CROSSSECTIONS

SUMMER 2022

UNI University of Northern Iowa

A MESSAGE FROM THE DEPARTMENT HEAD, DR. PAUL SHAND

Dr. Paul Shand
Professor and Head of the
UNI Department of Physics

Dear Friends,

Welcome to the 2022 issue of Cross Sections. Academic years 2019-20 and 2020-21 were disrupted and dominated by COVID. The current academic year (2021-22) was much closer to the pre-COVID status quo; in other words, what we used to call normal. Masks were optional during the entire academic year and there was no social distancing in classrooms. Fortunately, the Omicron surge occurred mostly during the winter break; thus, we were spared from having to deal with a spike in infections in an environment unfavorable to restrictions. The students were certainly happy to be back to full, in-person instruction and so, I believe, were most faculty members. In-person theater productions, musical performances, and academic presentations all made a comeback, and as many of you know, the Physics Homecoming picnic took place after a two-year hiatus. Though COVID will likely be a recurring part of our lives for years to come, we hope that vaccines and post-infection immunity will allow students to return to the exciting and enjoyable social environment that prevailed before the pandemic.

In last year's message, I mentioned that enrollment at UNI has been declining. As you probably know, this problem is not unique to UNI; it is a significant challenge for institutions of higher education in general. As of May 2022, the projected enrollment at UNI for Fall 2022 will be somewhat smaller than the enrollment for Fall 2021, continuing a general downward trend. Though the projected number of students may rise as we go through Summer Orientation, it is not expected to surpass the Fall 2021 figure. The situation in Physics, as in most departments, mirrors that of UNI. The good news is that through intensive recruitment efforts, UNI's incoming freshman enrollment has been increasing over the last three years. All hands are on deck to ensure that this trend continues and ultimately reverses the declining enrollments of the recent past. So, what is being done to increase enrollment? There are many plans on various scales that are being implemented but describing all of them would fill the entire newsletter. I will limit myself to a brief description of one major initiative – Academic Positioning.

Academic Positioning (AP) is a process that first assesses the academic structure of the university (colleges, programs, curriculum, support processes and so forth) and then changes that structure to position the university for growth in a changing and highly competitive higher-education landscape. A central theme is collaboration across campus to promote ideas for new programs that address employment trends, employer needs, and student interest. Phase 1 of AP entails information gathering and the identification of thematic areas around which future programs will be built. Phase 1 has been completed and Phase 2 is underway. Focused working groups have been formed to develop new programs in two important areas: data science and health sciences. Two other working groups are focused on alternative credentials (certificates, badges, etc.) and advising.

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A NEWSLETTER FOR ALUMNI AND FRIENDS OF THE
DEPARTMENT OF PHYSICS, UNIVERSITY OF NORTHERN IOWA

The campus community has received regular updates from all four groups as they work toward new, collaborative offerings and processes to enhance marketability, flexibility, and student support.

The AP process also involves the reimagination of the teacher preparation curriculum. As you know, UNI has been the leader in Iowa in the area of teacher education for many decades. However, there has been strong competition in recent years, especially from Iowa State University. This has precipitated a comprehensive examination of the length and content of teacher education programs at UNI. One area of concern is program length. Many students find it difficult to graduate in four years because of the many requirements. With increasing cost already a major concern of students and parents, there is pressure to ensure that UNI teacher education programs can be completed in four years while maintaining the high quality for which UNI is well known. The process of transformation of the teacher education curriculum is in the relatively early stages, but I am sure that the leaders of the initiative will complete the task with some urgency.

In previous editions of Cross Sections, I mentioned that UNI had undertaken a redesign of its General Education program. The new program, called UNIFI (UNI Foundational Inquiry) will be offered for the first time in Fall 2022. I believe most students have switched from the current program to UNIFI because it is eight credit hours shorter. UNIFI will have embedded assessment of learning outcomes to promote a virtuous cycle of feedback and improvement.

At the departmental level, we have continued our remarkable run of producing nominees for UNI in the annual national Goldwater scholarship competition. Physics has generated four nominees over the past four years. Our latest nominee is BS Physics major Madelyn Johnson. Former physics and biochemistry major Joseph Tibbs won a Goldwater scholarship in 2019.

Our new BA Physics: Data Science Emphasis degree program produced its first two graduates this past spring. Troy Buzynski and Dhruv Patel are now proud holders of diplomas certifying their physics and data science skills. We hope to see increasing enrollments as this program becomes better known across Iowa and neighboring states.

UNI now has the approval of the Board of Regents to offer engineering programs. Along with the Chemistry & Biochemistry and Applied Engineering & Technical Management (formerly Industrial Technology) departments, Physics is developing a new program in materials science & engineering. The three departments have deep expertise in this area, especially in metals, which will be an area of emphasis. (Some of you may recall the Metal Casting Center housed in the Industrial Technology department.) Employers in Iowa have expressed significant interest in the new program and we have considered their input in developing the coursework. If things proceed smoothly, the new program will be available in Fall 2023.

I cannot end this message without thanking you for your generous support for our students and programs. Your donations allow us to offer research fellowships and scholarships to our very deserving majors. It is immensely rewarding and gratifying for me to be a member of the UNI Physics family. Please note that we are planning to host our annual Homecoming Picnic at noon on October 8th at Seerley Park in Cedar Falls. Mark your calendars! Please take care of yourselves and I hope to see you at the picnic.

Best wishes,

Paul Shand
Professor and head

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FACULTY PROFILE

Jeff Morgan, Associate Professor of Physics and Science Education

Jeff Morgan

Jeff Morgan attended Walla Walla College in southeastern Washington, originally majoring in engineering before switching to physics. The switch came after he had the opportunity to teach an introductory lab section while still an undergraduate. He completed a B.S. in physics with a minor in mathematics. He then taught physical science in a Chattanooga, Tennessee area high school for three years before moving to the University of Maine to pursue graduate studies. He completed his Ph.D. in physics with a physics education emphasis in 2006.

"I was like a lot of our incoming students – I did well in math and science in high school, but didn't really know what I wanted to do with those interests. In fact, I liked chemistry more than physics in high school," Morgan said. "I started engineering studies, but found the college physics courses to be the most interesting of my requirements. Around the same time, I read Paul Davies' About Time, which really expanded my view of what kinds of ideas physicists tackle. And I had opportunities to teach and tutor physics, which I found to be rewarding challenges."

Morgan was hired at UNI in 2006 with a joint appointment in physics and science education. "To be honest, I came to UNI because the university was the first to offer me a position while I was searching for a job," he related. "And Cliff (Chancey, department head at the time) told me they needed a decision within 72 hours. So my wife and I said 'yes,' figuring to be here for two or three years before moving back east to be nearer to family. I remember Tim Cooney (emeritus professor of Earth Science and Science Education) telling me he'd had similar thoughts. But here we are, 16 years later, with no plans to go elsewhere. I feel very fortunate to have found a professional home in a great department where physics education has a long history and is valued."

The structure of UNI's departments, collegial atmosphere, and history of teacher development were all appealing to Morgan. "I love that I have opportunities to teach science education methods courses to future and practicing teachers, as well as physics content courses. Many colleagues work at institutions where they only have the opportunity to do one or the other, and are in some cases the sole science educator in their department, even college. UNI has a great team and a strong history of science and specifically physics education. The work that Roy Unruh, Bob Ward, my current colleague Larry Escalada, and others have done to position UNI as a leader in physics education makes this a great institution with opportunities to work with a variety of audiences."

"I also appreciated the fact that the department seemed friendly and welcoming," Morgan continued. "I still remember having lunch with Cliff and Dale (Olson, former professor) during my interview. Cliff started a few of his conversations with "You know Dale, UNI…" Not used to the school initials, I remember hearing 'you and I…' and thinking 'wow, these guys must do a lot together…' But it's true – it's a very welcoming department where nobody is obsessed with hierarchy, position, or titles. Everyone just jumps in wherever it is needed and they seem to enjoy working together to offer students great opportunities."

Within the department, Morgan's recent teaching has been the two-semester introductory sequence Physics for Science and Engineering as well as Resources for Teaching Physics. "The commitment of the physics department to small class sizes has been wonderful," Morgan enthused. "When I took on the Physics I and II courses in 2010, I was allowed, even encouraged, to try new things. We used the Workshop Physics curriculum for ten years in that course, meeting in a studio space with lots of experimentation, derivation, and discussion. I've moved on to try a different blend of materials from the physics education research community to try and achieve better student learning gains. None of this, however, would be possible with larger class sizes that are common at other institutions. While I hope we succeed in attracting more students to the study of physics, I secretly hope we don't get too big, because I believe that the small class sizes in our program offer students a huge benefit of support and individualized attention, and provide faculty with an environment to try new things."

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FACULTY PROFILE cont.

Jeff Morgan

Morgan's recent research has been related to his courses and the workshops he has offered with Larry Escalada. "It's been my practice since graduate school to use conceptual assessments as well as conceptually-focused exam questions in my content courses to try and see what students do and don't understand," he stated. "I had so many 'aha' moments in my three years of high school teaching where I suddenly learned something I thought I knew from my undergraduate courses, but hadn't stuck for one reason or another. My hope is that using data to study learning in my courses will drive targeted course improvements and lead my students to understand ideas I didn't when I was in their position."

In fact, it was a research project with recent B.A. in Physics Teaching graduate Ernest Toutant (now teaching science in Central City, Iowa) that led to trying a new blend of approaches in Physics I and II. "Ernest examined all of the data we'd collected over the years related to the electromagnetism content in Workshop Physics," Morgan said. "He concluded that although students did reasonably well on some of the learning objectives, there were others (such as the forces current-carrying wires experience in fields created by other wires) where student performance was quite poor. This was one of the findings that led me to ask whether or not a different set of materials might improve student understanding, and to make a shift in course curriculum."

Morgan was awarded the 2021 Class of 1943 Faculty Award for Excellence in Teaching last year. "UNI provides a great environment for people like me who are interested in experimenting with teaching and learning," he stated. "I appreciate all of the students who have engaged in my courses over the time I've been here and tried new things, some of which worked and some didn't. Talking about physics with students has rarely felt like work, and I hope it continues to be that way." Morgan has also served for the past several years on the committee developing UNI's new general education program UNIFI, which launches this coming fall.

Outside of his work at UNI, Morgan enjoys working on home-improvement projects, playing games, biking, traveling with his wife Kelly and daughters Phoebe and Delia, and singing.

"If you told 12- or 14-year-old me that singing would be a hobby later in life, he'd have been mortified," Morgan joked, "but it's a fun hobby. I currently sing in a church choir, a men's chorus, and a barbershop quartet. But I have no plans to give up my day job."

Dr. Morgan's work involves examining how physics students learn some of the foundational ideas, such as potential energy diagrams and wave equations, needed to understand systems discussed in quantum physics

DEPARTMENT HAPPENINGS

Visits to Department

Several groups of K-12 students visited the department during the past academic year. The students engaged in hands-on activities, visited research labs, and in some cases, got lunch!

Two Waterloo West High students build a tower from pasta and spice drops. How fast can you build when you are eating the building materials?

A visiting Upward Bound student seems to (almost) have everyone, including faculty member Tim Kidd, eating out of his hand in the Electronics lab.

They want to remember this! Two 8th grade students photographically record their standing wave pattern. They were just getting started in the competition for the largest number of nodes.

Awards Banquet

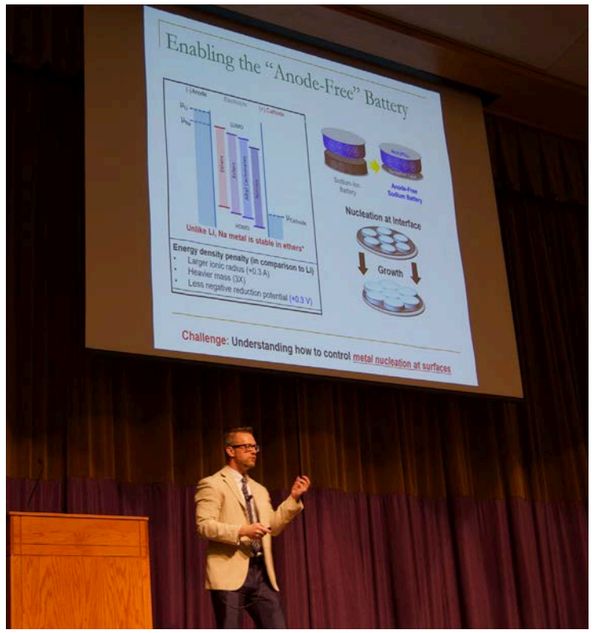
The annual Physics Banquet was back to being a real banquet again rather than an Awards Ceremony conducted via Zoom. It was marvelous to be able to sit down to an excellent meal before the presentation of awards!

TOP LEFT: Department head Paul Shand presents an award to physics major Jeff Carlson who also served as the master of ceremonies for the evening's event.
BOTTOM LEFT: Senior Aaron Kirchman receives a well-deserved award.

DEPARTMENT HAPPENINGS

Begeman Lecture

Like many other events, the Begeman Lecture returned this year after being canceled in 2020 and 2021. The speaker was Dr. Cary Pint, professor of mechanical engineering at Iowa State University and UNI Physics alumnus. (See Alumni News in this issue of Cross Sections.) The title of the lecture was "Batteries and Beyond: Advances to Address Critical Challenges in Energy and Sustainability."



Dr. Cary Pint explains his work at the 2022 Begeman Lecture.

New Format for Physics Competition

In the annual Physics Competition, high school students compete in five events, namely, soda straw arm, toothpick bridge, catapult, mousetrap car, and measurement (in which competitors figure out a method of measuring the value of a quantity with equipment provided). This year, for the first time, the entire statewide competition was completed in one day. The new format went quite smoothly, though it made for a long day.

TOP: A team observes as they launch a ping pong ball from their catapult, hoping to match prescribed horizontal ranges. BOTTOM: Two participants build a soda straw arm.

Holiday Colloquium

The annual Holiday Colloquium resumed in person after a two-year COVID hiatus. It was great to witness plain demonstrations, magic tricks and minor miracles again.

Tim Kidd showcases "rainbow chocolate." Delicious diffraction!

Physics major Erica Oler demonstrates the hoverboard she built to be a part of the up and coming Physics Roadshow. All aboard!

Science Education Update Conference

The Science Education Update Conference is an annual meeting for Iowa K-12 teachers hosted by the UNI Science Education faculty. The conference focuses on issues and topics related to K-12 Science and STEM. The conference also features breakout and workshop sessions, exhibits and access to instructional resources and strategies that can be implemented in the classroom. After a COVID break, the conference was back in session — in person — this year.

Science Education director and Physics faculty member Larry Escalada explains how to model phone damage to his audience of science teachers.

Homecoming Picnic

Our annual Homecoming Picnic was held in person for the first time since 2019. The picnic was held at Seerley Park. Though Seerley Park has long been the preferred venue, bad weather drove us inside for several consecutive years before the pandemic. It was great to be back at Seerley again!

The Hopkinses (clad in purple, with canine kin) and the Drillings deep in conversation.

Alumnus Jacob Weber (purple T-shirt) and friend, faculty member Larry Escalada and emeritus faculty member Mike Roth discuss the thrills and chills of teaching.

STUDENT PROFILE

Aaron Kirchman

Aaron Kirchman

Aaron Kirchman is originally from Eau Claire, Wisconsin, and attended Eau Claire North High School. He recently graduated from UNI with a B.S. in physics and a B.A. in mathematics. Aaron was the Physics Department's Purple and Old Gold Awardee for Meritorious Scholarship at the Spring 2022 Commencement ceremonies.

Why did you choose UNI?
When I was originally looking for colleges to attend, I was looking at a variety of schools that were a decent distance from home but also not too far away. UNI had that perfect balance since it was about a 4-hour drive from my hometown. In addition, I had the opportunity to visit the campus multiple times and meet with Dr. Shand in the UNI Physics Department. Being able to experience campus and the department was extremely beneficial in choosing to come to UNI. I loved the small department feel that the physics department gives while also providing opportunities that would not be accessible at other larger universities. Combining the opportunities offered everywhere on campus with the general feeling I had about the physics department really made the decision to come to UNI relatively straightforward.

What were some of the things you liked most about attending UNI?
One of my favorite things about UNI is the number of things happening related to the university despite it being a relatively small school. There are so many groups and opportunities all over campus for all sorts of interests. From recreation to academics there is always something going on around campus to do. The faculty and staff at the university really do care about students and have shown me that their main priority is helping me succeed in my goals, whatever they may be. In addition, I have come to recognize how valuable a degree from UNI is compared to other schools. The school builds such an impressive community of students and alumni that it is incredibly common to run into an alumnus of the university no matter where I am. At the very least, I regularly talk to people who have some connection to the school. Everyone is always interested about what UNI is like nowadays and they are always proud to have attended UNI. I think these connections and the general UNI community is something that I'm going to miss the most after I graduate.

Why did you choose physics as your major? What got you interested?
Since elementary school I have always loved science and learning about how the world works. Eventually I started to learn more about mathematics and applying it to the physical sciences which gradually grew into me being fascinated with physics. I learned that physics can be applied to so many systems and is a beautifully complex topic. Throughout my time studying physics at UNI, this fascination has only grown. I regularly found myself in classes learning about topics I had never considered before but being able to apply fundamental ideas to explain them. The seemingly complex nature of physics and the real-world, immediate applications is what I really love about the subject and hope to continue learning about in the future. It's something that often gets overlooked since most people's only experience with physics is introductory classical mechanics, but more advanced physics can often be wildly fascinating and mind-blowing at the same time.

Did you do any undergraduate research? What was the greatest value of the research experience from your perspective?
I have worked with Dr. Ali Tabei for nearly two years now performing undergraduate research. My project involved creating a computer model of how proteins interact with one another on single-stranded DNA during the DNA repair process of homologous recombination. Traditionally, these interactions are modeled using deterministic techniques. In reality though, they are very stochastic and random. Therefore, I have worked to implement a stochastic algorithm into these models and slowly build the level of complexity and realism until we can match the model's results to experimental results. These experimental results will come from Dr. Maria Spies who is a professor in the University of Iowa's Department of Biochemistry and Molecular Biology. The project will continue to be worked on by future UNI physics students after I graduate. I am excited to see where it goes and what results can be derived from my work.

STUDENT PROFILE

Throughout the two years of work, I have been able to present this research in a few different places. I have presented at multiple colloquiums within the UNI Physics Department, but also been able to present virtually at the American Physical Society's (APS) 2021 March Meeting, and at the Iowa Space Grant Consortium Student Symposium at the University of Iowa in April 2022. These presentations combined with the research itself has motivated me to pursue a future career in scientific research and has provided me with valuable skills and knowledge about the research process. Prior to this experience, I never really knew how research was conducted. So, I am incredibly grateful to Dr. Ali Tabei and the rest of the UNI Physics faculty for their mentorship and guidance throughout the project. I am incredibly excited to use these concepts and ideas in the future as I continue doing research in graduate school and hopefully a future career.

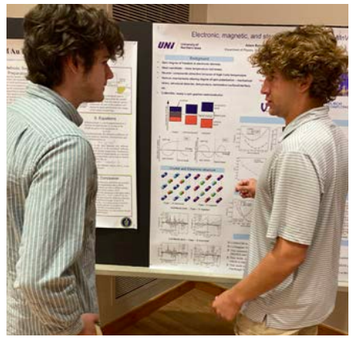
Are you involved in other activities at UNI?
I have tried to remain very active in a variety of ways while on campus. Academically, I double majored in physics and mathematics despite physics being my primary area of interest. Many of the courses I took in the math department lacked direct applications to my physics courses, but they did significantly contribute to the thinking strategies and logical problem-solving techniques that I then used in my physics classes and research. Having this background became very beneficial as I reached upper-level physics and was performing undergraduate research. Outside of the classroom, I was active within the School of Music as I played trumpet in the marching band, basketball pep band, and in the spring concert band for each of my four years. Within the marching band I was a member of leadership for two years serving as one of the band's librarians who oversaw the printing and organizing of music for the whole band. These opportunities were positive moments away from the classroom where I was able to simply do something that I loved and provide entertainment for others. Additionally, I also worked on campus all four years, a highlight being my service as Facility Manager at the Wellness and Recreation Center (WRC) for two and a half years. I have made many connections and built multiple relationships that I would not have without these jobs. Overall, I have really enjoyed being able to find multiple activities I can participate in, both inside and outside of Begeman Hall, where I can enjoy what I do and build friendships and relationships.

What do you like to do in your free time?
I have a lot of interests outside of the classroom, but during my free time I am often being active in some way. I regularly run along the sidewalks and trails of Cedar Falls, but also enjoy going to the WRC to work out and/or go rock climbing. All these things allow me to socialize with other students from a variety of academic backgrounds which is something I have come to enjoy doing. When I am finally able to convince myself to fully relax, I enjoy hanging out with friends and roommates in my apartment. This regularly consists of either watching random TV shows and movies or playing video games and board games together.

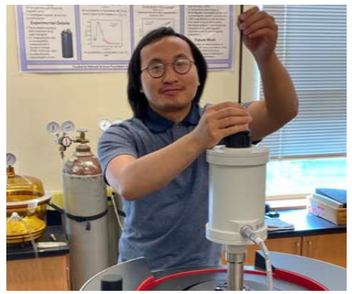
What are your future plans?
Starting next fall (2022), I will be attending Cornell University in Ithaca, NY and pursuing a Ph.D. in their Earth and Atmospheric Sciences Department. Specifically, I will be working in the atmospheric science side of things by performing research on the very upper region of the earth's atmosphere including the ionosphere. This is a small research area and uses many applications of physics. Because of that, I have come to be fascinated by it and am incredibly excited to learn more about the system and its fundamental science. The concepts I have learned in UNI physics classes in addition to the life skills UNI has given me has set me up for success in graduate school and beyond that. I am incredibly excited for my future and very thankful for all that UNI has done to motivate my success, both academically and personally.

Student Research

Our students were very active in research this past year, presenting at local and regional conferences, and attending a national conference. Lukas Stuelke and Young Moua attended the 2022 Joint MMM-Intermag Conference in New Orleans in January. They enjoyed this experience immensely.

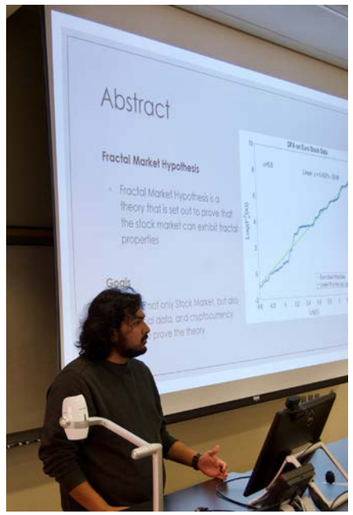


Adam Ramker (right) explains his summer research project at the Summer Research Symposium.



Young Moua inserting a sample in the DynaCool Physical Property Measurement System in Paul Shand's research lab.

Lukas Stuelke (left) and Young Moua attend the MMM-Intermag Conference in New Orleans.



Dhruv Patel presents his summer research project at a Physics Colloquium.

Goldwater Scholarship Nomination

Maddie Johnson was nominated by UNI to compete for the national Goldwater Scholarship, continuing the Physics Department's streak of 4 nominations in 4 years. Maddie will be spending this summer in Paris conducting research as a participant in a Research Experiences for Undergraduates (REU) program at the University of Michigan.

Maddie Johnson

SPS Chapter Award

The UNI Physics Department's Society of Physics Students (SPS) chapter has won yet another Outstanding Chapter Award. This is the third consecutive award for our very industrious students. Just 80 of the 844 SPS chapters across the country were honored with Outstanding Chapter awards this year. Bravo!

Physics students (including 3 from UNI) at the 2022 SPS Zone 11 Meeting in Nebraska.

PHYSICS SCHOLARSHIPS & AWARDS

Sigma Pi Sigma, Physics Honors Society

New Members as of 2022
Jeff Carlson
Ashley Harrington
Lukas Stuelke
Michaela Tweeton

2021-22 Physics Department Awards

Outstanding Performance in Introductory Physics
Jenna Heinen
Brandon Schmidt

Outstanding Performance in First-Year Projects in Physics
Brandon Schmidt
Dylan Seiffert

Prospective Physics Teaching Award
Lydia Butters

Outstanding Research Presentation
Aaron Kirchman

Physics Department Outstanding Service Award
Aaron Kirchman
Sophie Roberts

2022-23 Physics Department Scholarships

Robert E. Allender Physics Teaching Scholarship
Carter Bush

Grossman-Perrine Scholarship
Abby Hutchins

Louis Begeman Memorial Scholarship
Jeff Carlson
Isaiah Dempsey
Madelyn Johnson
Sabryn Labenz
Lukas Stuelke

Begeman Fund for Excellence in Physics Scholarship
Dylan Seiffert

Jourdan Excellence in Physics Scholarship
Brandon Schmidt

C. Clifton Chancey Scholarship in Physics
Stephen McFadden

Jourdan Mentor Scholarship
Ashley Harrington

2022-23 CHAS Scholarships

Frank W. Starr Science & Technology Scholarship
Dylan Seiffert

Jessica Allen Terri Scholarship
Madelyn Johnson

Summer Undergraduate Research Fellows

Summer 2022
Jeff Carlson
Ashley Harrington
Sabryn Labenz
Young Moua
Zach Pottebaum
Nathan Schmidt

PHYSICS EDUCATION

Maddie Johnson

Student Research

B.S. Physics major Maddie Johnson explored the effect of different modes of instruction on student learning during the COVID pandemic. A synopsis of her research findings is presented below.

Introduction and Background

The UNI Department of Physics has offered professional development programs for many decades, focused on helping Iowa secondary science teachers gain their physics teaching endorsement. After funding for these professional development programs was no longer available, the Department of Physics joined with UNI Continuing Education to offer professional development in the format of a summer course. The course was designed to utilize hybrid instruction, but due to the Covid-19 pandemic, the first two offerings of this course had to be completely online. This research looked at the differences in conceptual understanding of physics topics between participants of the in-person programs and participants of the online courses.

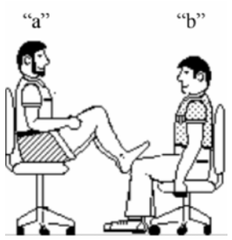
Physics Resources and Instruction for Secondary Science Teachers (PRISST) was offered in-person from 2006-2008 in order to train more physics teachers in Iowa as the state was experiencing a physics teacher shortage. Iowa Physics Teacher Instruction and Resources (IPTIR) was offered in-person from 2009-2011. This program was very similar to the PRISST program in its goal of training more physics teachers as well as its use of PRISMS PLUS and Modeling Instruction curricula.

In order to continue to support teachers seeking a physics endorsement without the funding previously available, the UNI Department of Physics currently offers two professional development courses through UNI Continuing Education on an alternating basis, one focused on mechanics and the other on electricity & magnetism. Originally, the courses were designed to include one week of face-to-face labs and three weeks of virtual meetings, but due to the Covid-19 pandemic, the 2020 and 2021 courses were taught entirely online. Twelve 3-hour Zoom sessions were held with the teachers during the summer. To help complete the modules virtually, videos, data, and online simulations were shared with the teachers.

The Force Concept Inventory (FCI) and Brief Electricity and Magnetism Assessment (BEMA) conceptual assessments were used to assess conceptual understanding of the subject matter. The conceptual assessments were taken by participants before and after completion of their program or course. These preliminary and postliminary scores were then compared using average gain and average normalized gain. Average gain = average posttest% – average pretest%. Average normalized gain = average gain/(100 – average pretest%). The BEMA assessment was used only for the 2021 online electricity & magnetism course.

Question from the Force Concept Inventory

In the figure at right, student "a" has a mass of 95 kg and student "b" has a mass of 77 kg. They sit in identical office chairs facing each other.



Student "a" places his bare feet on the knees of student "b", as shown. Student "a" then suddenly pushes outward with his feet, causing both chairs to move.

During the push and while the students are still touching one another:
(A) neither student exerts a force on the other.
(B) student "a" exerts a force on student "b", but "b" does not exert any force on "a".
(C) each student exerts a force on the other, but "b" exerts the larger force.
(D) each student exerts a force on the other, but "a" exerts the larger force.
(E) each student exerts the same amount of force on the other.

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Results
FCI Data:

Instruction Method	Year	Pre-test Average	Post-test Average	Average Gain	Average Normalized Gain
In-Person	2006	54%	71%	17%	**36%**
	2009	51%	67%	15%	**30%**
Virtual	2020	58%	66%	8%	**19%**

The PRISST program (2006) had 14 participants take the pre and post-test. The IPTIR program (2009) had 22 participants take the pre and post-test. The Summer 2020 course had 11 participants take the pre and post-test.

BEMA Data:

Instruction Method	Year	Pre-test Average	Post-test Average	Average Gain	Average Normalized Gain
Virtual	2021	35%	48%	13%	**21%**

The Summer 2021 course had 6 participants take the pre and post-test.

Reflections

The positive gain shown in the tables for the in-person and virtual programs show that both of these instructional methods are effective. One reason why the gain is much larger for the in-person programs could be because of the time spent in class or the backgrounds of the participants. Another reason could be because of the relative effectiveness of the virtual and in-person instructional methods, but I don't feel that there is enough data to definitively conclude this. Based on the observed advantages and data, I believe that in-person instruction may be slightly more effective. But, in order to take advantage of the strengths of both methods, I believe that a hybrid instructional method would be most effective, combining in-person and virtual instruction, which the future summer courses plan on utilizing.

Further research could include analyzing future summer professional development courses and programs. I think it would be really interesting to compare the average gains and average normalized gains analyzed in this project with the average gains and average normalized gains of future courses with the hybrid instruction method. Professional development programs prior to the PRISST and IPTIR could also be looked at if this project was continued.

ALUMNI PROFILE

Dr. Tyler Rash

Dr. Tyler Rash

Tyler Rash holds a Ph.D. in physics from the University of Missouri and works for Cummins Inc. in Columbus, Indiana. He gave a colloquium on transportation emissions control at UNI last September. He graciously agreed to be interviewed by Cross Sections.

Where were you born and where did you grow up?
I was born and raised in Sigourney, Iowa.

When were you a student at UNI?
I was a student at UNI from 2007 to 2010. Before that I was a student for two years at Indian Hills Community College in Ottumwa, IA.

Why did you choose UNI for your undergraduate studies? What degree program were you enrolled in?
I selected UNI because of its emphasis on creating good teachers. I was an aspiring physics professor. I received a BS in physics and minors in chemistry and mathematics.

What did you enjoy about being a student at UNI?
UNI's physics department has a unique combination of size and technical depth/research coupled with minimal to no emphasis on graduate students makes it an excellent place for undergraduate physicists to learn and gain experience. Support for my research and conference attendance were educational highlights. Beyond that, I also enjoyed taking a course on ultimate frisbee taught by Tim Morrill who now owns Morrill Performance which specializes in training professional ultimate frisbee players across the country. Attending football games was also fun.

What were your favorite courses? Why?
Modern Physics Lab seemed important and interesting at the time due to the rigor of the laboratory reports and the fact that we were able to do/recreate a Nobel Prize winning experiment virtually every week. In my professional life the value of this has been proven out. Just last week I provided one of my direct reports with the textbook for that course (Taylor's Introduction to Error Analysis) and he too is appreciating the content for his work at Cummins.

Do you have a favorite Physics Department-related memory from your time as a student?
My favorite memory is probably the time Dr. Shand blew everyone's mind by annihilating all the students in the department's ping pong tournament.

Where have you worked since graduating?
My first job after graduating from UNI was as a graduate student in Dr. Peter Pfeifer's lab at the University of Missouri doing research on porous materials. I also worked as a teaching assistant there. My second job was working as the Manager of ANG Development at Hicor Technologies in Houston, Texas. From there I became a Senior Engineer in Cummins' Sensor Fundamentals Group. Now I'm a Technical Specialist in the same group, where I manage a small team of technicians and engineers.

Who is your current employer and what is your position? Describe your duties in some detail.
As mentioned above, I am a Technical Specialist at Cummins Inc. I lead a team of engineers and technicians that does research and development on diesel exhaust sensors, especially NO_x and particulate matter sensors. This involves designing, building, maintaining, and operating laboratory equipment and creating methods to conduct experiments on said sensors. We also provide consulting services for the company regarding "New, Unusual, or Difficult" sensor topics related to NO_x and PM sensors as well as other sensors for other business segments (e.g. batteries and H_2). As a part of my role at Cummins I provide consulting services for the diesel engine industry more generally. This involves helping regulatory bodies (e.g. CARB and EPA) formulate next generation emissions regulations, especially regulations concerning real-world emissions measurement methods, often with support from the Society of Automotive Engineers (SAE) and Engine Manufacturers Association's Emissions Measurement & Testing Committee (EMTC). I also interface with other companies and laboratories in the sensor industry to help develop next generation sensors.

How has your UNI physics degree helped you succeed in your jobs?
My manager was looking for a combined physicist/engineer to do highly specialized engineering work when they found me. While I didn't take advantage of UNI's 3+2 physics/engineering program, the applied physics/experimental skills that I gained in both the building trades and in graduate school were worthy substitutes. The teaching opportunities I received in the physics department (especially as the Upward Bound teaching assistant) allowed me to achieve a level of mastery of the material that I likely wouldn't have gotten elsewhere. When solving "New, Unusual, or Difficult" problems in the real world, having a good handle on the fundamental operating principles of the universe as well as the various analytical techniques helps you in figuring out where to begin. The research opportunities I received in Dr. Kidd's lab, especially when I was given the opportunities to present my own research, shaped the way that I present material today.

ALUMNI PROFILE

What advice do you have for current students as they prepare to seek employment?
While I didn't do this, I think internships at large companies are a good starting point. Summer internship opportunities begin to fill up during the preceding fall. My team has had only two interns but both opportunities were created after the candidate reached out to me either through a professional network or by reaching out on LinkedIn unprompted. This is probably a low percentage path for juniors or seniors with a documented relevant skill of interest to the employer, but if you do get an opportunity that way it may be a better fit/opportunity as it is predicated on that employer being motivated to work with you specifically for one reason or another.

What do you do for fun?
I enjoy playing ultimate frisbee, broomball, distance running, and hiking/camping. I also really enjoy procuring my own food through foraging or hunting and preparing those ingredients for my friends and family.

Who are your immediate family members and where is your current hometown?
I reside in Columbus, Indiana, with my spouse Ashley and my daughter Sawyer (6).

ALUMNI NEWS

Dr. Cary Pint

Dr. Cary Pint

Cary L. Pint is currently the Charles Schafer Chair of Engineering and Associate Professor at Iowa State University. Before arriving at ISU in 2020, Pint was on the faculty of the Department of Mechanical Engineering at Vanderbilt University for 8 years and prior to that was a Research Scientist at Intel Labs. Pint received his B.S. in Physics at UNI in 2005, Ph.D. in Applied Physics at Rice University in 2010, and postdoctoral training at UC Berkeley. Pint has published over 120 journal articles and holds 17 granted US patents. Pint is currently an Associate Editor at Energy Storage Materials, a highly cited journal in energy storage research. Pint is also the co-founder and Chief Technical Officer of SkyNano LLC, which utilizes economical electrochemistry for the synthesis of carbon nanomaterials from CO_2 in the air. Pint has received a number of national awards, including being one of Forbes Magazine's "Top 30 under 30" disruptors in Science and Innovation. He has also been named a Kavli Frontiers Fellow of the National Academy of Sciences, a "Top 20 under 40" Talent in Academia by the American Society of Engineering Education, and a R&D 100 award winner for technology spun out of his research team and into SkyNano LLC. Pint was honored by the UNI Physics Department as the 2022 Begeman Lecturer.

DONOR FEATURE

Dr. Gerald Intemann

Dr. Gerald Intemann

Dr. Intemann served as the UNI Physics Department head from 1980 to 1990 and then Dean of the College of Natural Sciences until 2000. Dr. Intemann's generosity makes it possible for the department to award at least one Dr. Gerald Intemann Undergraduate Research Fellowship in Physics each year to a deserving student participating in our summer undergraduate research program. He has kindly agreed to be interviewed by Cross Sections as the first ever featured donor.

Where were you born and where did you grow up?
I was born in Jersey City, New Jersey, and grew up in North Bergen, New Jersey, a working-class community just across the Hudson River from New York City.

What is your connection to UNI?
I am connected to UNI through my 20 years as a physics faculty member and academic administrator, as an emeritus physics professor, and finally as the father of a UNI Chemistry alum.

Tell us more about this connection. What are some significant memories about your time at UNI?
I arrived at UNI in 1980 as Head of the Physics Department and Professor of Physics. I served as Department Head until 1990 when I was appointed as Dean of the College of Natural Sciences at UNI. I served as Dean until 2000 when I retired from UNI and was awarded emeritus faculty status in the Physics Department. In addition, one of my sons (Jeremy) graduated from UNI with a B.S. degree in Chemistry in 2006.

I have many wonderful memories of my years at UNI: working collaboratively with dedicated faculty and staff in Physics and other departments at the University, teaching and mentoring talented students, helping to build a strong research program in Physics with special emphasis on undergraduate research experiences, establishing study abroad opportunities for students and faculty, establishing new B.S. programs in physics and applied physics and a M.S. program in environmental science, and leading the College's first strategic planning efforts.

If any part of your professional career was not pursued at UNI, please tell us where and some details of what you did or are currently doing.
After my undergraduate and graduate education (B.S., M.S,, Ph.D. degrees in Physics) at Stevens Institute of Technology, I began my academic career in 1968 as an Assistant Professor of Physics at the State University of New York at Binghamton. My research specialty was theoretical particle physics with an emphasis on phenomenological studies of weak and electromagnetic decays of light and heavy meson resonances and the quark substructure of these resonances. I have also been interested in the connections of particle physics and cosmology. Over the course of my career, my work in particle physics led to more than 20 peer-reviewed publications in major physics journals and to numerous presentations at physics conferences. In 1972, I joined the Physics Department at Seton Hall University where I earned tenure and promotion to Associate Professor and Department Chairperson. In 1980 I left Seton Hall to come to UNI. After retiring from UNI, I accepted the Deanship in the College of Science and Mathematics at Towson University in Maryland. In 2008 I left Towson to accept the position of Provost and Vice President for Academic Affairs at Indiana University of Pennsylvania (IUP). I fully retired from my academic career in 2013. Since my retirement I have pursued my interest in international travel with trips to several countries including France, Spain, Norway, Canada, and New Zealand. I have also made several trips to Iowa and the UNI campus as well as visiting my daughter in Montana and my two sons who live in Wisconsin and Iowa.

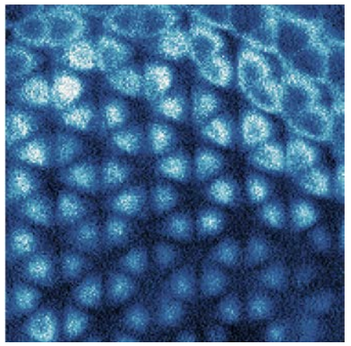
Why did you become a donor to the UNI Physics Department? What do you hope to accomplish through your donations?
I became a donor to the Physics Department because I wanted to further support and promote the efforts by the Physics faculty to provide an outstanding physics education to its students. As a longstanding advocate of undergraduate student research, I decided some years ago to establish the Gerald Intemann Endowed Undergraduate Research Fellowship in Physics. It is my hope that this endowed fellowship will ensure that a permanent level of funding will be available to provide summer stipends to talented undergraduate physics majors to conduct research in physics and physics education for many years to come.

If you were talking to someone else about the UNI Physics Department, what would you tell them? Would you encourage others to donate?
I would tell them that the department has a strong record of stewardship of its financial resources and has done a superb job of overseeing the endowment fund that I established and keeping me well informed annually of the impact the fund is having on undergraduate physics research at UNI. I would strongly encourage others to donate to whatever aspects of the Physics Department's operations that are of special interest.

What do you do for fun?
Before the pandemic, my wife and I enjoyed taking domestic road trips and traveling abroad. But since COVID arrived, we have suspended long distance travel and opted to remain at home on our 20 acres of wooded farmland. However, being fully vaccinated and boosted, we are hoping to resume our travels this summer or fall. In the meantime, I keep busy reading a lot (political and military histories, biographies, and some science fiction), and, of course, watching movies and series on various streaming services. Also, being a lifelong New York Yankees fan, I get to watch my team during the season.

Who are your immediate family members and where is your current hometown?
My immediate family is my wife, Christina, and our 2 two-year old sheep-a-doodles, Archie and Scout. We live in Indiana, Pennsylvania, located about 55 miles northeast of Pittsburgh. The winters can be cold and snowy but nothing like Iowa!

NEW PHYSICS



STM image of 2D Wigner crystal in WSe2/WS2 bilayer. (Courtesy of F. Wang, UC Berkeley)

Wigner Crystals Imaged for the First Time

In 1934, the Nobel Prize-winning physicist Eugene Wigner predicted that electrons could form a crystal under certain conditions. The "condensation" of electrons into the geometric positional pattern of a Wigner crystal is a quantum mechanical effect and depends on the density of the electrons in a material. If the electron density is less than a critical value, repulsive forces will cause the electrons to arrange themselves in the honeycomb pattern of a Wigner crystal. Though Wigner crystals have been produced and investigated before, one had never been directly imaged until recently. (See H. Li et al, Nature 597, 650–654 (2021)).

The formation of a Wigner crystal is somewhat counter-intuitive. In order to cause an ordinary gas (e.g., oxygen) to condense, one would increase its density by compressing it. In this case, the behavior of the gas can be understood on the basis of classical thermodynamics. However, to understand how electrons behave in metals and other materials, quantum mechanics is necessary. A simplified picture of a Wigner crystal is as follows. You might remember from Modern Physics that when you confine a quantum particle, you increase its kinetic energy (KE). The more localized the particle, i.e., the smaller the confining "box", the greater its KE. The KE is inversely proportional to the square of the width of the box. In an electron gas, you can take the width of the box to be the distance r between electrons. Thus, the KE of an electron is proportional to $1/r^2$. The repulsive potential energy (PE) of two electrons interacting via the electric (Coulomb) force is proportional to $1/r$. We see that as the electron density decreases (and r increases), the KE decreases more rapidly than the PE. At some critical density, the PE will become dominant and the energy of the system can be minimized by the crystallization of the electrons into a lattice. We have a Wigner crystal!

To create a Wigner crystal, Feng Wang and his team at the University of California Berkeley fabricated a thin (few nanometers) bilayer of tungsten selenide (WSe_2) and tungsten sulfide (WS_2).

Their slightly different lattice cell sizes forms a moiré lattice pattern, similar to what happens if you overlay two combs that have slightly different teeth spacings. The moiré lattice pattern has a greater spacing consistent with the lower density required for the Wigner crystal to form. Wang's team used a scanning tunneling microscope (STM) to image the Wigner crystal. This was a delicate operation given the fragile nature of the crystal. Too strong an interaction with the imaging instrument would destroy the crystal. To prevent this, Wang's team used a graphene overlayer to sense the underlying Wigner crystal. The STM uses a sharp tip to scan over a surface within nanometers of the surface. Electrons tunnel between the tip and the surface at a rate dependent on the electron density at the surface. The tunneling current from the graphene reflects the underlying Wigner crystal formed by the WS_2/WSe_2 bilayer below, thereby allowing the two-dimensional Wigner crystal to be imaged. Long-range Coulomb interactions cause the localized electrons in the Wigner crystal to change the electron distribution in the graphene, thereby providing an accurate map of spatial arrangement of the Wigner crystal. It is worthwhile to note that this method of forming and imaging a Wigner crystal requires no magnetic field.

Readers of Cross Sections may remember that we featured Pauli crystals in the 2020 issue. Though Pauli crystals also involve a spatially correlated arrangement of electrons, the correlation depends only on the Pauli principle, and is therefore quite distinct from Wigner crystals.

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ALUMNI INFO REQUEST

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