Physics, engineering, and design using wind tunnels in the high school classroom

Dr. Eric M. Edlund, Physics Department, SUNY Cortland
Mr. Anthony Canestaro, Cortland High School

June 15, 2021

Abstract

This proposal defines our plan for a 3-year project for enriching high-school physics education, increasing students' interest in studying physics in college, and broadening the experience of high school teachers through a series of events centered on the study of fluid dynamics, concluding with a multi-school competitive event. The geographic target of this project is the central and upstate area of New York, a region that is economically and culturally diverse. The primary focus of this project is the development of new curricular materials intended to directly support the movement to new curricular standards under the Next Generation Science Standards (NGSS). To support the high school teachers in these activities, a series of online sessions and a 2-day, in-person event will be hosted by the project leaders the summer prior to the school year. During these training sessions, teachers will study fluid dynamics using conceptual, analytical, and experimental approaches. The culminating experience for the high school classes engaged in this project will be an end-of-year competition, hosted at SUNY Cortland and using the WEN-D wind tunnel facility there. This competition will require presentations on design, analysis, testing, as well as performance measurements in the wind tunnel. The broad range of aspects in these competitions is meant to foster an atmosphere of inclusive education and interdisciplinary studies. All of these project elements align with and support the new standards for science education in New York that will require the integration of engineering design throughout the K-12 science curriculum. Some of the financial support from the Meggers award will be used to purchase materials for small, table-top scale wind tunnels for each of the high school programs selected for participation in this project. The products of this work, including the wind tunnel designs and curricular content, will be made publicly available at the conclusion of the project. This proposal seeks funding from 2021-2024 so that two full cycles of this competition can be completed.

Contents

1 List of Personnel

Applicant Institution
SUNY Cortland
PO Box 2000
Cortland, NY 13045

Project Lead
Asst. Prof. Dr. Eric Edlund
Physics Department
Tel. 607-753-5697
eric.edlund@cortland.edu

Administrative Contact
Thomas Frank
Research and Sponsored Programs
Tel. 607-753-2511
thomas.frank@cortland.edu

Collaborating Institution
Cortland High School
8 Valley View Drive
Cortland, NY 13045

High School Coordinator
Mr. Anthony Canestaro
Science Department
Tel. 607-758-4110 x1281
ccanestaro@cortlandschools.org

Administrative Contact
John Zarcone
High School Principal
Tel. 607-758-4110
jzarcone@@cortlandschools.org

2 Project Objectives

The project objectives are defined in three main areas: pedagogical, curricular, and cultural. In the following paragraphs we elaborate on our specific objectives within each of these areas.

Pedagogical objectives

The over-arching goal of this work is to bring a new dimension of hands-on and creative enterprises to high school physics classes. The vehicle for this effort is the general subject area of fluid dynamics, which will be brought to life in the classroom with a small-scale wind tunnel and engaging interdisciplinary problems. Fluid dynamics is an incredibly rich subject and provides immense opportunities for teachers to discuss the connections between physics, biology, chemistry, geology, climate science, engineering, and even more remote subjects such as art and consumer product design. The boundaries between our scientific and cultural subjects are blurring and we see that people with the ability to speak and create in the areas between disciplines are often highly successful. This project aims to foster a sense of creativity through a pedagogical framework that emphasizes hands-on experiences, integration of science and engineering design, small-scale and inexpensive wind tunnels that are the embodiment of DIY culture, and a competitive challenge intended to spur student engagement in their studies.

Curricular objectives

The United States is currently transitioning its science curriculum to a program called The Next Generation Science Standards (NGSS).* In this model, the engineering design process is given as much significance in teaching as content knowledge and all levels of education K-12 must incorporate engineering design throughout science lessons. At the center of this project are a series of summer workshops for high school teachers, where we will examine experiment and theory with the aim of building proficiency in fluid dynamics. A set of supporting curricular materials will be created and shared with the teachers to supplement the core physics curriculum. One of the authors of this project is a high school teacher and is therefore very familiar with the constraints and needs of this population. The teacher workshops will focus heavily on building an understanding of the foundational equations that define this field: the Navier-Stokes equation, the Bernoulli equation, and conservation of mass. Examples from the interface of physics with other fields will be used to motivate interest in fluid dynamics as a critical component of many interdisciplinary subjects.

Cultural objectives

Central New York is a diverse region, consisting of vast rural communities, dense urban areas (e.g. Syracuse, Rochester, Binghamton), and unique communities (e.g. Ithaca). One of the primary goals of this project is to bring together teachers and students representing a range of geographic, economic, cultural, and racial backgrounds - to learn from each other, share with each other, and challenge each other through a competition that seeks creative solutions to original problems. In a more abstract sense, a goal of this work is to influence the culture of physics education by promoting fluid dynamics, a subject that is often skipped in high school and college physics curricula. This project's emphasis on hands-on work using small wind tunnels aims to provide students with novel experiences leading to authentic research, a cultural aspect that is often reserved for elite institutions and private schools. Additionally, the integration of friendly competition and engineering design is meant to foster an interest in career possibilities that may seem inaccessible to many students from these regions that exhibit a wide range of socioeconomic conditions. Lastly, another cultural byproduct of this endeavor will be the creation of a stronger network of physics teachers who share a common history and can continue to work and learn together.

*NGSS Lead States. (2013). Next generation science standards: For states, by states. The National Academy Press.

3 Description of Activities

The activities supported by this project can be separated into two distinct, but connected, categories: teacher-focused activities, and student-focused activities. The major components of each are discussed subsequently.

Teacher-focused activities

Fluid dynamics is an excellent subject for high school physics teachers because it woven throughout almost every scientific and engineering discipline. Quantum mechanics can be described as the fluid-like dispersion of a probability fluid. The magnetic field inside and outside of an inductor is similar to the motion of air through an open ended wind tunnel, allowing the field intensity to be sensed with the hand. In a more practical application, the movement of water through a series of reservoirs and pipes has been used to model the general equilibrium of national economies[†]. Life and the entire cosmos itself are fluid in nature.

To help our teacher participants develop greater understanding of the connection of fluid dynamics with many diverse fields, a series of collaborative study sessions will introduce the major concepts of and introductory mathematical analysis in fluid dynamics over the course of the summer. These lessons will take place online for the period of approximately 6 weeks, meeting 1-2 times per week, to establish a basis of experience leading up to a culminating, multi-day, in-person workshop. This workshop will be hosted at SUNY Cortland will engage teachers in a wide range of activities including hands-on experiences with fabricating parts, group activities of a more theoretical nature, and experimental analysis using the WEN-D wind tunnel facility at SUNY Cortland. These experiences will provide the foundation for these teachers to carry this knowledge into their teaching and conduct their independent projects in preparation for the end-of-year competition. Supplementary lesson plans and auxiliary materials will be provided to build upon this base, with opportunities for teacher-led collaboration on the development of interactive lessons and demonstrations. Additional support will be provided to teachers throughout the year in the form of group discussions on curricular content.

Student-focused activities

A series of student activities will be designed to take place throughout the year, culminating with an end-of-year competition between schools. The expertise of Mr. Canestaro, a current high school physics teacher, will be instrumental in designing a series of activities that can introduce students to concepts necessary for successful completion of this exercise while maintaining the integrity of the core content that must be taught. For example, lift and drag forces can be discussed as specific examples of forces in a larger discussion of Newton's laws of motion. The measurement of these forces in a wind tunnel, where counter-balancing masses are used to find equilibrium in the presence of applied lift and/or drag forces, is an excellent opportunity to show both the importance of these concepts and the connection between theory and experiment. Furthermore, the flow of air around an object can be introduced qualitatively and intuitively. By discussing these patterns as a result of fundamental conservation laws (energy and mass), these ideas can be introduced alongside a more general discussion of conservation of energy earlier in the year. A series of staged lessons will be developed to help teachers integrate the wind tunnel experience into their curricula, building toward the culminating design experience and final competition.

[†]A. Adamatzky, "A brief history of liquid computers." *Phil. Trans. R. Soc. B* **374**, 20180372 (2019).

4 Dissemination of Information

We envision this project to have two distinct paths and types of information sharing. The first involves the sharing of information within the arc of the project and the recruitment of teacher/school participants. The second form of information sharing is that which occurs beyond the immediate scope of this project and involves sharing the products of this work publicly, including the overall project design, curricular materials, wind tunnel designs, and the competition format. These two aspects of dissemination are described separately in the following.

Within the project

- We will solicit applications for participation at a broad range of schools. Application questions will ask teachers about their willingness to dedicate time to this project, their interest in incorporating fluid dynamics into their curriculum, and gather some information about the composition of their classes.
- Support for teachers will begin in the summer before they introduce the fluid dynamics curricular content. They will be supported through a series of online sessions and a culminating, 2-day in-person event hosted at SUNY Cortland.
- Lesson plans and specific curricular content, including lecture slides, problems, and experiments, will be shared with teachers.
- Regular communication between the teachers in the program and the project leaders will continue throughout the year to build a support network.

External to the project

- This project will be presented at the annual AAPT conference and, depending on the availability of additional funding from SUNY Cortland, also the APS Division of Fluid Dynamics (DFD) conference.
- The project leaders will write an article for *The Physics Teacher* and/or other similar education-focused journals.
- The curricular content created through this project will be made publicly available.
- The plans and design notes for the small wind tunnels will be made publicly available.
- The project leaders will create and release a YouTube video showing the construction of one of the small wind tunnels.

5 Comprehensive Plan

Our plan for enacting this project will be described first by giving an overview of the sequence of events and activities that we are planning, followed by more detailed notes about the specifics of each of the major components of this project.

5.1 Timeline of activities

In the broadest of strokes, work on content development will begin immediately following notice of funding by AIP through the Meggers Project, and will continue into the summer of 2024. The following defines our vision for all activities relating to this project.

Year 1: July 2021-June 2022

- July: create an outline of curricular content on fluid dynamics and the wind tunnel competition for high-school classes
- August: contact high school teachers in central/upstate NY about the project to solicit applications for the 2022-2023 project
- September-December: develop detailed curricular materials
- January: select 5 teachers for the 2022-2023 program
- January-March: share drafts of curricular materials with selected high school teachers and gather feedback
- April-May: revise curricular materials
- June: develop content and plan for the teacher summer sessions that are focused on supporting the developed curricular materials

Year 2: July 2022-June 2023

- July: begin online sessions (1-2 times per week) with the selected high school teachers (5) to review curricular content and develop familiarity with theoretical descriptions of fluid dynamics
- August: bring teachers (5) to SUNY Cortland for a 2-day intensive session, including experiments in the wind tunnel and construction of half-scale wind tunnels
- September: contact NY high school teachers and solicit applications for the 2023-2024 project
- October-December: support teachers as they integrate the fluid dynamics curricular materials in their classes
- January: select 10 teachers for the 2023-2024 program
- February: share competition goals and rules with the teachers
- March-May: hold meetings with each class to discuss ideas and answer questions about the competition
- June: bring the selected high school physics classes to SUNY Cortland for a day of competition and interactive demonstrations

Year 3: July 2023-June 2024

- July: begin online sessions with the selected high school teachers (10) to review curricular content and develop familiarity with theoretical descriptions of fluid dynamics
- August: bring teachers to SUNY Cortland for a 2-day intensive session, including experiments in the wind tunnel and construction of half-scale wind tunnels
- September-December: support teachers as they integrate the fluid dynamics curricular materials in their classes
- January: share competition goals and rules with the teachers
- February-May: hold meetings with each class to discuss ideas and answer questions about the competition
- June: bring the selected high school physics classes to SUNY Cortland for a day of competition and interactive demonstrations
- Summer: a discussion of this project will be presented at the 2024 AAPT conference

5.2 Summer teacher-training program

The backbone of this project will be the summer teacher-training program. As a series of live courses spanning approximately 6 weeks, these activities will focus on developing essential knowledge and core skills in fluid dynamics so that these teachers can successfully conduct in-class activities with their respective classes.

These sessions will begin with a series of online lectures and interactive sessions. During these online activities, the teachers will focus on examining a broad range of physical systems to discuss how fluid dynamics helps us interpret and predict. Examples will focus on natural systems, from the microscopic to the cosmic, and engineered systems. Among the latter, we will discuss the shape of wings, the aerodynamics of vehicles, and fluid dynamics in sports, among other things. Following conceptual analysis, these sessions will embark on the application of theory to creating quantitative descriptions. A rough outline of the sessions is presented here.

- Session 1 (online): Introduction, laminar and turbulent flow, why fluid dynamics is difficult
- Session 2 (online): Force and energy in fluid dynamics
- Session 3 (online): Laminar flow, reversible flow, motion of micro-organisms
- Session 4 (online): Reynolds number and Mach number, fluid dynamics in astrophysics
- Session 5 (online): The transition to turbulence and turbulent viscosity
- Session 6 (online): Lift and drag forces on wings
- Session 7 (in-person): Culminating 2-day workshops at SUNY Cortland

The culminating experience will be a 2-day event hosted by the project leaders at SUNY Cortland. The goal of these experiences is to create a workshop-like experience where the teachers can work together on a series of challenges that are central to the fluid dynamics content they will share with their students. In addition to conducting theoretical analysis of problems, the teachers will have large periods of time to work with models and make measurements using the SUNY Cortland wind tunnel. A rough draft of the content for these days follows here.

- Day 1
  - **Morning:** tour and demo of the SUNY Cortland wind tunnel, discussion of measurements and experiment design
  - **Early afternoon:** application of linear & quadratic drag forces
  - **Late afternoon:** application of Bernoulli's equation to calculate lift forces
  - **Evening:** group dinner
- Day 2
  - **Morning:** discussion and presentation of results from experiments on Day 1
  - **Early afternoon:** how and why, dissecting the wind tunnel and discussion on its construction
  - **Late afternoon:** tour of research facilities at Cornell or Lockheed-Martin (Syracuse)

Upon departure from SUNY Cortland, each teacher will be given the materials to construct a small wind tunnel. All materials will be cut to size, formed to fit, and will come with all necessary sealing and retaining hardware. A Pitot tube and pressure gauge will be included to enable teachers to make measurements of wind speed. A video of the assembly process will be created to help guide the teachers through the assembly process.

5.3 Construction of small wind tunnels for high school physics classes

The wind tunnel at SUNY Cortland, WEN-D (Windy ENvironment-Developer), is about 9.25 feet in length, constructed of 1/2" thick plywood, and was constructed for about $1200, including all instrumentation. For a 1/2-scale version of the WEN-D wind tunnel, a substantially lower cost is expected. Material costs will roughly scale like the square of the linear size (reduced by a factor of 4). Aspects of the cost that are more-or-less fixed are the Pitot tube, pressure gauge, and other measurement systems. Given these effects, the cost of producing the 1/2-scale devices is estimated at approximately $500 per wind tunnel. Should cost overruns be realized in the first year of this project, the number of teachers involved in the second year can be reduced to compensate.

5.4 Advertising to and selection of high school participants

In support of the cultural objectives of this project, which include reaching a diverse population of students, this program will be advertised to high school teachers in urban and rural areas. Urban areas will include those of Syracuse, Binghamton, and Rochester. A list of rural and small-town schools will be compiled. Advertising for the program will occur by directly contacting the administrations of these schools and inviting physics teachers to submit an application to the project leaders.

Applications will be evaluated collectively following a specified close date. Selection criteria will focus on the following aspects, in order of importance: (1) teacher commitment to the summer training programs, (2) dedication to incorporating fluid dynamics content in the curriculum, (3) diversity statement, and (4) ability to participate in the final competition.

5.5 Curricular developments for high school physics courses

The materials developed for teachers to use in their high school classes have not yet been developed, but is the first major part of the work that will be undertaken by the project leaders following notification of funding. We anticipate that the curricular materials will be comprised of a focused program of fluid dynamics and smaller, supporting modules that can be inserted throughout the curriculum to emphasize the interdisciplinary nature of fluid dynamics. The curriculum will be aligned to the New York State Science Learning Standards (NYSSLS), adapted from the NGSS mentioned in Section 2, specifically

Figure 1: A photograph of the WEN-D wind tunnel at SUNY Cortland (dated May 6, 2021). The fan is located at the far right side of the runnel, with the test chamber in the middle. The Pitot tube can be seen on the top-left of the test chamber, with the pressure gauge to the right. A two-axis force balance (lift and drag) can be seen below the wind tunnel.

building on the criteria of incorporating engineering design.[‡] As New York is one of the leaders in reform the high school physics curriculum, this project could become an important example of successful integration of physics and engineering with other interdisciplinary aspects. The engineering-relevant NYSSLS performance expectations that are connected to this work are:

- **HS-ETS1-1:** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- **HS-ETS1-2:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- **HS-ETS1-3:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- **HS-ETS1-4:** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

5.6 The competition

While this project could survive and thrive without a competitive aspect, the authors believe that a spirit of amicable competition can be a great motivating force, spurring all parties to achieve more than they would by themselves. The goal of the competition is to create a welcoming and dynamic atmosphere where students have the opportunity to compete on multiple dimensions. Similar to many other engineering competitions, participating schools will compete for points in multiple project areas:

- design and goals

[‡]The standards specific to physics and engineering can be found on pages 58-63 and 83 of the NYSSLS document: http://www.nysed.gov/common/nysed/files/programs/curriculum-instruction/p-12-science-learning-standards.pdf

- analysis and testing
- overall presentation
- experimental results

The exact nature of the competition has not yet been determined. However, some guiding principles have been determined to help create a competition rich enough that it does not devolve into repetition of what has been done, and yet constrained enough so that differences in financial and auxiliary resources do not become a deciding factor. Toward these ends, each school will be given a strict list of off-the-shelf materials that will be allowed, and each design must be produced with an upper limit of $60 (accounted for in the project budget). Some preliminary thoughts about the nature of the competition have focused on concepts that are sufficiently outside common experience that everyone will start at nearly the same point. A few possibilities are things like:

- maximizing drag in a structure created from woven yarn
- a device that transitions from minimum drag to maximum drag at a critical speed
- lift generation with toroidal structures
- rigidity optimization in a 32-element tensegrity structure
- maximum variation in drag force in a deformable structure
- a power harvesting device with a rotation axis inclined at 45° to the wind

The central characteristic of all of these ideas is that they require both that the teachers and students learn about things outside the standard curriculum of introductory physics (e.g. toroidal geometry, tensegrity, wind turbines). For the latter two ideas, which incorporate dynamic aspects into the design, groups may be given an Arduino computer and a small set of motors and gears to accomplish their goals (feasible within the $60 limit).

Prior to the competition, and as close to the start of the spring semester as possible, teachers will be given a summary of the competition. The rules will clearly specify the goals and rules of the competition, what resources and materials are allowed to be used, the criteria on which their projects will be assessed, and the date and location of the competition. Given that SUNY Cortland typically completes its spring semester by the second week of May, and most high schools continue well into June, there will be ample opportunity to use a weekday in late May or early June for the competition at SUNY Cortland.

5.7 Summary of major developments from this project

- 15 high-school teachers will develop engaging curricula in the interdisciplinary field of fluid dynamics.
- Each teacher will build a small wind tunnel, complete with instrumentation, which they will keep as a demonstration device and for classroom experiments.
- Curricular materials, including lecture notes, demonstrations, experiments, and discussion problems will be created and made publicly available.
- The designs for the small wind tunnels, along with a parts list, will be made publicly available.
- A YouTube video showing the assembly of the wind tunnels will be made publicly available.
- Classes involved in this project will be given the opportunity to participate in a design and science competition.
- This project and the work products funded by the Meggers award will be presented at the AAPT conference in the summer of 2024, and possibly others depending on additional financial support from SUNY Cortland.

6 Project Budget

This proposal seeks $25k in funding, which will be spent over approximately three years and distributed over the following expense categories.

materials, supplies, and tools for 15 wind tunnels	47%
support for the summer teacher training sessions	26%
summer salary for the project leaders (total over 2 years)	21%
funding for presentation at the AAPT conference	6%

Budget breakdown per project phase

The following presents the proposed budget for each phase of the project: the planning phase, the first year of project activity, and the second year of project activity, and the post-project phase.

Planning phase (July 2021 - June 2022)

The planning phase, during the 2021-2022 academic year, will be largely free of costs as it will mainly focus on the development of curricular material for use in the following summer and year. The one purchase that will take place in this period is the acquisition of the gantry mill, which will be used to manufacture the parts for the wind tunnels. We believe that it is important to purchase this piece of equipment during this phase so that it can be set up, tested, and wind tunnel parts fabricated prior to the arrival of the teachers.

gantry mill for fabricating wind tunnel parts	$3300

Year 1 project (July 2022 - June 2023)

Beginning in the summer of 2022, the first year activity will focus on 5 teachers/schools for involvement in this project.

2 day summer teacher-training program for 5 teachers:	
Teacher stipend, $100 per day per person	$1000
Hotel expenses, $100 per person	$500
Travel expenses, $100 per person	$500
Institutional expenses	$200
material for 5 wind tunnels, $500 each	$2500
supplies for 5 competition kits, $60 each	$300
Summer salary for project leaders, $1300 each	$2600
subtotal for year 1 activities	$7600

Year 2 project (July 2023 - June 2024)

The second year of the project will expand our outreach to 10 new schools.

2-day summer teacher-training program for 10 teachers	
Teacher stipend, $100 per day per person	$2000
Hotel expenses, $100 per person	$1000
Travel expenses, $100 per person	$1000
Institutional expenses	$400
material for 10 wind tunnels, $500 each	$5000
supplies for 10 competition kits, $60 each	$600
Summer salary for project leaders, $1300 each	$2600
subtotal for year 2 activities	$12600

Post-project phase (Summer 2024)

Following the completion of the main two-year project phases, the focus will be on sharing the experiences of this work in a conference presentation and a written paper. We expect negligible publication costs, so the primary cost to the grant here is for the conference presentation. Additional funds will be sought from SUNY Cortland to allow Dr. Eric Edlund to present this work at the APS Division of Fluid Dynamics conference.

AAPT conference registration	$400
Airfare for 1 person	$650
Hotel for 3 nights $150 per night	$450
subtotal for the post-project activities	$1500
Grand total	$25000

7 APPENDIX: Supporting Documents and Curriculum Vitae

The following documents are attached:

- Letter of institutional support from SUNY Cortland
- CV for Eric Edlund
- CV for Anthony Canestaro

SUNY Cortland
Provost and Vice President
for Academic Affairs

June 14, 2021

Mr. Brad Conrad
One Physics Ellipse
College Park, MD 20740-3843

Dear Mr. Conrad,

I am pleased to provide this letter of support for the proposal "Physics, engineering, and design using wind tunnels in the high school classroom" submitted to the American Institute of Physics Megger Project Award. The project will be led by Dr. Eric Edlund, Assistant Professor of Physics at SUNY Cortland.

Dr. Edlund is an outstanding physicist with a growing research portfolio. This project fits in well with Cortland's longstanding tradition of engagement with regional schools and professional development of teachers. Dr. Edlund's design for an educational competition should prove to be an excellent learning opportunity for students and teachers alike. Programs that bring together collaboration with secondary education are wonderful tools in maintaining relationships with our regional high schools.

Let me extend my wholehearted support for this project in regards to Dr. Edlund's effort as well as the campus facilities available to fulfill this program. We look forward to the success of this project.

Sincerely,

Mark J. Prus
Provost and Vice President for Academic Affairs

Miller Building, Room 408 • P.O. Box 2000 • Cortland, NY 13045-0900
Phone: (607) 753-2207 • Fax: (607) 753-5993

Eric Matthias Edlund

Assistant Professor of Physics
SUNY Cortland
eric.edlund@cortland.edu

EMPLOYMENT

Teaching Appointments

SUNY Cortland, Physics Department — Cortland, NY
Associate Professor — effective September 1, 2021
Assistant Professor — 2017 - present

California Polytechnic University, Physics Department — San Luis Obispo, CA
Visting Lecturer — Winter & Spring quarters, 2013

Princeton University, Physics Department — Princeton, NJ
Preceptor — Fall, 2012

Rider University, Department of Chemistry and Physics — Lawrenceville, NJ
Lecturer — Fall 2010

Research Appointments

Max Planck Institut für Plasmaphysik — Greifswald, Germany
Turbulence and Transport Group — August 2015 - December 2017
Visiting Scientist

Massachusetts Institute of Technology — Cambridge, MA
Plasma Science and Fusion Center — August 2015 - December 2017
Staff Scientist
Project Lead for the W7-X PCI Collaboration

US Department of Energy — Germantown, MD
Office of Fusion Energy Sciences — April-May 2015
Temporary Interdepartmental Work Detail
Research Scientist

Princeton Plasma Physics Laboratory — Princeton, NJ
ITER and Domestic Tokamak Collaborations — March 2015 - August 2015
Research Physicist, RM-2

Princeton Plasma Physics Laboratory — Princeton, NJ
Plasma Science and Technology Division — September 2009 - March 2015
Associate Research Physicist, RM-1

EDUCATION

Massachusetts Institute of Technology — Cambridge, MA
Ph.D., Physics — 2009

California State University Chico — Chico, CA
B.S., Physics and Mathematics — 2003

COURSES TAUGHT

SUNY Cortland
PHY 105 - Elementary Mechanics and Heat (algebra-based)
PHY 201 - Principles of Physics I (calculus-based mechanics, lecture & lab)
PHY 202 - Principles of Physics II (calculus-based E&M, lecture & lab)
PHY 203 - Principles of Physics III (calculus-based, waves, optics, thermodynamics)
PHY 357 - Intermediate Laboratory
PHY 420 - Classical Mechanics
PHY 429 - Special Topics: Advanced Classical Mechanics
Summer Python Programming School (unofficial, Summer 2020)

Cal Poly
PHYS 121 - College Physics I (algebra-based mechanics)
PHYS 132 - General Physics II (calculus-based, waves, optics and thermodynamics, lecture & lab)

Princeton University
PHY 103 - General Physics I (calculus-based mechanics, precept)

Rider University
PHY 200 - General Physics I (algebra-based mechanics, lab only)

GRANTS, PATENTS & INVENTIONS

"Phase contrast imaging for Wendelstein 7-X"
M. Porkolab (Principal Investigator), MIT and E. M. Edlund (co-Investigator), SUNY Cortland
submitted to: US Department of Energy, Office of Science, Office of Fusion Energy Sciences (2021)
total award: $900k, August 2021 - August 2024

"Construction of a Taylor-Couette device for the study of rotating turbulence"
E. M. Edlund
Submitted to: SUNY Cortland Faculty Research Program
total award: $1250

"Diagnostic equipment for the Red Dragon Wind Tunnel facility"
E. M. Edlund and S. Nolan
Submitted to: SUNY Cortland Faculty Small Grant program
total award: $500

"Optictool: the intuitive optical design platform for Research, Engineering, and Education"
E. M. Edlund and N. Rose
Application submitted to the SUNY Technology Accelerator Fund (July 2020)

"Intuitive optical design with web technologies"
E. M. Edlund and N. Rose
SUNY Invention Disclosure (April 23, 2020)

"Advanced liquid centrifuge using differentially rotating cylinders and optimized boundary conditions, and methods for the separation of fluids"
H. Ji, A. Cohen, P. Efthimion, E. Edlund, and E. Gilson
US Patent No. 10,300,410 (May 28, 2019)

"Phase contrast imaging for Wendelstein 7-X"
M. Porkolab (Principal Investigator), MIT and E. M. Edlund (co-Investigator), SUNY Cortland
submitted to: US Department of Energy, Office of Science, Office of Fusion Energy Sciences (2017)
total award: $900k, August 2018 - August 2021, US Department of Energy

"Construction of a phase contrast imaging diagnostic for Wendelstein 7-X"
M. Porkolab (Principal Investigator) and E. M. Edlund (author and key personnel), MIT
submitted to: US Department of Energy, Office of Science, Office of Fusion Energy Sciences (2014)
total award: $1.039M, August 2015 - August 2018

PUBLICATIONS

First Author

E. M. Edlund, "Interception and rendezvous: an intuition-building approach to orbital dynamics" *The American Journal of Physics* 89, 559 (2021).

E. M. Edlund and S. Kadas, "Visual storytelling of scientific data: collaborations between physics and graphic design in the college classroom" *The SUNY Journal of the Scholarship of Engagement* 1, article 2 (2020).

E. M. Edlund, M. Porkolab, Z. Huang, O. Grulke, L.-G. Böttger, C. von Sehren and A. von Stechow, "Overview of the Wendelstein 7-X phase contrast imaging diagnostic" *Review of Scientific Instruments* 89, 10E105 (2018).

E. M. Edlund, P. T. Bonoli, M. Porkolab and S. J. Wukitch, "Modeling of EAST ICRF heating with the full-wave code TORIC" *21st Topical Conference of Radio Frequency Power in Plasmas*, (2015).

E. M. Edlund and H. Ji, "Reynolds number scaling of the influence of boundary layers on the global behavior of laboratory quasi-Keplerian flows" *Physical Review E* 92, 043005 (2015).

E. M. Edlund and H. Ji, "Nonlinear stability of laboratory quasi-Keplerian flows" *Physical Review E* 89, 021004 (2014).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin, N. Tsujii and S. J. Wukitch, "Experimental study of reversed shear Alfvén eigenmodes during the current ramp in the Alcator C-Mod tokamak" *Plasma Physics and Controlled Fusion* 52, 115003 (2010).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin and S. J. Wukitch, "Phase contrast imaging measurements of reversed shear Alfvén eigenmodes during sawteeth in Alcator C-Mod" *Physics of Plasmas* 16, 056106 (2009).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin and S. J Wukitch, "Observation of RSAEs during sawteeth in Alcator C-Mod" *Phys. Rev. Lett.* 102, 165003 (2009).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin and S. J. Wukitch, "Reversed shear Alfvén eigenmodes in Alcator C-Mod during ICRF minority heating and relationship to sawtooth crash phenomena" *Proceedings of the European Physics Society Plasma Physics Conference* (2008).

Contributing Author

S. Kadas and E. M. Edlund, "A multidisciplinary collaboration between graphic design and physics classes responding to COVID-19" submitted to the *Journal of the Scholarship of Engagement: JoSE*, February 2021.

J.-P. Bähner, J. A. Alcusón, S. K. Hansen, A. von Stechow, O. Grulke, T. Windisch, H. M. Smith,Z. Huang, E. M. Edlund, M. Porkolab , M. N. A. Beurskens, S. A. Bozhenkov, O. P. Ford, N. Pablant, G. G. Plunk, A. Bañón-Navarro, F. Jenko and the W7-X Team, "Phase contrast imaging measurements and numerical simulations of turbulent density fluctuations in gas-fuelled ECRH discharges in Wendelstein 7-X" submitted to the *Journal of Plasma Physics* (March 2021).

Z. Huang, E. M. Edlund, M. Porkolab, A. von Stechow, J.-P. Bähner, L.-G. Böttger, C. von Sehren, and O. Grulke, "The Wendelstein 7-X phase contrast imaging diagnostic" accepted for publication in *the Journal of Instrumentation*, January 2021.

A. von Stechow, O. Grulke, T. Wegner, J. H. E. Proll, J. A. Alcusón H. M. Smith, J. Baldzuhn, C. D. Beidler, M. N. A. Beurskens, S. A. Bozhenkov, E. M. Edlund, B. Geiger, Z. Huang, O. P. Ford, G. Fuchert, A. Langenberg, N. Pablant, E. Pasch, M. Porkolab, K. Rahbania, J. Schilling, E. R. Scott, H. Thomsen, L. Vanó, G. Weir, and the W7-X Team, "Suppression of core turbulence by profile shaping in Wendelstein 7-X" submitted to *Physical Review Letters*, April 2020.

A. Marinoni, C. P. Moeller, J. C. Rost, M. Porkolab, and E. M. Edlund, "A heterodyne phase contrast imaging system for ion cyclotron emission detection" submitted to *Review of Scientific Instruments*, June 2020.

M. J. Burin, K. J. Kaspary, E. M. Edlund, R. Ezeta, E. P. Gilson, H. Ji, M. McNulty, J. Squire and G. R. Tynan, "Turbulence and jet-driven zonal flows: Secondary circulation in rotating liquids due to asymmetric forcing" *Physical Review E* 99, 023018 (2019).

A. Marinoni, C. P. Moeller, M. Porkolab, J. C. Rost, E. M. Davis, and E. M. Edlund, "A wide frequency heterodyne detection method using the Pockels effect" *MIT Plasma Science and Fusion Center internal report*, PSFC/RR-18-3 (2018).

T. Golfinopoulos, B. LaBombard, D. Brunner, J. Terry, S.-G. Baek, P. Ennever, E. Edlund, W. Han, W. Burke, S. Wolfe, J. Irby, J. Hughes, E. Fitzgerald, R. Granetz, M. Greenwald, R. Leccacorvi, E. Marmar, S. Pierson, M. Porkolab, R. Vieira, S. Wukitch, Stephen, "Edge Transport and Mode Structure of a QCM-Like Fluctuation Driven by the Shoelace Antenna" *Nuclear Fusion* 58, 056018 (2018).

A. Creely, A. White, E. M. Edlund, N. Howard, A. Hubbard, "Perturbative thermal diffusivity from partial sawtooth crashes in Alcator C-Mod", *Nuclear Fusion* 56, 036003 (2016).

J. L. Terry, M. L. Reinke, J. W. Hughes, B. LaBombard, C. Theiler, G. M. Wallace, S. G. Baek, D. Brunner, R. M. Churchill, E. M. Edlund, P. Ennever, I. Faust, T. Golfinopoulos, M. Greenwald, A. E. Hubbard, J. Irby, Y. Lin, R. R. Parker, J. E. Rice, S. Shiraiwa, J. R. Walk, S. J. Wukitch, P. Xu, "Improved confinement in high-density H-modes via modification of the plasma boundary with lower hybrid waves" *Physics of Plasmas* 22, 056114 (2015).

J. H. Rhoads, E. M. Edlund and H. Ji, "Effects of magnetic field on the turbulent wake of a cylinder in MHD channel flow" *Journal of Fluid Mechanics* 742, 446 (2014).

S. E. Sharapov, B. Alper, H. L. Berk, D. N. Borba, B. N. Breizman, C. D. Challis, I. G. J. Classen, E. M. Edlund, J. Eriksson, A. Fasoli, "Energetic particle instabilities in fusion plasmas", *Nuclear*

Fusion 53, 104022 (2013).

A. H. Roach, E. J. Spence, C. Gissinger, E. M. Edlund, P. Sloboda, J. Goodman and H. Ji, "Observation of a free-Shercliff-layer instability in cylindrical geometry" *Physical Review Letters* 108, 154502 (2012).

E. J. Spence, A. H. Roach, E. M. Edlund, P. Sloboda and H. Ji, "Free MHD shear layers in the presence of rotation and magnetic field" *Physics of Plasmas* 19, 056502 (2012).

L. Lin, M. Porkolab, E. M. Edlund, J. C. Rost, C. Fiore, M. Greenwald, Y. Lin, D. R. Mikkelsen, N. Tsujii and S. J. Wukitch, "Studies of turbulence in Alcator C-Mod H-Mode plasmas with phase contrast imaging and comparisons with GYRO" *Physics of Plasmas* 16, 012502 (2009).

L. Lin, M. Porkolab, E. M. Edlund, J. C. Rost, M. Greenwald, N. Tsujii, J. Candy, R. E. Waltz and D. R. Mikkelsen, "Studies of turbulence in Alcator C-Mod ohmic plasmas with phase contrast imaging and comparisons with GYRO" *Plasma Physics and Controlled Fusion* 51, 065006 (2009).

M. Porkolab, E. M. Edlund, L. Lin, R. Parker, C. Rost, J. Sears, J. A. Snipes, S. J. Wukitch, B. N. Breizman, N. N. Gorelenkov, G. J. Kramer, A. Fasoli and H. Smith, "Experimental studies and analysis of Alfvén eigenmodes in Alcator C-Mod" *Proceedings of the 21st IAEA Conference*, IAEA-CN 149 (2006).

L. Lin, E. M. Edlund, M. Porkolab, Y. Lin and S. J. Wukitch, "Vertical localization of phase contrast imaging diagnostic in Alcator C-Mod" *Review of Scientific Instruments* 77, 10E918 (2006).

M. Porkolab, C. Rost, N. Basse, J. Dorris, E. M. Edlund, L. Lin, Y. Lin and S. J. Wukitch, "Phase contrast imaging of waves and instabilities in high temperature magnetized fusion plasmas" *IEEE Transactions on Plasma Science* 34, 229 (2006).

N. P. Basse, E. M. Edlund, D. R. Ernst, C. L. Fiore, M. J. Greenwald, A. E. Hubbard, J. W. Hughes, J. H. Irby, G. J. Kramer, L. Lin, Y. Lin, E. S. Marmar, D. R. Mikkelsen, D. A. Mossessian, M. Porkolab, J. E. Rice, J. A. Snipes and J. A. Stillerman, "Characterization of core and edge turbulence in L- and enhanced D-alpha H-mode Alcator C-Mod plasmas" *Physics of Plasmas* 12, 052512 (2005).

E. Scime, R. Murphy, E. M. Edlund and G. Ganguli, "Electrostatic ion-cyclotron waves in a currentless, anisotropic plasma with inhomogeneous flow" *Physics of Plasmas* 10, 4609 (2003).

Publicity and Interviews

"Physics class using brand-new wind tunnel" *SUNY Cortland Bulletin* (May 4, 2021).

"Physics and graphic design students work together on COVID-19" *SUNY Cortland Bulletin* (May 19, 2020).

"SUNY Cortland's academic odd couples address real-world problems " *SUNY Cortland Bulletin* (May 21, 2019).

"Angular momentum transport in astrophysics and in the lab" *Physics Today* 66, 27 (August 2013).

PRESENTATIONS

Talks

"First experiments from SUNY Cortland wind tunnel" SUNY Cortland seminar, a collaborative presentation with students from PHY 357 (May 7, 2021).

"Visual storytelling of scientific data: collaborations between art and physics in the college classroom" SUNY Applied Learning Conference, Albany, NY (October 2019).

"Branches, paths, and junctions: what do electrons know of free-will?" Physics Department Colloquium, SUNY Cortland (September 2019).

"Comparison of sawtooth heat pulses across confinement regimes in Alcator C-Mod" 56th annual meeting of the APS-DPP, New Orleans, LA (2014).

"Boundary layers and global stability of laboratory quasi-Keplerian flow" 66th annual meeting of the APS-DFD, Pittsburgh, PA (2013).

"Experimental studies of turbulence lifetimes in differentially rotating flows" 65th annual meeting of the APS-DFD, San Diego, CA (2012).

"A new concept for an advanced liquid centrifuge" Savannah River National Laboratory, Director's Colloquium (October 2012).

"Searching for a subcritical transition in quasi-Keplerian flows" 64th annual meeting of the APS-DFD, Baltimore, Maryland (2011).

"Studies of Rossby waves and hydrodynamic turbulence in a Taylor-Couette device" 63rd annual meeting of the APS-DFD, Los Angeles, California (2010).

"A new experiment for the study of hydrodynamic waves and turbulence" 52nd annual meeting the APS-DPP, Chicago, Illinois (2010).

(invited) "Observation of revered shear Alfvén eigenmodes during the sawtooth cycle in Alcator C-Mod" 50th annual meeting of the APS-DPP, Dallas, Texas (2008).

(invited) "Phase contrast imaging diagnostics on the Alcator C-Mod and DIII-D tokamaks" 17th Topical Conference on High-Temperature Plasma Diagnostics, Albuquerque, New Mexico (2008).

Posters

"Overview of measurements from the Wendelstein 7-X stellarator phase contrast imaging diagnostic and plans for the OP-2 campaign" 62nd annual meeting of the APS-DPP, online (2020).

"Upgrades to the Wendelstein 7-X phase contrast imaging diagnostic and plans for the OP2 campaign" European Physics Society Conference, (2020) - Cancelled.

"Observation of electron-driven Alfvén eigenmodes in Wendelstein 7-X" European Physics Society Conference, Prague, Czech Republic (2018).

"Overview of the phase contrast imaging diagnostic for Wendelstein 7-X" High Temperature Plasma Diagnostics conference, San Diego, California (2018).

"First results from the Wendelstein 7-X phase contrast imaging diagnostic" 59th annual meeting of the APS-DPP, Milwaukee, Minnesota (2017).

"Overview of the design of the phase contrast imaging diagnostic for Wendelstein 7-X" 58th annual meeting of the APS-DPP, San Jose, California (2016).

"Modeling of ICRF wave propagation and heating in EAST with the full-wave code TORIC" 57th annual meeting of the APS-DPP, Savannah, Georgia (2015).

"Recent results from the Princeton MRI and HTX experiments" 54th annual meeting of the APS-DPP, Providence, Rhode Island (2012).

"In search of a subcritical transition to turbulence in rotating hydrodynamic flows" 53rd annual meeting of the APS-DPP, Salt Lake City, Utah (2011).

"A method for minimizing secondary flows in Taylor-Couette experiments" 52nd annual meeting the APS-DPP, Chicago, Illinois (2010).

"Diagnostic systems of the Princeton MRI Experiment" 51st annual meeting of the APS-DPP, Atlanta, Georgia (2009).

"Experimental study of reversed shear Alfvén eigenmodes during ICRF minority heating and relationship to sawtooth crash phenomena in Alcator C-Mod" 21st Transport Taskforce Workshop, Boulder, Colorado (2008).

"Reversed shear Alfvén eigenmodes in Alcator C-Mod during ICRF minority heating and relationship to sawtooth crash phenomena" 35th European Physics Society Plasma Physics Conference, Crete, Greece (2008).

"Mode structure and stability analysis of RSAEs with NOVA-K" 49th annual meeting of the APS-DPP, Orlando, Florida (2007).

"Alfvén eigenmode activity during the sawtooth phase in Alcator C-Mod" 48th annual meeting of the APS-DPP, Philadelphia, Pennsylvania (2006).

"Observation of reverse shear Alfvén eigenmodes in Alcator C-Mod and their modeling with NOVA" 47th annual meeting of the APS-DPP, Denver, Colorado (2005).

"Measurement and modeling of Alfvén cascades in Alcator C-Mod" 46th annual meeting of the APS-DPP, Savannah, Georgia (2004).

"Effects of temperature anisotropy and shear flow on ion-cyclotron instability of a magnetized plasma" 44th annual meeting of the APS-DPP, Orlando, Florida (2002).

Workshops, Discussions, and Panels

"Teaching science labs during a pandemic", Institute for College Teaching, SUNY Cortland (November, 2020).

"Strategies for increasing student engagement in synchronous instruction", Institute for College Teaching, SUNY Cortland (August, 2020).

"Scientists as writers: Commonalities and distinctions of writing across different disciplines", Institute for College Teaching, SUNY Cortland (March 2020). Co-presenter with Professor Karen Downey (Chemistry, SUNY Cortland).

"Panel discussion with the artists", Dowd Gallery *Measured Confluence* exhibition, SUNY Cortland (February 2020). Co-presenter with Professor Robert Vlasak (Jan Evangelista Purkyne University, Czech Republic) and Gallery Director Jaroslava Prihodova (Dowd Gallery, SUNY Cortland).

"Rubrics and contract grading", SUNY Cortland Writing in the Disciplines Fellows program (January, 2020). Co-presenter with Professor Jessica Carrick-Hagenbarth (Economics, SUNY Cortland).

CREATIVE ENDEAVORS

A $b-1$ multiplicative identity for digit summing in base b, a proof of the optimality of a base 1 counting system. August 2020.

Binary Processes, art installation in the *Measured Confluence* exhibition at the Dowd Gallery, SUNY Cortland. January-February, 2020.

Forbidden Regions, with Jaroslava Prihodova, art installation in the *Measured Confluence* exhibition at the Dowd Gallery, SUNY Cortland. January-February, 2020.

SERVICE AND ASSOCIATIONS

Current Service

Educational Policy Committee (Chair)

Physics Department Curriculum Committee (Chair)

Alumni-Undergraduate Research Science Symposium

Physics Department 3+2 Program Coordinator

Physics Department Personnel Committee

Physics Department Scholarship Committee

Physics Department Faculty Search Committee

Physics Department orientation advisor for new and transfer students

UUP area activist for Physics & Geology

Past Service

Chair, Physics Department Program Review Committee (2019-2020)

Event Coordinator, Physics Department "Celebration of Graduates" Event (2020)

Physics Department colloquium coordinator

Member, Dowd Art Gallery Director Search Committee (2018-2019), SUNY Cortland

Member, Physics Department Faculty Search Committee (2018-2019), SUNY Cortland

Member, Computational physics curriculum committee, Cal Poly (2013)

Referee, Physical Review Letters, Physics of Plasmas and Nuclear Fusion (varied)

Proposal Reviewer, High Energy Density Plasma grant proposals, Department of Energy

Colloquium Coordinator, Plasma Science and Technology Division, PPPL (2011-2013)

Treasurer, Griggstown Volunteer Fire Department, (2011-2012)

Volunteer Fire Fighter, Griggstown Volunteer Fire Department (2010-2014)

Executive Officer, MIT Club Sports Council (2007-2009)

Captain, MIT Cycling Team (2006-2007)

Tutor, MIT Office of Minority Education (2006-2007)

Vice President, CSU Chico chapter of the Society of Physics Students (2001-2003)

Tutor, CSU Chico chapter of the Society of Physics Students (1999-2003)

Associations

American Physical Society

American Association of Physics Teachers

AWARDS AND HONORS

Recipient (3 times) of the Award for Excellence in Research and Scholarship (SUNY Cortland)

Writing in the Disciplines Fellow, SUNY Cortland (2019-2020)

Fine Teaching Award, SUNY Cortland (2019)

Men of Value and Excellence (MOVE) Award, SUNY Cortland (2018)

MENTORED STUDENT RESEARCH

Fall 2020, SUNY Cortland
Student: Olivia Wilburn
Project: Numerical modeling of flocking behavior

Summer 2020, SUNY Cortland
Student: Hunter Reid
Project: Experimental and theoretical study of a process to create ice in the desert

Spring 2020, SUNY Cortland
Students: Scott Blankenbaker and Tyler Edgar
Project: Measurements of wave dispersion in a coupled oscillator system

Spring 2019 - present, SUNY Cortland
Student: Karl Hipius
Project: Simulation of a coupled oscillator system
Presented at the 2020 SUNY Cortland Transformations event

Summer 2018 - present, SUNY Cortland
Student: Nathaniel Rose
Project: Development of a gaussian optics program for optical design iteration

Spring 2019, SUNY Cortland
Students: Karl Hipius and Nathaniel Rose
Project: Construction of a macroscopic model of quantum mechanical systems
Presented at the 2019 SUNY Cortland Transformations event

Fall 2016 & Winter 2017, MIT
Student: Jeannette Maisano-Brown
Project: Development and testing of an arrayed light source for W7-X PCI detector calibration

Summer 2011, Princeton Plasma Physics Laboratory
Student: Michael Pretko
Project: Theoretical analysis of surface waves in rotating flows
Presented at the 2011 APS DFD Conference in Baltimore, MD

Summer 2010, Princeton Plasma Physics Laboratory
Student: Zoe Yan
Project: Measurement of the vortex lifetime in rotating flows

Fall 2009, Princeton Plasma Physics Laboratory
Student: Peter Humanik
Project: Development of a line-laser scanner for measurement of surface waves in rotating flows

Charles Anthony Canestaro

8 Valley View Drive
Cortland, NY 13045
607--758-4110 ext. 1281
ccanestaro@cortlandschools.org
charles.canestaro@gmail.com

Objective

To better facilitate student learning in the subject areas of physics and mathematics while maintaining a productive class environment where students feel comfortable with inquiry-based learning and reflection

Education

January 2018-December 2018 **Adams State University**
Alamosa, CO

- Certificate in Leadership in STEM Education accredited from Teachers College at Columbia University through the NASA STEM Endeavor STEM Teacher Certificate Leadership Project
- First-ever recipient of the Glen Schuster Memorial Scholarship
- 4.00 overall GPA

August 2014-December 2016 **State University of New York, College at Cortland**
Cortland, NY

- Master's Degree of Science in Adolescence Education: Physics and Mathematics
- New York Professional Certificate in Physics and Mathematics grades 7-12
- 4.07 overall GPA

August 2010-May 2013 **State University of New York, College at Cortland**
Cortland, NY

- Bachelor's Degree of Science, Adolescence Education: Physics and Mathematics
- New York Initial Certificate in Physics and Mathematics grades 7-12
- Dean's List every semester, President's List three semesters
- 3.94 overall GPA, 4.15 GPA in Physics, 3.75 GPA in Mathematics, and 3.93 in Pedagogy
- Recipient of SUNY Cortland Outstanding Senior Physics Major Award

August 2008-December 2009 **Tompkins Cortland Community College**
Dryden, NY

- Associate's Degree in Science: Liberal Arts and Sciences-Math/Science
- Dean's List every semester, Phi Theta Kappa member
- 3.78 overall GPA

Teaching Experience

September 2013-Present **Cortland Senior High School** Cortland, NY
Regents, Honors, and AP (B,1, and C) Physics

- Utilizes current Physics Education Research findings to continually alter teaching style to offer as effective teaching as possible, including employing the modeling physics approach and open-inquiry lab activities to teach physics and promote a growth mindset in class
- Implements project-based learning in energy and electricity units to bring research and presentation skills into the classroom, as well as emphasize the application of physics to every facet of life and the interdisciplinary nature of science
- Takes physics students to local elementary schools in the Spring to perform physics activities and demonstrations for first grade students
- Started and lead professional development "Fisiks Phun" nights on a monthly basis where educators and methods students from the local area share lessons, best lab and demonstration practices, as well as create common formative assessments
- Created suite of common formative assessments which give differentiated feedback using google forms and google classroom as an online platform
- Mentored twenty-three physics practicum students and five student teachers
- Designed and implemented the first calculus-based physics course in the area to receive college credit from the local community college (Physics 211 as a concurrent enrollment class from Tompkins Cortland Community College)
- Increased enrollment in Physics by 94% over four years, increased average passing rate on Physics Regents Exam up to 93%, increased mastery rate on Physics Regents exam up to 50%

August 2020-Present **Rider University**
Guest Lecturer

- Co-taught CURR 667 Physical Science in Motion through the NASA STEM Endeavor STEM Teacher Certificate Leadership Project

December 2018-present **New York State Master Teacher Program** Cortland, NY
Master Teacher: Central Region

- Developed and lead the Professional Learning Team *STEAM Mania* where cross-cutting concepts where chosen as topics for an interdisciplinary share session
- Participate and lead targeted professional development with local physics teachers in a Professional Learning Team (PLC)

July 2017 **Oak Ridge National Laboratory** Oak Ridge, TN
Adirondack Regional Commission/Oak Ridge National Laboratory Summer Math-Science Institute

- Collaborated with STEM teachers from across the Appalachian Region to research the physics of protein folding under the mentorship of Oak Ridge researcher Jeremy Smith
- Created a cross-cutting lesson plan to connect physics, biology, chemistry, and engineering to teach electrostatics in the Regents Physics classroom

Related Work Experience

June 2017-Present **Cornell University** Ithaca, NY
Upward Bound Program Physics Instructor

- Designed a two week long, project-based course to teach introductory circuitry and magnetism concepts to first generation college students
- Focused on building constructive relationships with students to foster a positive attitude toward science and help teach college readiness skills

September 2013-present **Cortland Senior High School** Cortland, NY
Cortland High School Science Olympiad Team Coach

- Lead team practices and helped advise students prior to competition
- Regional judge for the past four years and created *Fermi Questions* event for the Fayetteville-Manlius Invitational

September 2016-June 2020 **Cortland Senior High School** Cortland, NY
Cortland High School Student Council Advisor

- Planned, coordinated, and supervised meetings with the student council
- Worked with students to develop leadership skills and have a positive role in the school and local community
- Planned and carried out numerous school and community events, including spirit week, teacher appreciation week, school dances, the United Way Day of Caring food drive, Red Cross Blood drives, the community harvest festival, the community *Polar Express Night*, and the annual *Leadership Breakfast*

Publications and Presentations

- Canestaro, Charles A., and Moataz H. Emam. "The Five Dimensional Universal Hypermultiplet and the Cosmological Constant Problem." Physics Letters B 726.4-5 (2013)
- *The Five Dimensional Universal Hypermultiplet and the Cosmological Constant Problem* talk given to SUNY Cortland Physics Department and presentation at *Transformations* event (May 2013)
- *Molecular Dynamics Simulations to Visualize and Understand Prion Structure* presented to select faculty and staff at Oak Ridge National Laboratory (July 2017)

- Electric Circuits Workshop collaboration with Cornell CHESS Lending Library (2018) https://www.chess.cornell.edu/workshop-electric-circuits-spreads-current-enthusiasm-nys-puerto-rico (December 2018)
- Cornell Laboratory for Accelerator-Based Sciences and Education (CLASSE) video on determining the speed of light (October 2019) https://www.youtube.com/watch?time_continue=5&v=e6ZTFaCt3H8&feature=emb_logo
- *Women in Physics: Introducing the STEP UP for Women in Physics* presented to NYS Master Teachers at the 2020 Summer Conference (August 2020)
- *Women in Physics: Introducing the STEP UP for Women in Physics* presented to students in the Endeavor STEM Teacher Leader Certificate Project (November 2020)

Special Skills and Interests

- Ambassador Lead for the APS/AAPT STEP UP for Physics program which aims to increase the number of women that pursue an undergraduate degree in physics
- Proficient in LaTeX writing program, Modeling Physics Curriculum, screencasting, Geometer's Sketchpad, Microsoft programs, SMARTboard, Vernier software, and implementation of iPads in the physics and mathematics classrooms
- Researching various branches of physics including string theory cosmology and Physics Education Research
- Recipient of the 2016-2017 Eleanor Schwartz award for "unusual contributions to the welfare of Cortland High School, its staff and/or students, a person of excellent character, unselfishly willing to make those contributions"
- Voted by Cortland High School Staff as the October 2019 "Staff Member of the Month"
- Recipient of the Tompkins Cortland Community College 2019 "Concurrent Enrollment Instructor of Excellence" Award
- Recipient of the Cayuga Radio Group 2019 "Apple for the Teacher" Award
- Member of STANYS, AAPT, APS, and AMTNYS
- Regional Spontaneous Judge for Odyssey of the Mind
- Semi-professional chef who has catered bridal showers, housewarming parties, and a wedding
- Currently learning construction and interior design to remodel our 1900 Victorian brick "fixer upper" house