ECOR 1606 Practice Lab Final

The Sine Integral is defined as

$$Si(x) = \int_0^x \frac{\sin(t)}{t}\,dt$$

Gauss-Legendre quadrature can be used to accurately approximate *Si*(*x*). The approximation is:

$$Si(x) \cong \sum_{n=0}^{4} A_n \sin(x\tau_n)$$

where $A_0 = 2.5253303767$ $\tau_0 = 0.0469100770$
$A_1 = 1.0370462484$ $\tau_1 = 0.2307653450$
$A_2 = 0.5688888889$ $\tau_2 = 0.5000000000$
$A_3 = 0.3111070642$ $\tau_3 = 0.7692346550$
$A_4 = 0.1242940878$ $\tau_4 = 0.9530899230$

examples: *Si*(1) = 0.946083 *Si*(2) = 1.60541 *Si*(3) = 1.84865

Write a C++ **function**, ***Si***, that takes *x*, and approximates *Si*(*x*) and returns the result. Note that it is NOT necessary to convert from degrees to radians when using function *sin* because the argument is already in radians. Your function must correspond exactly to this specification.

Then write a C++ **program** ("***practice.cpp***") that finds the largest and smallest values of *Si*(*x*) for $a \le x \le b$. The largest and smallest values are to be found by evaluating *Si*(*x*) at *N* equally spaced values for *x*, starting with *x* = *a* and ending with *x* = *b*. Your program must make use of the function required above.

Your program should repeatedly read in values for *a*, *b*, and *N* until 0 0 0 is entered. Note that *N* is an integer. For each set of values entered your program should either i) output an error message (if the values are unacceptable -- see next paragraph) or ii) find and output the largest and smallest values of *Si*(*x*), and, if N is less than or equal to 5, output every *x* considered and the corresponding value for *Si*(*x*).

The value of *a* must be greater than zero, *b* must be greater than or equal to *a*, and *N* must be greater than or equal to 2.

Hint: Keep in mind that loops based on floating point values are inherently a bad idea and are likely to produce difficulties. It is much better to use integer variables in your loops.

Notes:

1. Copy-and-paste the code below into your C++ function instead of typing in all of the numbers required. Ask a TA to help if needed.

```
const double A0 = 2.5253303767;
const double A1 = 1.0370462484;
const double A2 = 0.5688888889;
const double A3 = 0.3111070642;
const double A4 = 0.1242940878;
```

```
const double t0 = 0.0469100770;
const double t1 = 0.2307653450;
const double t2 = 0.5000000000;
const double t3 = 0.7692346550;
const double t4 = 0.9530899230;
```

2. As well as comparing your program to the provided sample executable, here are some test cases that you should try.

Test Cases:

Enter a, b, and N (0 0 0 to exit): **1 2 2**
x = 1, Si(x) = 0.946083
x = 2, Si(x) = 1.60541
The largest value is 1.60541
The smallest value is 0.946083
Enter a, b, and N (0 0 0 to exit): **4 10 4**
x = 4, Si(x) = 1.7582
x = 6, Si(x) = 1.42468
x = 8, Si(x) = 1.57399
x = 10, Si(x) = 1.65805
The largest value is 1.7582
The smallest value is 1.42468
Enter a, b, and N (0 0 0 to exit): **0 1 2**
*** Invalid input -- try again ***
Enter a, b, and N (0 0 0 to exit): **2 3 1**
*** Invalid input -- try again ***
Enter a, b, and N (0 0 0 to exit): **1 2 0**
*** Invalid input -- try again ***
Enter a, b, and N (0 0 0 to exit): **1 2 -1**
*** Invalid input -- try again ***
Enter a, b, and N (0 0 0 to exit): **0.1 0.5 3**
x = 0.1, Si(x) = 0.0999445
x = 0.3, Si(x) = 0.298504
x = 0.5, Si(x) = 0.493107
The largest value is 0.493107
The smallest value is 0.0999445
Enter a, b, and N (0 0 0 to exit): **1 10 10**
The largest value is 1.84865
The smallest value is 0.946083
Enter a, b, and N (0 0 0 to exit): **0 0 0**
Press any key to continue . . .