos = -0.831470 Tan = -0.668179
REAL: Abs = 2.552544  Sqrt = 1.597668 Sin = 0.555570Cos = -0.831470 Tan = -0.668179
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = -0.000000 Tan = 0.000000
USER: Abs = 2.748894  Sqrt = 1.657979 Sin = 0.382683Cos = -0.923880 Tan = -0.414214
REAL: Abs = 2.748894  Sqrt = 1.657979 Sin = 0.382683Cos = -0.923880 Tan = -0.414214
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = 0.000000
USER: Abs = 2.945243  Sqrt = 1.716171 Sin = 0.195090Cos = -0.980785 Tan = -0.198912
REAL: Abs = 2.945243  Sqrt = 1.716171 Sin = 0.195090Cos = -0.980785 Tan = -0.198912
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 3.141593  Sqrt = 1.772454 Sin = -0.000000Cos = -1.000000 Tan = 0.000000
REAL: Abs = 3.141593  Sqrt = 1.772454 Sin = -0.000000Cos = -1.000000 Tan = 0.000000
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = -0.000000 Tan = -0.000000
USER: Abs = 3.337942  Sqrt = 1.827004 Sin = -0.195090Cos = -0.980785 Tan = 0.198912
REAL: Abs = 3.337942  Sqrt = 1.827004 Sin = -0.195090Cos = -0.980785 Tan = 0.198912
DIFF: Abs = 0.000000  Sqrt = -0.000000  Sin = -0.000000  Cos = -0.000000 Tan = -0.000000
USER: Abs = 3.534292  Sqrt = 1.879971 Sin = -0.382683Cos = -0.923880 Tan = 0.414214
REAL: Abs = 3.534292  Sqrt = 1.879971 Sin = -0.382683Cos = -0.923880 Tan = 0.414214
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = -0.000000 Tan = -0.000000
USER: Abs = 3.730641  Sqrt = 1.931487 Sin = -0.555570Cos = -0.831470 Tan = 0.668179
REAL: Abs = 3.730641  Sqrt = 1.931487 Sin = -0.555570Cos = -0.831470 Tan = 0.668179
DIFF: Abs = 0.000000  Sqrt = -0.000000  Sin = -0.000000  Cos = 0.000000 Tan = 0.000000
USER: Abs = 3.926991  Sqrt = 1.981664 Sin = -0.707107Cos = -0.707107 Tan = 1.000000
REAL: Abs = 3.926991  Sqrt = 1.981664 Sin = -0.707107Cos = -0.707107 Tan = 1.000000
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 0.000000 Tan = 0.000000
USER: Abs = 4.123340  Sqrt = 2.030601 Sin = -0.831470Cos = -0.555570 Tan = 1.496606
REAL: Abs = 4.123340  Sqrt = 2.030601 Sin = -0.831470Cos = -0.555570 Tan = 1.496606
```

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DIFF: Abs = 0.000000  Sqrt = -0.000000  Sin = 0.000000 Cos = -0.000000 Tan = -0.000000
USER: Abs = 4.319690  Sqrt = 2.078386 Sin = -0.923880Cos = -0.382683 Tan = 2.414214
REAL: Abs = 4.319690  Sqrt = 2.078386 Sin = -0.923880Cos = -0.382683 Tan = 2.414214
DIFF: Abs = 0.000000  Sqrt = -0.000000  Sin = 0.000000 Cos = -0.000000 Tan = -0.000000
USER: Abs = 4.516039  Sqrt = 2.125098 Sin = -0.980785Cos = -0.195090 Tan = 5.027339
REAL: Abs = 4.516039  Sqrt = 2.125098 Sin = -0.980785Cos = -0.195090 Tan = 5.027339
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = -0.000000 Tan = -0.000000
USER: Abs = 4.712389  Sqrt = 2.170804 Sin = -1.000000Cos = 0.000000 Tan = -135129532984634.093750
REAL: Abs = 4.712389  Sqrt = 2.170804 Sin = -1.000000Cos = 0.000000 Tan = -144472545332950.906250
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = 9343012348316.812500
USER: Abs = 4.908739  Sqrt = 2.215567 Sin = -0.980785Cos = 0.195090 Tan = -5.027339
REAL: Abs = 4.908739  Sqrt = 2.215567 Sin = -0.980785Cos = 0.195090 Tan = -5.027339
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = 0.000000
USER: Abs = 5.105088  Sqrt = 2.259444 Sin = -0.923880Cos = 0.382683 Tan = -2.414214
REAL: Abs = 5.105088  Sqrt = 2.259444 Sin = -0.923880Cos = 0.382683 Tan = -2.414214
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = 0.000000 Tan = 0.000000
USER: Abs = 5.301438  Sqrt = 2.302485 Sin = -0.831470Cos = 0.555570 Tan = -1.496606
REAL: Abs = 5.301438  Sqrt = 2.302485 Sin = -0.831470Cos = 0.555570 Tan = -1.496606
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = 0.000000Cos = -0.000000 Tan = 0.000000
USER: Abs = 5.497787  Sqrt = 2.344736 Sin = -0.707107Cos = 0.707107 Tan = -1.000000
REAL: Abs = 5.497787  Sqrt = 2.344736 Sin = -0.707107Cos = 0.707107 Tan = -1.000000
DIFF: Abs = 0.000000  Sqrt = -0.000000  Sin = 0.000000 Cos = 0.000000 Tan = 0.000000
USER: Abs = 5.694137  Sqrt = 2.386239 Sin = -0.555570Cos = 0.831470 Tan = -0.668179
REAL: Abs = 5.694137  Sqrt = 2.386239 Sin = -0.555570Cos = 0.831470 Tan = -0.668179
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = -0.000000 Tan = -0.000000
USER: Abs = 5.890486  Sqrt = 2.427032 Sin = -0.382683Cos = 0.923880 Tan = -0.414214
REAL: Abs = 5.890486  Sqrt = 2.427032 Sin = -0.382683Cos = 0.923880 Tan = -0.414214
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = -0.000000
USER: Abs = 6.086836  Sqrt = 2.467151 Sin = -0.195090Cos = 0.980785 Tan = -0.198912
REAL: Abs = 6.086836  Sqrt = 2.467151 Sin = -0.195090Cos = 0.980785 Tan = -0.198912
DIFF: Abs = 0.000000  Sqrt = 0.000000 Sin = -0.000000Cos = 0.000000 Tan = -0.000000
```

References