Curriculum Development for Project-Based Applied Mathematics Courses

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CFI Grant Proposal

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CFI Proposal

Overarching goals for our project:

- Expose students to familiar and new mathematical theory along with its implementation in a practical (real-world) setting.
- Teach mathematics as an integrated discipline (theory, history, application).
- Give students practical skills they can use in the future (coding and debugging, algorithmic thinking, reading/wiring circuits, etc).

Two Courses

We believe we can achieve the above goals by designing curriculum that makes explicit the connection between Mathematics and Computer Science (both hardware and software). We propose two courses:

1. Applied Mathematics: Theory and Practice of Logic through Digital Circuits (H)

2. Introduction to Computational Mathematics and Numerical Analysis (S)

Digital Logic (H)

- Number Systems, Operations, Boolean Algebra and Logic.
- Logic Gates, Combinational Logic, Sequential Logic.
- Projects: Adders, Counters, 4-bit ALU, Final Capstone Project
- Introduction to Micro-controllers and Coding using Arduino Platform (Hardware⇒Software)

Digital Logic (H)

- Should be accessible to almost all students
- Corequisite: 422 (or higher)
- Would be nice to have a full year so that students can digest.
- In general, more time = better projects (more time to work in class)

Numerical Analysis (S)

- Introduction to algorithms, convergence, mathematics on a computer (floating-point arithmetic)
- Without calculus:
  - Rootfinding
  - Elementary linear algebra
  - Number Theory, Cryptography and Cybersecurity
- With calculus:
  - First Order Differential Equations

Numerical Analysis (S)

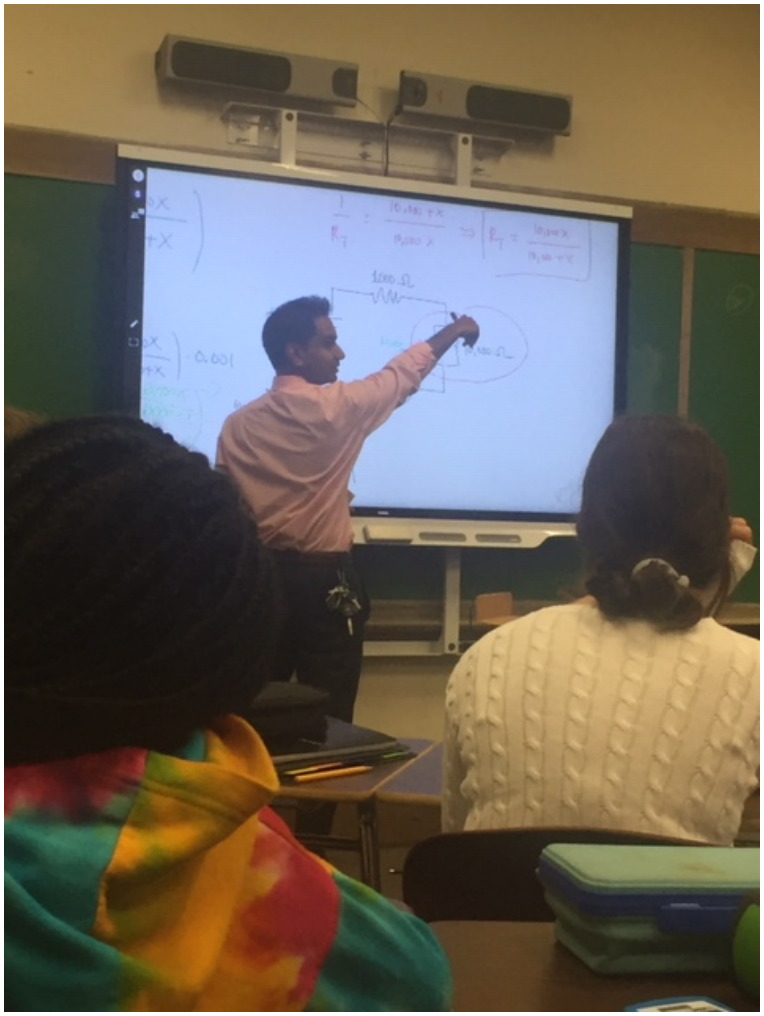
- Coding will most likely be done in Python (free and easy to learn).
- Would like to open this to as many students as possible - maybe 443 or higher. But I suspect it may need to be 444 or higher (I will defer to your expertise!)
- For a half-year course, must have taken at least Intro to Computer Science.
- Eventually (for a full-year course), can add a unit and projects on Statistical Regression and Machine Learning (black box method). This needs to be explored more, though...

Department-Wide Benefits

Hopefully we can scale parts of this curriculum down to be used in other 400 courses:

- Simple digital logic circuits can be built to implement truth tables [422, 423, 424]
- Fractional Equations with Ohm's Law [432, 433, 434]
- Rootfinding Algorithms (doesn't have to include code) [442, 443, 444]
- Integrator/Differentiator Circuits [454, 455]
- Algorithms for Differential Equations [455BC]
- Most of the projects can be used in CS courses

Testing it Out!



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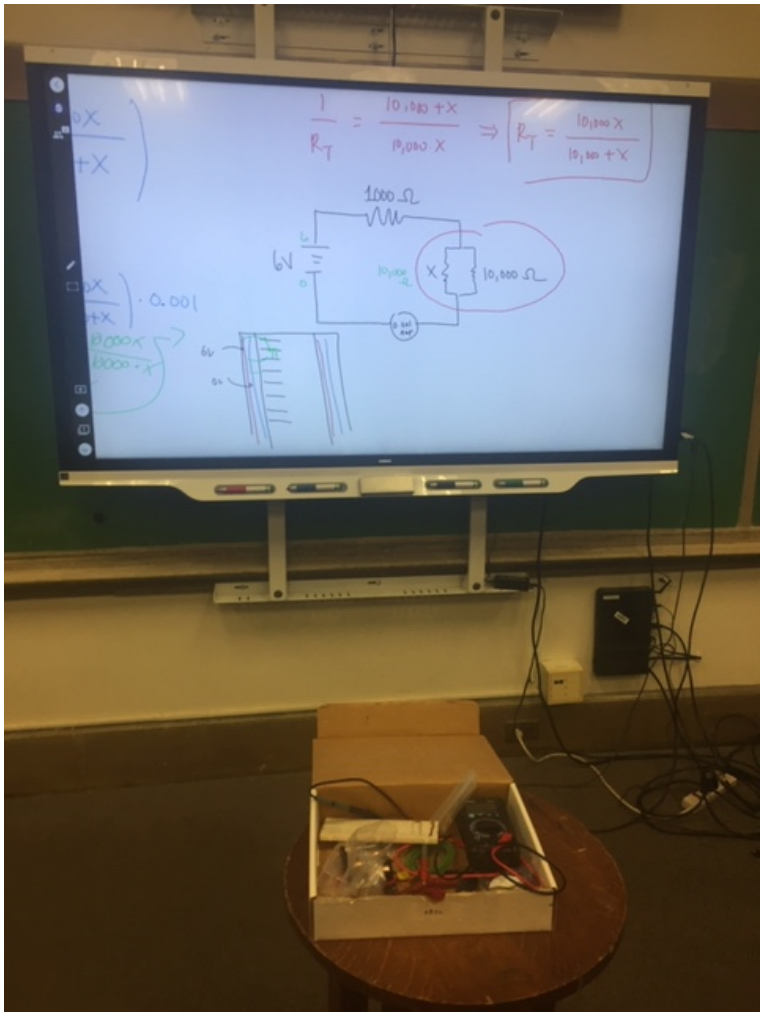

Testing it Out!

Acknowledgments

- Maureen, Monica and Greg A
- Questions?