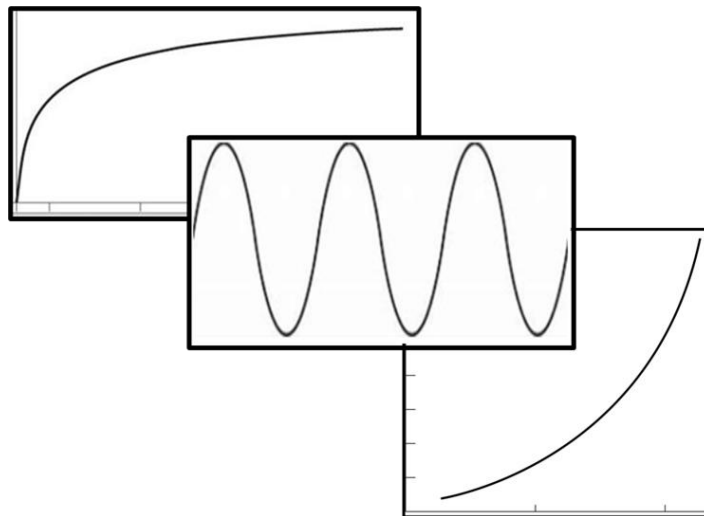# Transcendental Math

<u>Functions</u>: CORDIC, Taylor series expansion
<u>Inputs:</u> numeric data, desired precision
<u>Metrics:</u> processing time

1. Overview

Transcendental functions are those which cannot be accurately reduced to polynomial form. These include such things as trigonometric functions (sine, cosine, tangent, etc.), hyperbolics, e^x, and logarithms, which are fundamental building blocks of many algorithms (particularly in signal processing). Evaluating these functions typically requires iterative approximation, with an explicit tradeoff between result precision and performance.

As many transcendental functions can be represented in terms of other transcendentals, MilSpec's transcendental math benchmark centers on three fundamental operations: sin, $\log_2$, and exp. sin may be computed with either a Taylor series expansion or via CORDIC,[1] an iterative shift-and-add approach. $\log_2$ uses an iterative approximation,[2] and exp uses a power series. The benchmark for each function takes a configuration file specifying what particular values to compute and the number of CORDIC trials, power series terms, etc. to use for the computation; these parameters are detailed in the README within the benchmark archive.

2. System requirements

<u>Platform:</u> Ubuntu 18.04 LTS with g++ 7.4.0. Code may build and run successfully on other versions/platforms, but has not been tested with them.
<u>Storage:</u> ~1MB.
<u>Dependencies:</u> None.

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[1] http://people.math.sc.edu/Burkardt/cpp_src/cordic/cordic.html
[2] https://ieeexplore.ieee.org/document/1451248

3. Build and run

To benchmark:
- Download and extract the zipfile from www.adacenter.org/milspec
- From the `Transcendentals/` directory, `make clean && make`
  - Running sin: from the `sin` directory, `./trigtest`
  - Running log_2: from the `log` directory, `./logtest`
  - Running exp: from the `exp` directory, `./exptest`
- Results for mean compute time and mean-squared-error (vs "golden" approximations of very high order) across the input set are displayed in the terminal, as below:

```
 --- CORDIC STATISTICS ---
Average time to compute sin(x) for 20 iterations : 232.939 ns
MSE sin(x) for 20 iterations : 6.6551e-13
 --- POWER SERIES STATISTICS ---
Average time to compute sin(x) for degree 2 approximation : 52.1725 ns
Average time to compute sin(x) for degree 4 approximation : 57.8981 ns
MSE sin(x) for degree 2 approximation : 6.194e-05
MSE sin(x) for degree 4 approximation : 1.63257e-12
 --- END STATISTICS ---
```

4. Code structure

Coming soon!

5. MilSpec development notes, errata, changelog

v0.9:
- Built baseline transcendental function implementations:
  - sin: built power-series implementation, incorporated open-source CORDIC option
  - log_2: built iterative approximation method
  - exp: built power-series implementation
- Added config file-based input options
- Added performance instrumentation

6. Acknowledgements