Apache Commons Math

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What key problems are solved?

- This software does: Rootfinding, Interpolation, and Regression.
- Is it general-purpose software?
  - This is general purpose software for apache.

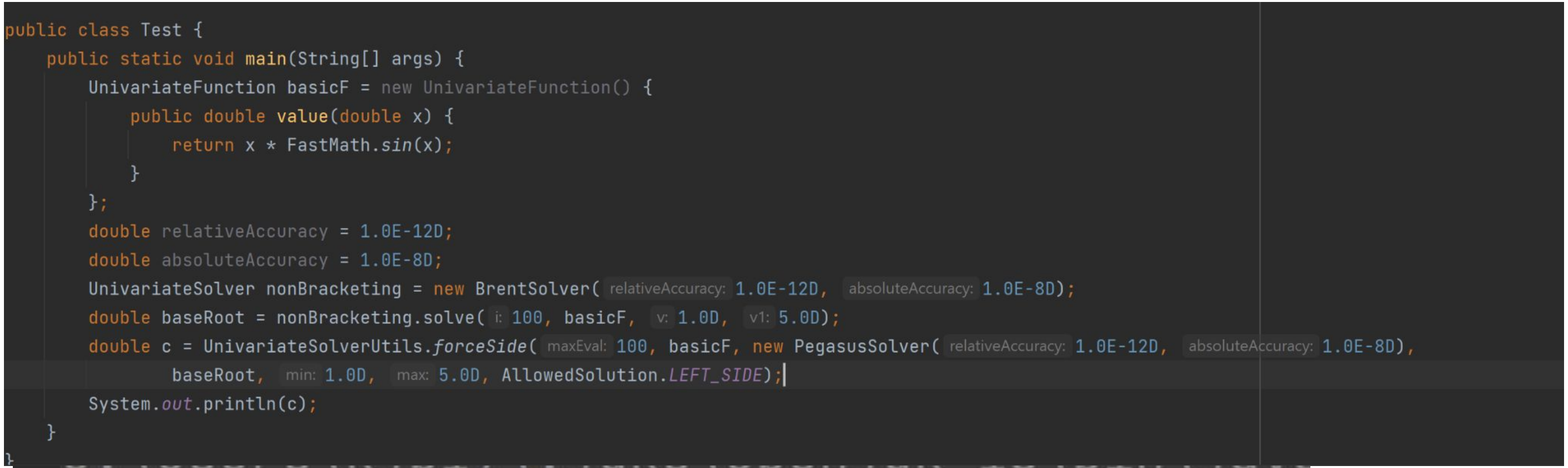
Who are the stakeholders?

- Who develops the software, who uses it, who pays for it?
  a. Apache Commons is open source and maintained by Apache Software Foundation (ASF)
- What are they looking for?
  a. A reusable Java math library
- How do they communicate and collaborate?
  a. Through the Apache Software Foundation, and Github
- Who uses the software?
  a. “Some high-profile companies using Apache include Cisco, IBM, Salesforce, General Electric, Adobe, VMware, Xerox, LinkedIn, Facebook, Hewlett-Packard, AT&T, Siemens, eBay, and many more (source)”
- Who is impacted (positively or negatively) by use of the software?
  a. Competitors such as AWS and Oracle are negatively impacted by its use but companies and individuals looking for an open source Java Library benefit positively.

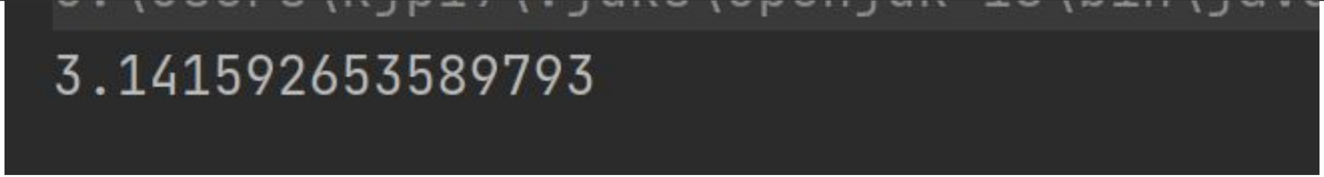
Metrics and Features

- How do concepts like accuracy, conditioning, stability, and cost appear?
    a. Accuracy is indicated by the solver, conditioning of the problem will affect accuracy and stability. Cost is not shown but could be measured by resource utilization when running function.
- If the software is accurate, what does accuracy mean? Could you make a plot, say accuracy vs cost? How would you label the axes to make it relevant to a stakeholder?
    a. You could make a plot of accuracy vs computation time or resource utilization there isn’t any inherit cost function present.
- Would different stakeholders want different axes (because they care about different things)?
    a. Absolutely if you’re a company who cares about how much memory this will use or cpu flops you would want a plot of accuracy against that in order to see if the software fits your cost model.
- Are there modeling decisions made in the interest of good conditioning? Are there algorithmic choices made for stability?
    a. The conditioning of the function is left up to the user a modeling decision likely used to decrease the complexity of the code necessary. Function Value accuracy is used by some algorithms to prevent numerical instabilities.

Example - Using Brent Solver to find root of xsin(x)



```
public class Test {
    public static void main(String[] args) {
        UnivariateFunction basicF = new UnivariateFunction() {
            public double value(double x) {
                return x * FastMath.sin(x);
            }
        };
        double relativeAccuracy = 1.0E-12D;
        double absoluteAccuracy = 1.0E-8D;
        UnivariateSolver nonBracketing = new BrentSolver( relativeAccuracy: 1.0E-12D,  absoluteAccuracy: 1.0E-8D);
        double baseRoot = nonBracketing.solve( i: 100, basicF,  v: 1.0D,  v1: 5.0D);
        double c = UnivariateSolverUtils.forceSide( maxEval: 100, basicF, new PegasusSolver( relativeAccuracy: 1.0E-12D,  absoluteAccuracy: 1.0E-8D),
                baseRoot,  min: 1.0D,  max: 5.0D, AllowedSolution.LEFT_SIDE);
        System.out.println(c);
    }
}
```



```
3.141592653589793
```

Questions

- I haven’t had much time to play around with this so I would be interested to see what edge cases this library does not account for. If there are functions that would return unexpected output.
- All the examples we’ve used in class have been in julia I’m interested to dig into the code and see how it is implemented in java and what design choices were made in contrast to the examples we’ve worked with in class.

Experiment

- For a group experiment it could be interesting to explore the stability of a single root finding algorithm against higher order polynomials and create a plot of the error on one axis and the order of the polynomial on the other.