

## **Integrating Engineering Design using CAD Software with Force and Motion Concepts in Middle School (Resource Exchange)**

### **Dr. Nidaa Makki, University of Akron**

Dr. Nidaa Makki is an Associate Professor in the LeBron James Family Foundation College of Education at The University of Akron, in the department in Curricular and Instructional Studies. Her work focuses on STEM curriculum integration and science inquiry practices in middle and high school. She is a co-PI on an NSF funded project to investigate the impact of integrating engineering on middle school students' interest and engagement in STEM. She has also received funding to conduct teacher professional development in the areas of engineering education, problem based learning and inquiry instruction.

### **Dr. Nicholas G. Garafolo, University of Akron**

Dr. Nicholas G. Garafolo is a researcher in the broad area of thermo-fluids and aerospace, with an emphasis in advanced aerospace seals, near-hermetic fluid flows, and turbomachinery modal analysis. Dr. Garafolo currently holds a position as Assistant Professor at The University of Akron. Supporting the dissemination of his research activities, Dr. Garafolo has six journal manuscripts, over 30 conference papers and presentations, and \$868,647 of total project funding. Prior to his appointment, Dr. Garafolo worked as a federal contractor, under the umbrella of a multi-million dollar contract, in space flight hardware research and development to NASA Glenn Research Center in Cleveland, Ohio. Dr. Garafolo was instrumental in developing a synergistic approach in the research and component modeling of elastomeric space seals for manned spaceflight; an asset to NASA and the development of advanced aerospace seals for the next generation of manned spacecraft. The unique problem necessitated a grasp of both fluid dynamics and material science, as well as experimental and computational analysis. As a DAGSI/Air Force Research Laboratory Ohio Student-Faculty Fellow, Dr. Garafolo gained experimental knowledge in structural dynamics of turbomachinery. In particular, his research on engine order excitation yielded insight into generating high cycle fatigue of turbomachinery using acoustic excitation.

### **Dr. Wondimu Ahmed, University of Akron**

Dr. Wondimu Ahmed is an Assistant Professor in the LeBron James Family Foundation College of Education at the University of Akron. He received his Ph.D. from University of Groningen, The Netherlands. His research focuses on motivation and emotions in education, particularly in STEM subjects.

### **Dr. Kristin L. K. Koskey, University of Akron**

Dr. Kristin Koskey is an Associate Professor in the LeBron James Family Foundation College of Education at The University of Akron. She holds a Ph.D. in Educational Research and Measurement and M.E. in Educational Psychology. Dr. Koskey teaches courses in evaluation, assessment, research design, and statistics. She also works as a psychometric consultant and serves on the Editorial Board for the journal of Psychological Assessment. Her work is published in leading journals such as Studies in Educational Evaluation, Journal of Applied Measurement, Journal of Mixed Methods Research, Journal of Experimental Education, International Journal of Qualitative Methods, and Educational and Psychological Measurement. Further, she has authored book chapters on Norming and Scaling for Automated Essay Scoring and Data-driven STEM Assessment. Dr. Koskey has secured grant funding from the Ohio Department of Education and National Science Foundation (NSF), as well as contributed to the evaluations on grants funded by the ODE, U.S. Department of State, and NSF.

### **Dr. Donald P. Visco Jr., University of Akron**

Donald P. Visco, Jr. is the Associate Dean for Undergraduate Studies at The University of Akron and Professor of Chemical & Biomolecular Engineering.

### **Dr. Katrina B. Halasa, Akron Public Schools**

Science and Health Learning Specialist k-12 since July 2006 for Akron Public Schools. She is in charge of professional development, curriculum and assessment development. She taught biology, chemistry, human anatomy, forensic and environment during 1995-2006.



# Integrating Engineering Design with CAD Software into Middle School Science

Partners:



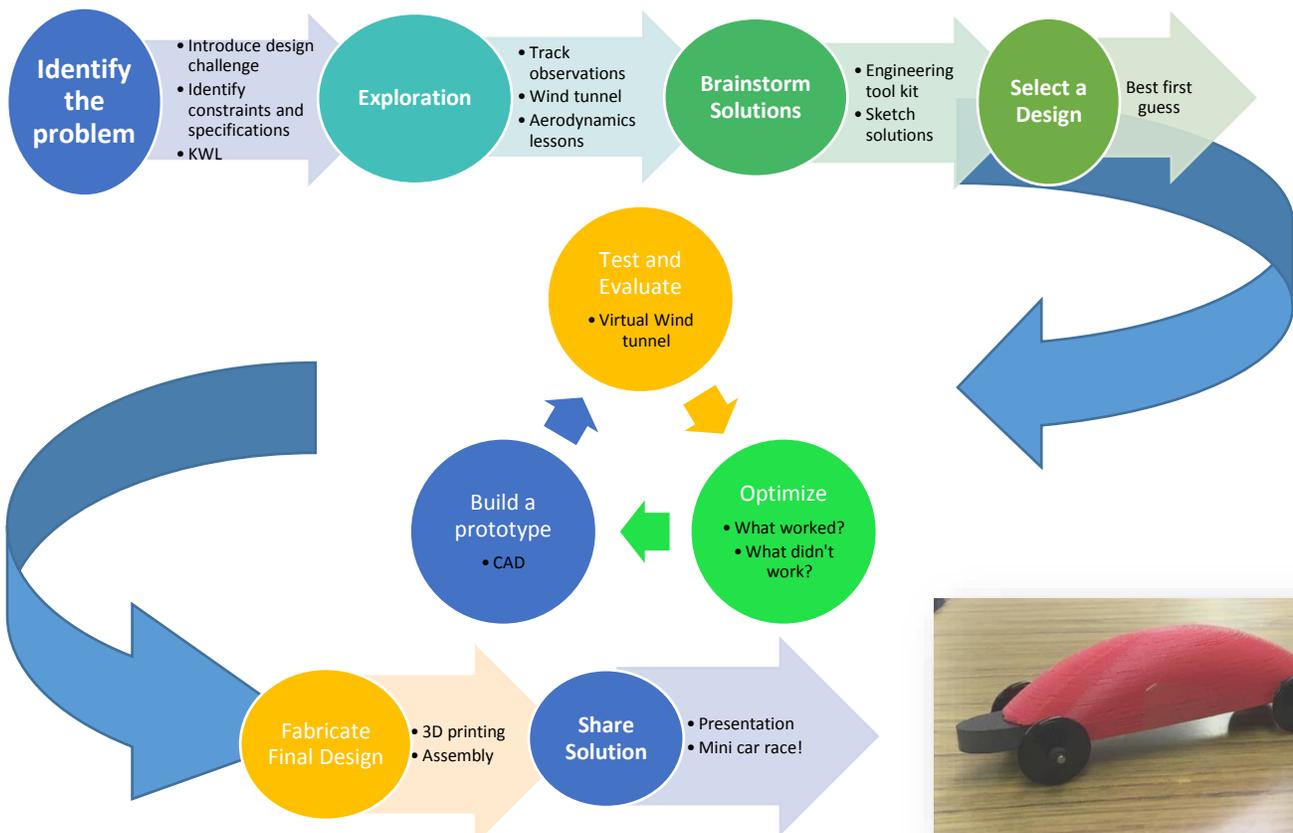
Akron Public Schools

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This program integrates technology and engineering concepts and practices in the Force and Motion science curriculum in Middle School (8<sup>th</sup> grade). Students are presented with a hands-on, practical engineering design experience through a performance optimization of a model race car. They are engaged in using technology (CAD software, virtual wind tunnel simulation) to design and test a shell for a mini model car, while learning science concepts and practices. This approach allows true integration of STEM disciplines (science, technology, engineering, and mathematics).

The presentation of the content follows the Engineering Design Cycle. Students were presented with a problem that they needed to solve (how to optimize the performance of a mini Soap Box Derby Car). They investigated the aerodynamics of the car through guided activities using hands-on and virtual labs. Using knowledge gained from these activities, they brainstormed and designed a car shell using CAD software, tested their designs virtually, optimized, and then 3-D printed their designs. Groups of students then test their manufactured car shells in a class competition, and proceeded to a district wide competition.



## Unit Summary:

**Identify the Problem-KWL Activity:** Teachers introduce the design challenge and guide students to identify requirements, constraints, and the need to do research/investigations.

*“How can we optimize a mini Soap Box Derby Car?”*

**Exploration!:** Students investigate how various shapes (box, trapezoid, semi-circle, etc.) can affect the performance of the mini car using observations of a car moving down the track; they clarify the problem by making connections between track performance and experimental testing observations; students also explore how engineers use computational simulation by investigating the aerodynamics of various shapes using a computer simulation.



**Brainstorm Solutions:** In groups, students sketch possible design solutions for the car shell based on the investigations from the *Exploration!* phase.

**Select a Design and Prototype:** Students create possible mini car shells with CAD, utilizing knowledge about aerodynamics acquired from experimental explorations with shapes in real and virtual experiments.

**Test and Evaluate:** Students evaluate car shells with 3D virtual wind tunnel simulation. Collect data and compare designs.

**Optimize:** Students revise their designs using qualitative and quantitative assessment from 3D virtual wind tunnel simulation.

**Fabricate Final Design:** Students 3D print their designs and explore advances in manufacturing and prototyping “tools” with additive manufacturing (3D printing).

**Share Solution:** Students share their solutions during class presentations and compete with their 3D printed designs in a district wide race.

## Connection to Next Generation Science Standards:

**MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**MS-ETS1-4:** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

