How do you run physics lab courses where collaboration and hands-on experience are at the core, where students work in pairs, record and analyze data, diagnose and solve problems together, in the age of a pandemic?

Earlier this year back in March, when Northeastern decided to switch to fully online and remote education, the Introductory Physics Laboratory (IPL) had to quickly adapt. Luckily, running labs ‘remotely’ was not something that we were completely unfamiliar with. We had virtual labs which consisted of videos of the experiments that students could watch and record their data, and randomized data sets for the experiments that require computer data acquisition. They were originally designed for snow days and for holidays that allowed no room for postponing labs. However, we had only created online content for a few of the labs. We quickly developed additional virtual labs, and even interactive applets for some labs, to allow students to collect data using a simulation. Almost overnight, our teaching assistants switched to MS Teams or Zoom and learned how to run a class online, and not just a single class but the many different experiments presented in all of our introductory physics lab courses.

As we entered the Fall semester under the Hybrid NUflex model, most of the students returned to campus. Labs reopened, but the reduced density requirements meant that we could only allow half of the usual number of students in each lab room at a time. This meant that students would be unable to attend half of the labs during the semester unless we could develop and implement a solution. There is, of course no substitute for using the lab equipment in person, but equally important is collaborating with a partner to solve problems, analyzing the data and drawing conclusions from the results of the analysis. We realized we could replicate those experiences by having up to half of the students perform the lab in person while the remaining half of the class connected remotely for one-on-one interaction with students in the lab room.

We installed webcams to the lab computers at each bench. They are mounted on flexible arms, enabling students in the lab to show their remote lab partners what they are doing. Both in-person students and TAs use headsets to communicate so that the TAs can simultaneously help the student partners with the experiment. This setup helps students to work in pairs as they would normally do, collaborating at each step during the lab and analyzing their data together with shared Excel worksheets on the cloud. Everyone follows the Covid-19 safety protocols. Students

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Image: Experimental image of cultured human lung epithelial cell monolayer after compression, with segmented cell boundaries; cells colored by like-orientations show formation of multiple cell packs with different orientations. Scale bar: 50 microns https://cos.northeastern.edu/news/getting-under-your-skin-how-a-interdisciplinary-team-of-scientists-came-together-to-study-epithelial-cells/

Notes from the Chair

As Chair of the Physics Department, I am proud of the way the faculty, staff, and students in our department have stepped up to face the unprecedented challenges presented by the COVID-19 pandemic. In spring 2020, as it became clear what was happening, we managed to successfully convert all our courses including lab classes to online instruction. Then, over the course of the summer, we developed plans to allow us to implement NUflex instruction, in which students are rotated through in-person attendance in order to allow for safe social distancing. All our faculty have put in a lot of work to modify their courses to teach in this new hybrid format. We have also set up our lab courses so that students could attend in person or remotely, with the remote person working with a partner who is doing the experiments in the lab. This has worked well thanks to the dedicated efforts of Baris Altunkaynak and our graduate Teaching Assistants, allowing all students the opportunity to perform labs in person.

I would like to thank the faculty leadership team, which includes our new Executive Officer Emanuela Barberis, Alessandra Di Credico, Swastik Kar, Tim Sage, Bryan Spring, and Meni Wanunu. Stephen Savitsky continues as our Co-op Coordinator, and he has been able to place our students in exciting co-op positions despite the pandemic. Sheila Magee continues as Business and Operations Manager, overseeing the entire department organization, which includes administrative staff members Molly Chen, José Cruz, Alina Mak, and Nancy Wong. I very much appreciate the many contributions of these staff and faculty leaders, particularly in these challenging times.

Although we cannot hold in-person department events, we continue to have virtual meetings, including weekly meetings of the Society of Physics Students group and drop-in sessions for graduate students. I am happy to see continued leadership from our SPS students, which includes a student-organized peer mentoring program that connects new students with more experienced undergraduate students in our majors. Our active seminar series are being held virtually and attendance and discussion at these seminars is strong, allowing us to maintain a lively intellectual climate despite the current physical limitations.

-Mark Williams, Chair
New Faculty to the Physics Department

In January 2020 we welcomed Michele Di Pierro, a theoretical biological physics researcher who is studying the dynamic structure of large genomic complexes. We have three new tenure-track faculty members joining us in the 2020-2021 academic year. Jonathan Blazek is an astrophysicist who studies the large-scale structure of the Universe, and he started this fall. Astroparticle physics experimentalist Tsuguo Aramaki starts January 2021. These two new faculty members are part of our efforts to develop an astrophysics concentration for the Physics major. Finally, Paul Stevenson, an experimentalist with expertise in quantum sensors, including their use to study biological systems, also joins us in January 2021. We are very excited about the new ideas and promising research programs that these faculty members will be bringing to the department.

Jonathan Blazek works in cosmology and astrophysics. He is interested in the nature of dark matter, dark energy, and the processes that occurred in the earliest moments after the Big Bang. Working at the intersection of theory and observation, Jonathan models how we can understand the structure of the Universe using large telescopes that survey the night sky, mapping out the positions and shapes of millions of galaxies.

After growing up in Chicago, Jonathan studied physics and astronomy at Harvard before receiving a PhD in physics from the University of California, Berkeley. After postdoctoral fellowships at Ohio State and the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, he is excited to return to Boston. He is particularly looking forward to joining a growing astrophysics group at NU and in helping to develop an expanded curriculum in astrophysics.

Tsuguo Aramaki received his PhD in physics at Columbia University, New York, and then worked at SLAC/Stanford as a postdoc/project scientist. His research focuses on experimental astrophysics with an emphasis on dark matter searches. He will continue to work on SuperCDMS (Cryogenic Dark Matter Search) and GAPS (General AntiParticle) while developing a new project, GRAMS (Gamma-Ray and AntiMatter Survey) that he has conceptualized. SuperCDMS is a direct dark matter search experiment at the deep underground lab, SNOLAB in Canada, starting from 2021/2022. GAPS is a balloon-borne indirect dark matter search project, and the first science flight will be from the Antarctic in 2022. GRAMS is a next-generation balloon/satellite mission that will be the first to target both MeV gamma-ray observations and antimatter-based indirect dark matter searches. He is very excited to be a part of Northeastern University!

Paul Stevenson’s research focuses on building new quantum technologies using defects in diamonds as a platform to manipulate and detect single spins. These defects have a wide range of applications ranging from ultrasensitive nanoscale sensors to nodes in a quantum communication network.

Paul received his PhD from MIT in 2017 and has since been a research associate at Princeton University.

The National Science Foundation (NSF) has announced a five-year grant to support a Physics Frontiers Center (PFC) headquartered at Rice University. This effort will include opening a satellite location this Fall at Northeastern under the direction of University Distinguished Professor of Physics and Bioengineering, Dr. Herbert Levine.

The Center for Theoretical Biological Physics (CTBP) was founded in 2002 at the University of California-San Diego and moved to Rice in 2011 when biophysicists Herbert Levine, José Onuchic and Peter Wolynes were recruited to join the faculty. Levine, a founding co-director of the Center, came to Northeastern in 2019 and facilitated the partnership to expand its reach to the Boston area. Baylor College of Medicine and the University of Houston round out this dynamic nationwide collaboration of scientists.

“The full integration of research across all of our locations has been critical to our success,” says Levine. “Formally expanding the program here at Northeastern, in the heart of the medical and scientific hub of Boston, brings even greater resources, talent and skills to our endeavors.

The research, focusing on the fundamental science needed to understand biological systems, will encompass a host of projects, including computational studies of the structure of the genome and how that structure couples to physiology through its effects on gene expression; dynamical systems of interacting molecules that enable biological systems to sense their surroundings and adjust their behavior accordingly; and the properties of non-equilibrium physical structures that make up biological cells (e.g. the mechanical properties of the cell's cytoskeleton and its role in organizing cell structure and dynamics).

"In addition to the research, the Center creates an environment for broadly-focused training of graduate students and postdoctoral researchers, providing a framework for them to become leaders of the field in future years," says Mark Williams, Chair of the Department of Physics at Northeastern. "This is a major accomplishment for our University."

NSF’s Physics Frontiers Centers program supports the collective efforts of large group of researchers, enabling transformational advances in the most promising research areas. PFCs also include creative, substantive activities aimed at enhancing education, broadening participation of traditionally underrepresented groups, and outreach to the scientific community and general public.

"The Physics Frontiers Centers program enables major advances at the frontiers of physics," said Jean Cottam Allen, NSF program officer who oversees the agency’s PFCs. "Researchers at the Center for Theoretical Biological Physics conduct innovative and forefront work at the intersection of physics and biology."

One of only 10 such centers in the United States, the CTBP mission will continue to be devoted to the sophisticated analysis, computation, and quantitative experimentation needed for understanding the living world. The $12.9M grant will allow the center to continue to pursue its critical research, training and outreach efforts over the next 5 years. This is the third time the center has been awarded a renewal and makes them the longest running PFC in the nation.
Assistant professor James Halverson and Professor Brent Nelson, have been selected to help lead the National Science Foundation’s newly established Institute for Artificial Intelligence and Fundamental Interactions along with researchers from Massachusetts Institute of Technology, Harvard University, and Tufts University.

The institute, which will receive $20 million from the National Science Foundation over the next five years, is one of a handful of new institutes designed to further advance the use of artificial intelligence in fields of science that don’t usually use machine learning.

“Things exploded in our area of research three or four years ago,” Nelson says. “We took the opportunity to put Northeastern at the front of that by hosting conferences and networking with people who do this for a living at tech companies. Tech companies could actually learn a lot about machine learning from applications in physics, Nelson says.

“The industry uses AI to predict what you’re going to buy. Will you or will you not buy toilet paper? How many cartons of milk are you going to buy?” he says. These questions have definite answers.

But in physics, the problems are continuous, more complex, and can predict much more than just yes or no answers.

For physicists like Halverson and Nelson, the question is: Can we do something more important than predict purchases with these techniques? Things like understanding the evolution of the universe, for example.

The Huntington 100, which honors outstanding students for achievements that are commensurate with the university’s mission, ideals, values and Academic Plan included three Undergraduate Physics students Matthew Cook, Theodita Pedersen and Christopher Reusch.

Northeastern has already announced that classes will be run in the hybrid NUFlex model with reduced classroom density in the Spring semester as well. We will continue to improve the lab experience to make it as similar as possible to a normal semester without a pandemic. Physics lab courses are at the heart of hands-on and experiential learning and we are happy that students are not missing out on this important aspect of their education - even during a pandemic.

Photograph and article by Baris Altunkaynak
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