SimCenter

National Center *for* Computational Engineering

at

HCDE County-wide Math/Science In-service

January 5, 2010

My take on STEM Outreach

- The SimCenter and the university as a whole working with schools to foster interest in Science, Technology, Engineering, and Mathematics careers

- Try to help Engineering move up from the position of "silent E" in STEM

- Giving students relevant, real-world experience with what people in these careers actually do and how to attain the necessary skills to work in such a field

- Working with teachers to give them tools to foster student understanding and interest in STEM disciplines, as well as help them incorporate the new engineering standards into their curriculum

Importance of Outreach

- Students are having to make career/college decisions earlier than ever before.
- The numbers of students enrolling in math, engineering, and computer science programs is shrinking.
- Students come to college without having realized that their core course preparation early in high school might not be sufficient to get them into the high level math courses required to undertake a scientific major in a reasonable amount of time, and so they opt for other career choices.
- The goal is to expose students to the relevance of their math and science courses and spur them on to continue to take more math and science courses so that they can more readily reach into their areas of interest in the sciences.
- By showing students how we use mathematical models to simulate real-world problems and then comparing our results with real experiments, students were given the knowledge of the power behind even the most rudimentary mathematics.

Progress up to now

- We have hosted Tyner Middle School, Normal Park Museum Magnet Upper School, Central High School AP Physics, Soddy-Daisy Middle School, Brown/Battle Elementary School, Girls, Inc., Signal Mountain High School AP Physics and AP Calculus, a week-long inter-session activity with Chattanooga Girls' Leadership Academy, freshmen computer science students from Southern Adventist University

- Activities included touring the super computer, fuel cell, EMCS facilities and labs

- Exercises included demonstrations of the scientific method, comparison of experiment with expected mathematical results, discussion of error analysis, a paper airplane contest, and making connections using the online Euler Emulator

Extending our presence

- The Euler Solver Emulator is up and running on the internet (http://www2.utc.edu) to attract graduate students, help current students, and use as a teaching tool for high school field trips

- Includes discussion of both the fine details of implementation and relation to subjects taught in high school

- We wish to open our doors to as many students and teachers as we can to help in any way possible to assure that our regional educational institutions graduate as many future engineers, mathematicians, and scientists as possible for the continuing economic viability of Greater Chattanooga

Relating to the Standards

- Standards can be viewed at http://www.state.tn.us/education/curriculum.shtml
- Website most easily relates to Calculus, Precalculus, and Physics standards
- These standards also take into account the AP guidelines http://www.collegeboard.com/student/testing/ap/about.html

Engineering Standards

- The following come from the high school physics standards, specifically the "Embedded Technology and Engineering" section.
- *Course Level Expectations*:
- **CLE 3231.T/E.2** Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
- *Checks for Understanding*:
- **CU3231.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.
- **CU3231.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
- **CU3231.T/E.6** Present research on current engineering technologies that contribute to improvements in our daily lives.
- *State Performance Indicators*:
- **SPI 3231.T/E.1** Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.
- **SPI 3231.T/E.2** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
- **SPI 3231.T/E.3** Evaluate the overall benefit to cost ratio of a new technology.
- **SPI 3231.T/E.4** Use design principles to determine if a new technology will improve the quality of life for an intended audience.
- Students will be calculating multiple values based on the results they obtain from the online flow solver, and they will be synthesizing the information they obtain to make design decisions about wings. In future contests and curricular offerings, this will be taken even further by asking students to consider cost effectiveness and broad applicability of their design for improving a geometry. The geometry will be set forth by students and teachers through online submissions, and simulations will be run by the SimCenter giving solution data for pertinent configurations. Then, students will use that data to determine how to better design the given vehicle, wind turbine, etc. as well as compare computed results with experimental results to determine if their design will stand up to rigorous testing.

- The following standard was taken from the "Embedded Mathematics" section of the Tennessee high school physics standards.
- *Checks for Understanding:*
- **CU3231.Math.15** Link various calculus procedures to solve physics problems.
- The primary disconnect for most students going into STEM courses is a lack of mathematical preparation, specifically applied mathematics. As such, the goal of each and every project is to take mathematical concepts (such as Riemann sums) and apply them directly to solving a physics problem (such as determining the lift from the area between the coefficient of pressure curves for the top and bottom surfaces of the airfoil, as is done in the current contest).

Calculus/Precalculus Standards

- The following standards were taken from the Tennessee high school calculus standards.
- **Standard 3.0:** Integrals
- Students will develop the concepts of integrals and their applications.
- **Learning Expectations:**
- The student will:
- 1. define and apply basic properties of definite integrals;
- 2. evaluate or approximate define integrals;
- 3. apply techniques of antidifferentiation.
- **Student Performance Indicators:**
- communicate the relationship between a Riemann sum and a definite integral;
- apply basic properties of definite integrals;
- evaluate definite integrals using the Fundamental Theorem;
- find specific antiderivatives using initial conditions, including applications to motion along a line;
- use separable differential equations in modeling;
- use Riemann sums and the Trapezoidal Rule to approximate definite integrals of functions represented algebraically, geometrically, and by tables of values.

- The following standards were taken from the Tennessee high school precalculus standards.
- **Standard 3.0: Trigonometric Functions**
- The student will
- 1. apply trigonometry concepts and applications to model and solve problems;
- 2. use trigonometric concepts to represent, apply, and operate with complex numbers;
- 3. solve trigonometric equations and inequalities algebraically or graphically;
- 4. interpret transformations of trigonometric functions.
- **Student Performance Indicators:**
- apply radian measures in problems related to linear and angular velocity;
- understand and apply vectors to solve real world problems;

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ENGINEERING

Online Euler Emulator with Adaptive Refinement

NOTE 1: No flux limiters are employed (this allows students to use this as a tool in verifying their basic code).
Discussion of Flux Limiters and Results for Comparison

NOTE 2: Menus will automatically update to show only cases that ran completely through the adaptation cycles solely first or second order. The order of accuracy denotes the stencil used to determine gradients. First order accuracy denotes the use of only the nearest neighbors, while second order accuracy denotes the use of neighbors of the nearest neighbors in calculating the gradient. Also, first order accurate solutions will often lack the resolution of second order accurate solutions, but occasionally first order accurate solutions must be run and restarted at second order accuracy because the speed of the change in gradients can cause numerical instability in the initial iterations. Due to the massive numbers of cases, anything that needed to be run multiple times and hand generated (i.e., needed to be run first order for an unspecified number of iterations then second order to allow for massively changing gradients) was left out.

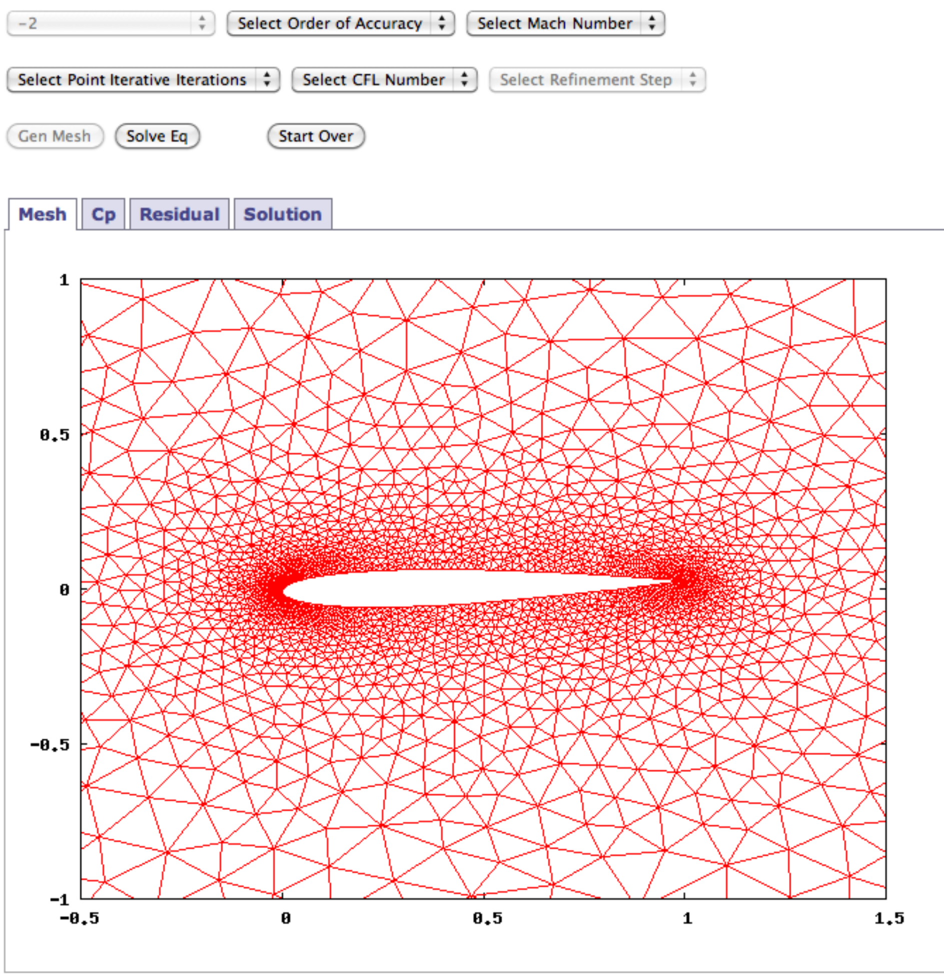
NOTE 3: Images were generated using Gnuplot, XMGrace, and Tecplot. You will need Adobe Acrobat to view the PDF files, which can be downloaded for free at Adobe's website.

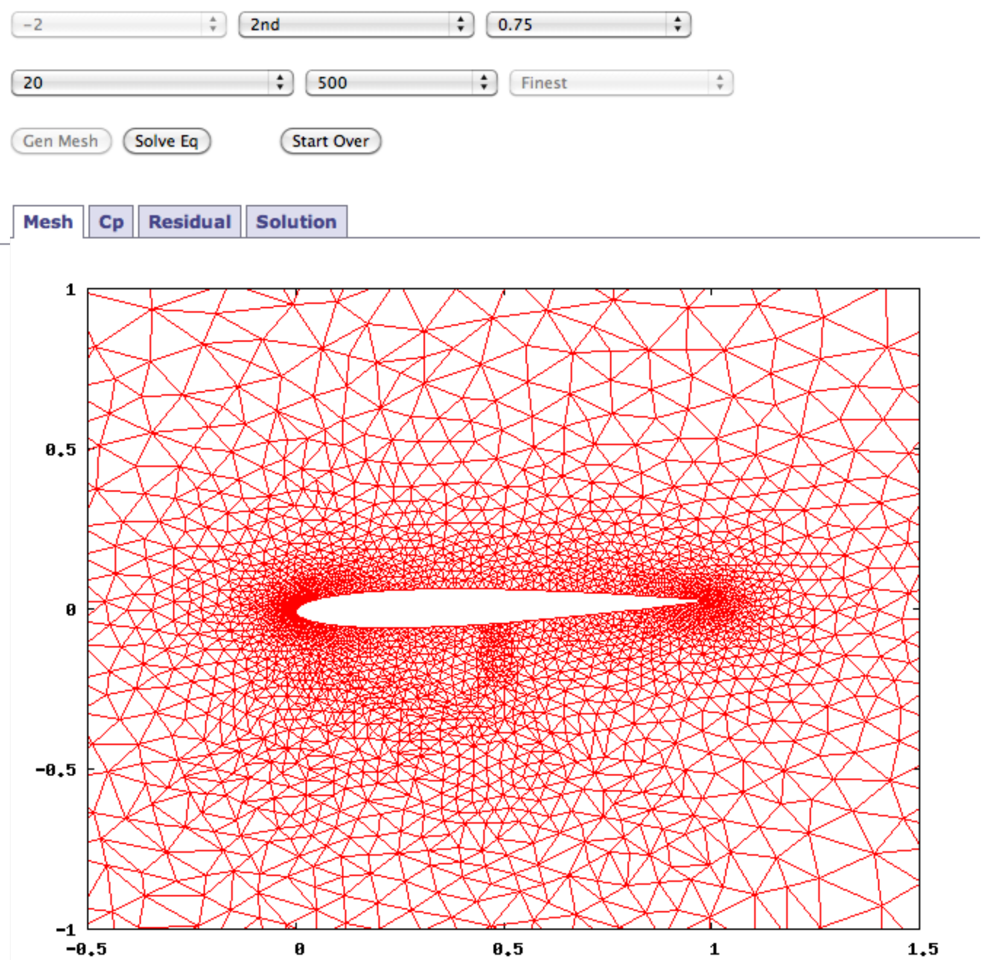
Any questions, comments, or bug reports should be sent to Vincent C. Betro, STEM Outreach Coordinator, UT SimCenter at Chattanooga: National Center for Computational Engineering

Discussion of Euler Solver Methodology for Prospective Graduate Students
Tutorial for Students Regarding Use of the Euler Solver Emulator and Relations to Secondary Mathematics

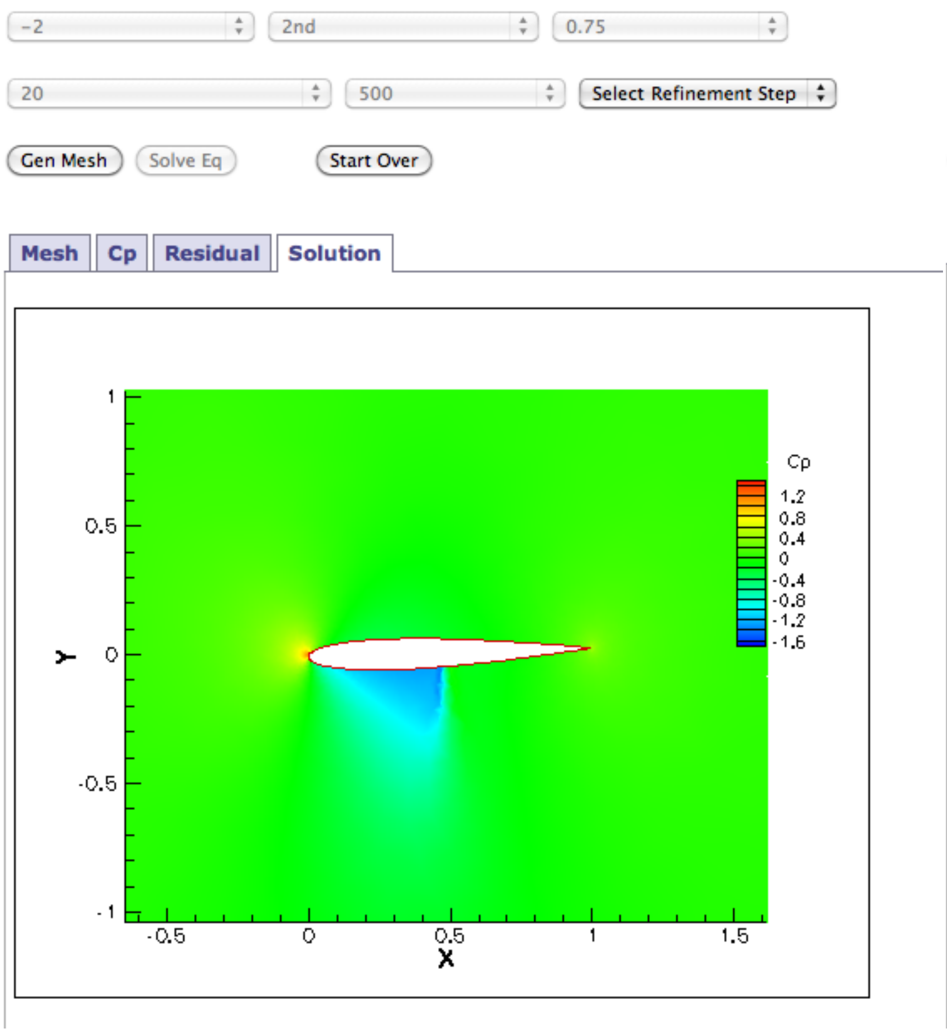
Euler Solver Interface

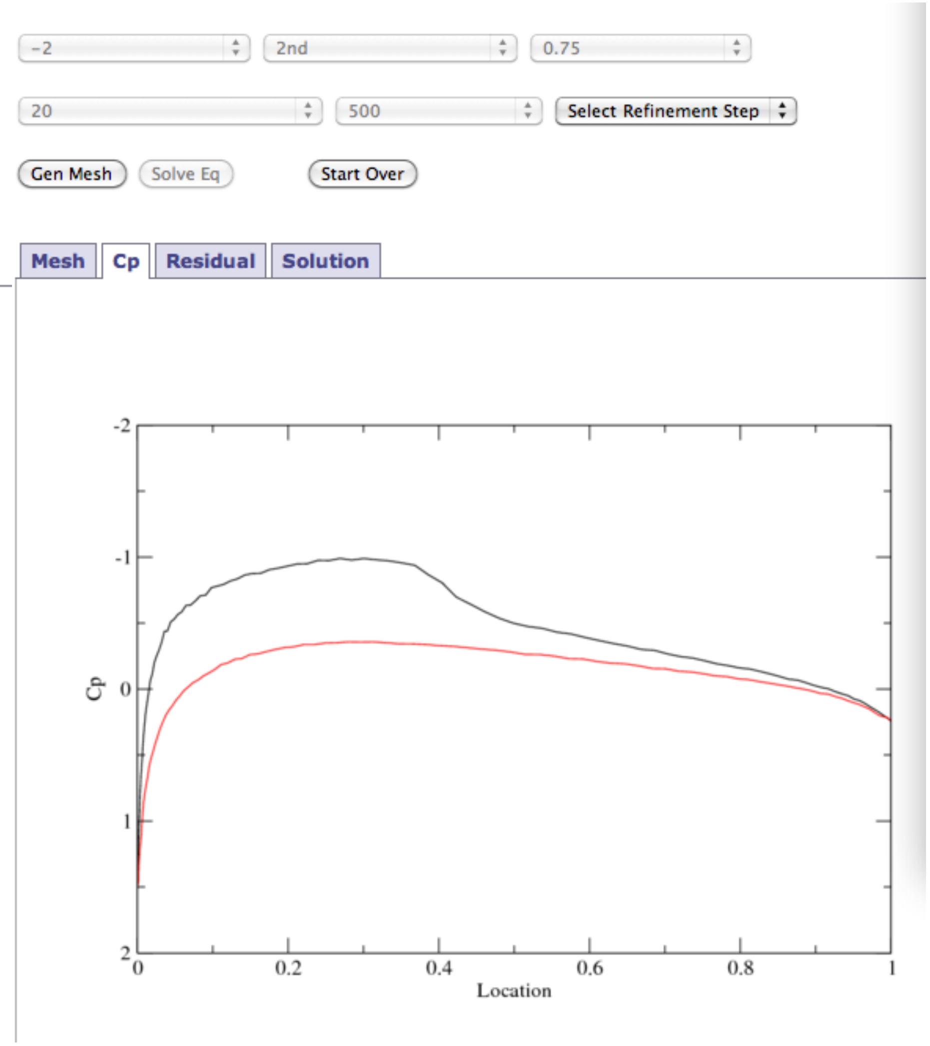
Concepts of Adaptive Refinement





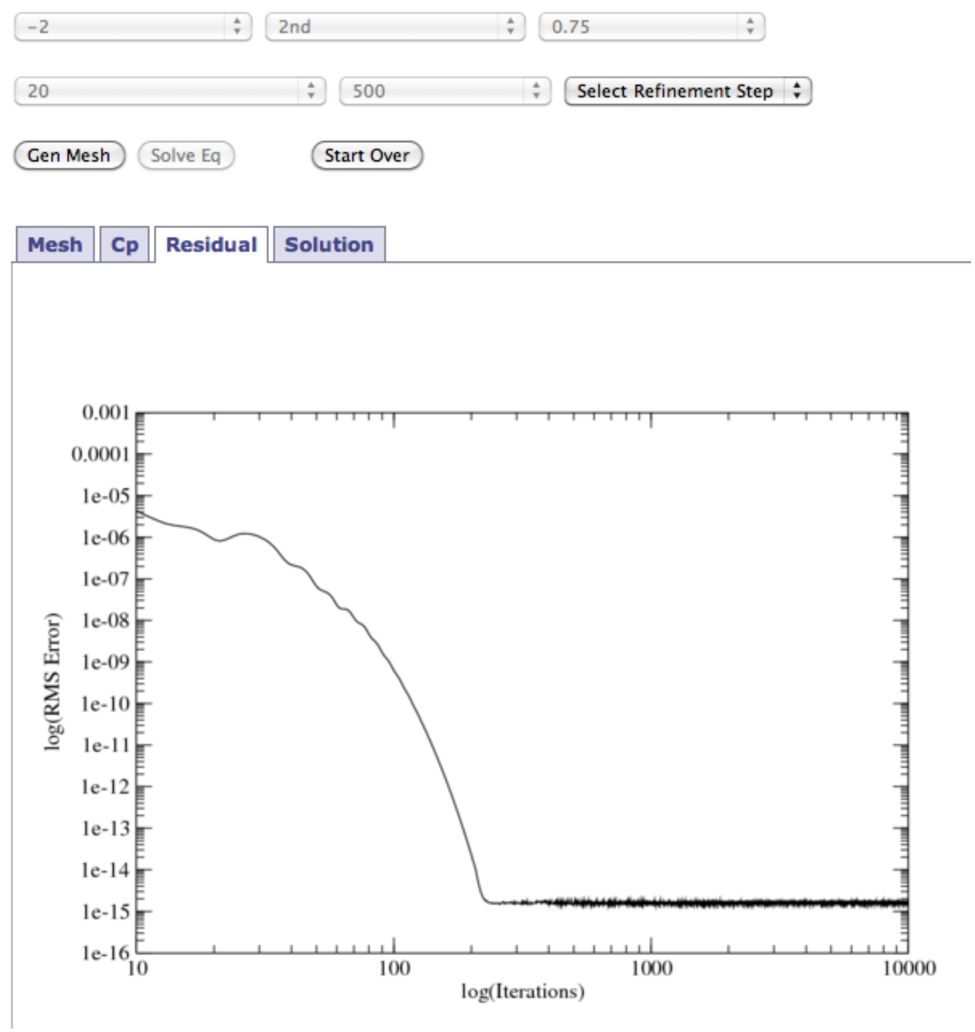
View Solutions in Different Contexts





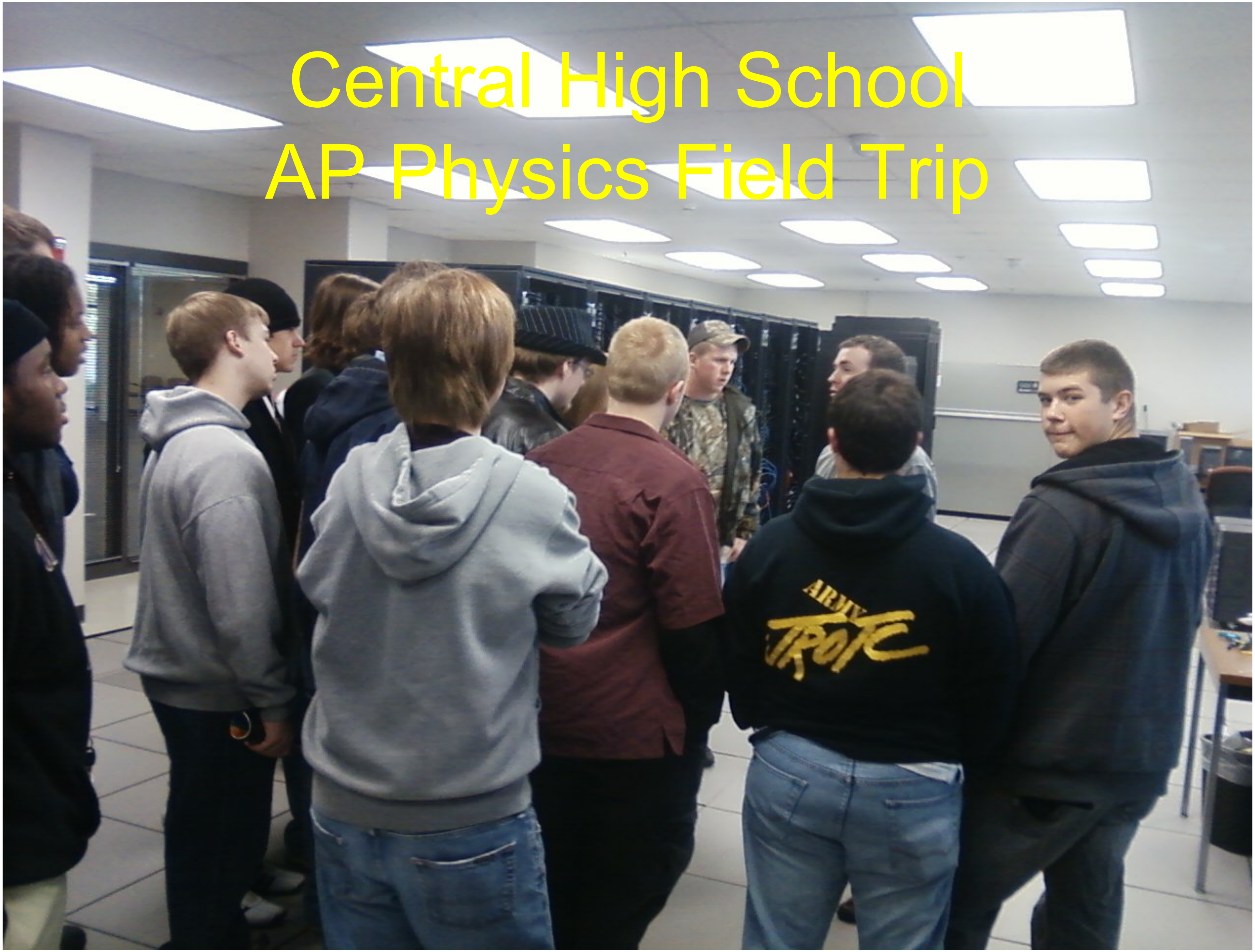
Conceptualize Iterative Solution Algorithms

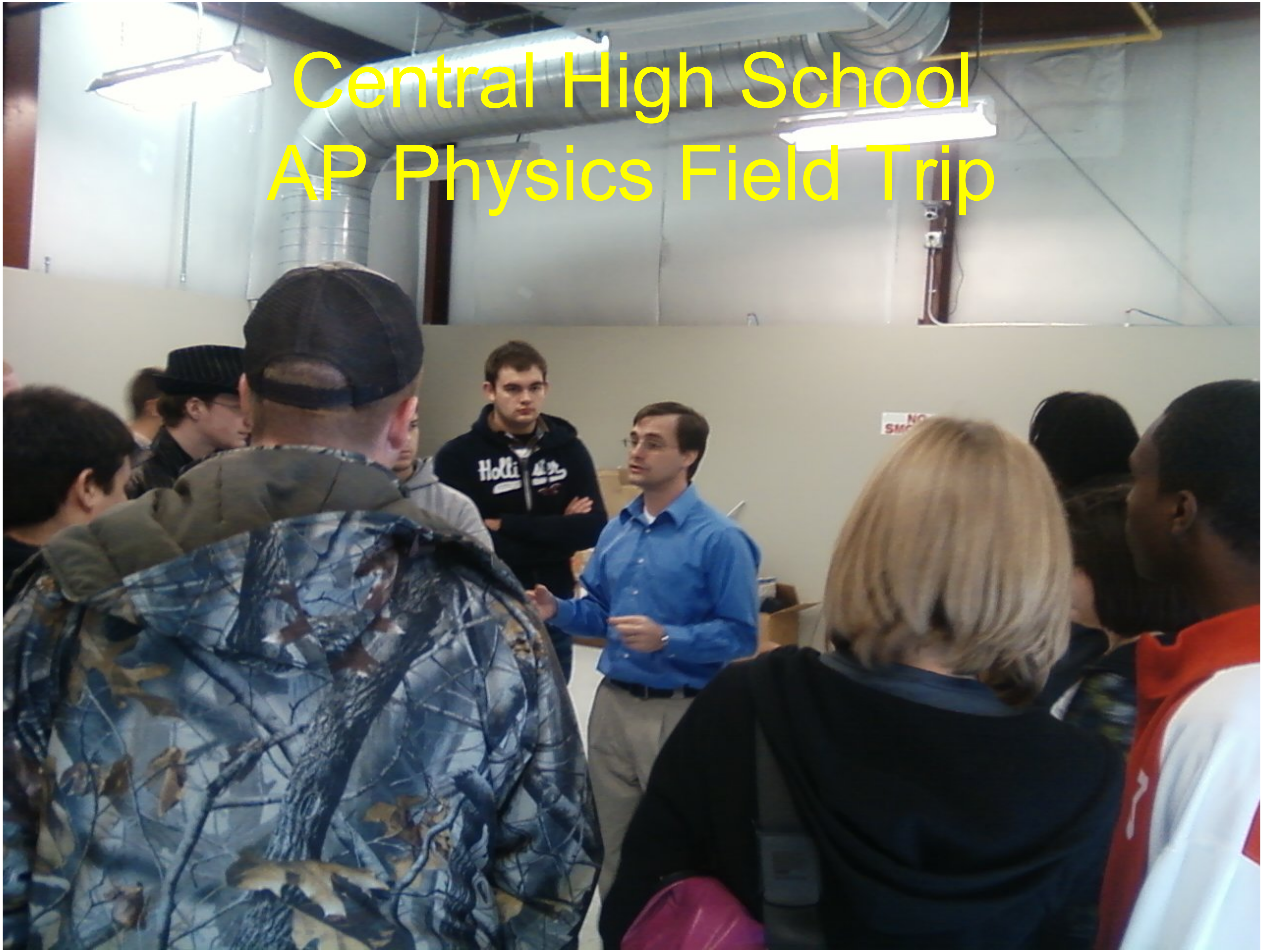
- Try to understand factors that contribute to speed in computing



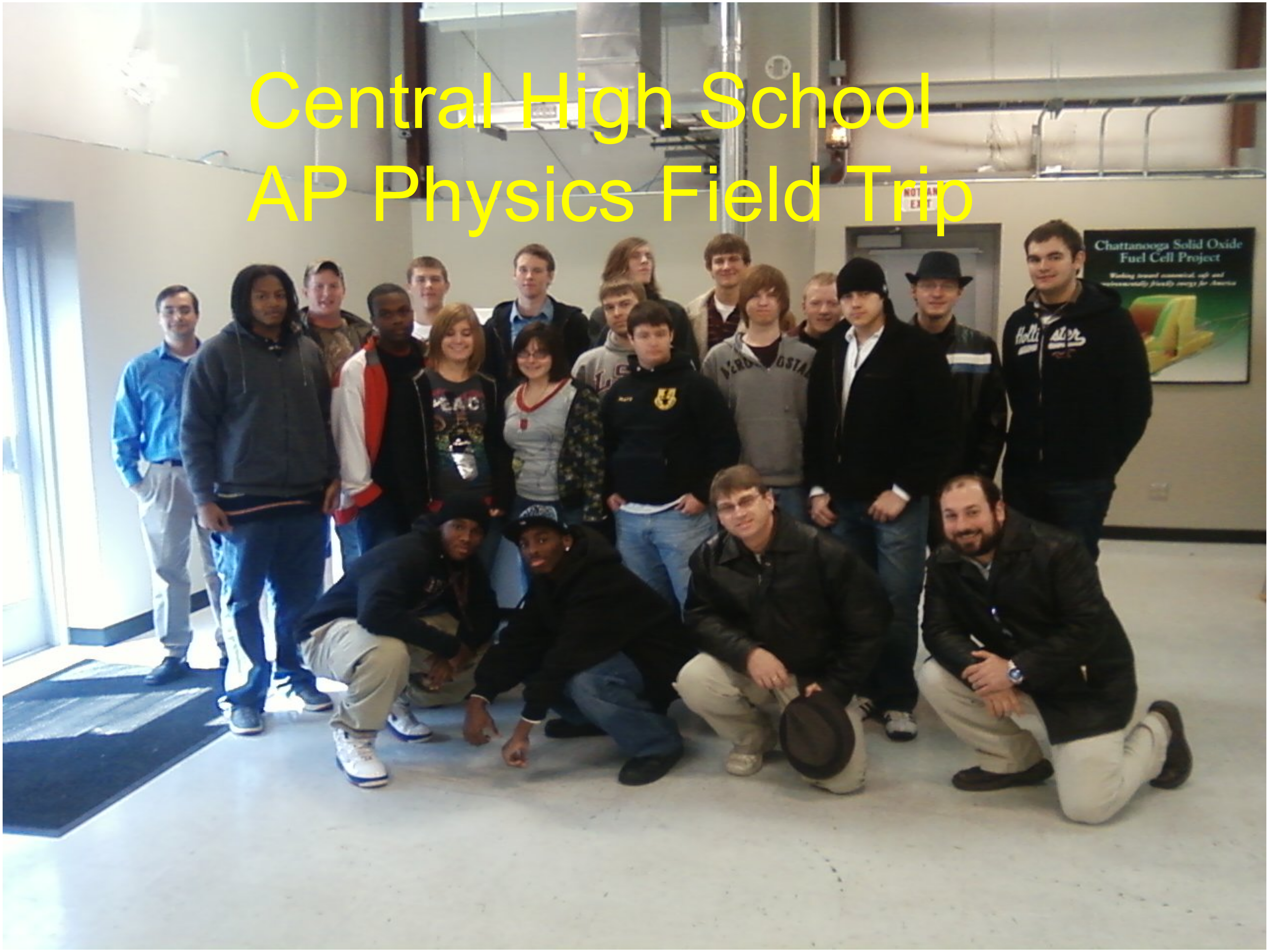

Tyner Middle School
“Math Counts” Field Trip


Girls, Inc. Summer Camp
Field Trip


Central High School
AP Physics Field Trip
ARMY
JROTC


Central High School
AP Physics Field Trip

Central High School
AP Physics Field Trip



Dear Vince,

Thank you for your personal commitment in furthering the scientific education of my SDMS students through their participation and involvement in the real world application of Science, math and computer technology. The dedication and enthusiasm, as demonstrated by you and your colleagues, will certainly inspire some of these Students to consider careers in Science and math when making decisions in the pursuit of their career paths. I appreciate the support and invaluable time that you, Ryan and Wally gave so generously to make our trip to the SDM Center so success,

With Sincere gratitude,

Judy Mulkey
SDMS Physical Science teacher

Vince,
~~Thank~~ Thank you Carey for all you did on our recent visit. I hope your enthusiasm for young kids is always there! Earl

Thank you for taking time out. The kids really enjoy it
-Wel

Erica
Robert Hinton
Ellie
O'Shawna Porter
C. Smoot
Destaneh
Tori
Natalie
DeCaina
Jorden
Thomas
Denzel
Damichia Little
Jayla Copeland
Tamia Hill
Serenity Roberson
Jazlyn Norman
Anthony
Kyshira

Conclusions

- We are working with a variety of students and teachers in an attempt to help them foster interest in STEM areas as well as assure students have the skills they need to succeed
- We would like to continue to branch out to more age groups and areas as we find methods that make our help applicable
- We are creating an internet presence that allows our services to be online, 24 hours a day, 7 days a week to multiple groups that need our help
- We need your help to determine how to most effectively help the students and teachers that will be using our product (YOU ALL!)

An open invitation!

- Please consider bringing your students to UTC to see Engineering in Action!
- Contact: Vincent-Betro@utc.edu
- 423-425-5434
- Vince Betro

SimCenter

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