Jason Hancock

Quantum and applied materials research
and
Educational reform at UConn

UCONN

UConn Quantum Club Presentation

September 19, 2023

Hancock group

Former PhD students:

Dr. Sahan Handunkanda
PhD 2018, now Intel Corp
Portland, OR

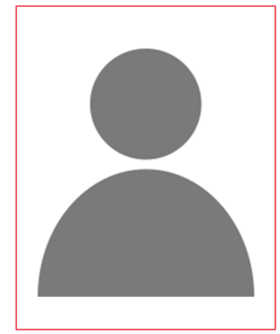
Dr. Erin Curry, PhD 2021
now Coherent Laser
Bloomfield, CT

Dr. Donal Sheets
PhD Aug 2022
now Postdoc, UConn

Current PhD students:

Kaitlin Lyszak
PhD 2024 (expected)

Lauren Gorman
PhD 2028 (expected)



You?

Undergraduate students:

Connor Occhialini '18
now PhD student, MIT

Julian Ivaldi '21
now Electric Boat

Matthew
Mooneyham '22

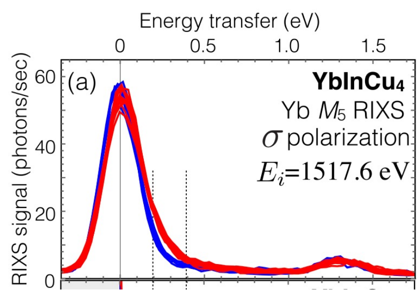
Also…
Jessica Wessner '23
Meagan Sundstrom '18
Filip Bergabo '18
Louis Antoine '20
Joe Giangregorio '20
…
Daniel Rinaldi '14
Nikita Twaalfhoven '14

Group leader:
Jason Hancock

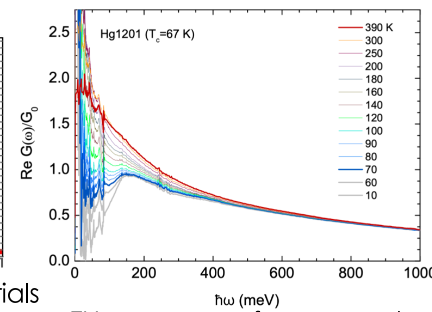
Funding sources:

Expertise and Core Strengths, basic research

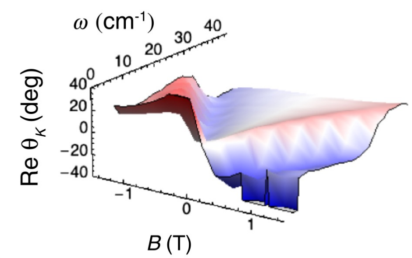
- Spectroscopy of quantum materials
  - Broadband infrared, THz, RIXS spectroscopy
  - Inelastic X-ray scattering
  - Core level spectroscopy
  - Laser-based pump-probe for acoustics
- Scientific areas
  - Structural quantum phase transitions
  - Superconductors
  - Topological materials
  - Correlated/magnetic materials
  - Negative thermal expansion



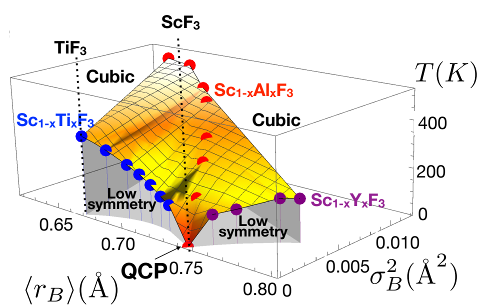
Core level excitation of quantum materials

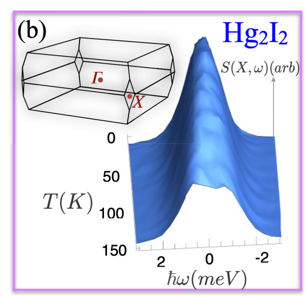


THz response of superconductors



THz-cyclotron resonance of topological surface states

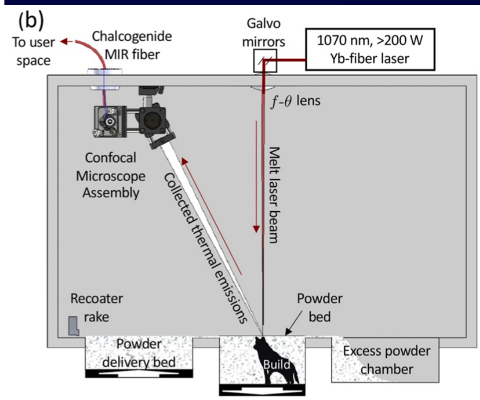


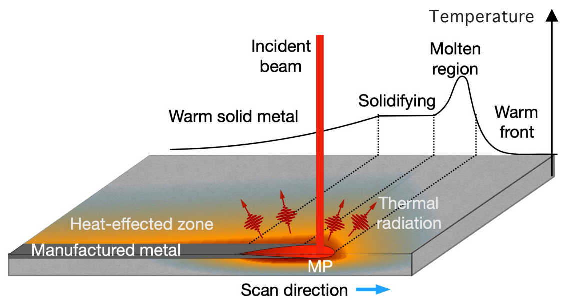


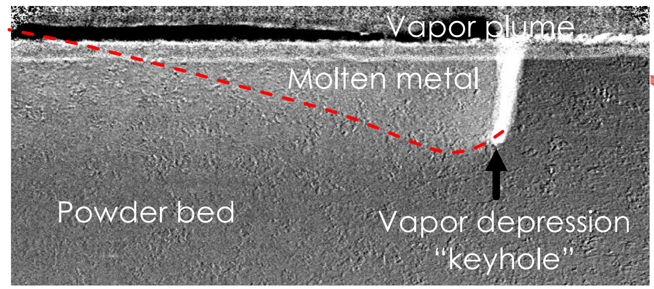
Negative thermal expansion near structural quantum phase transitions

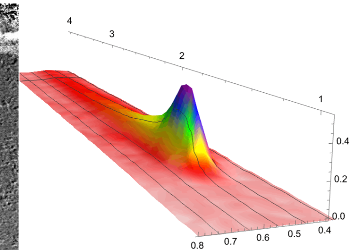
Soft mode spectroscopy of incipient phases

Expertise and Core Strengths, applied research

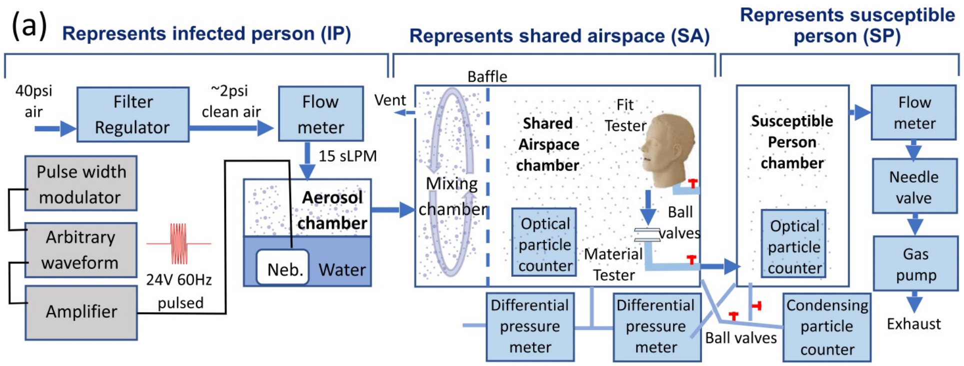


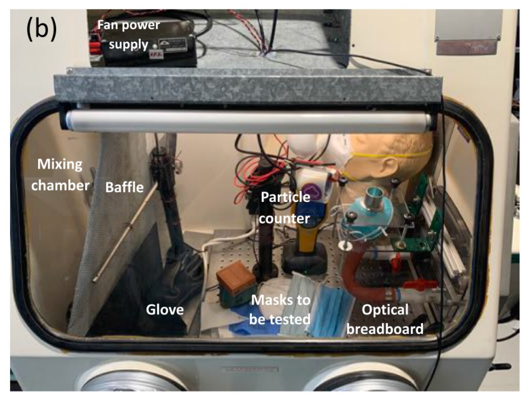


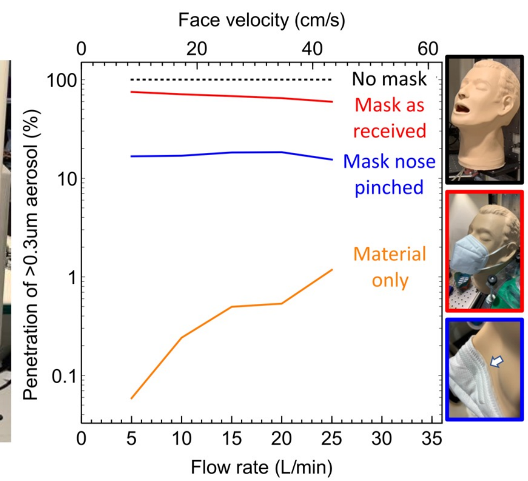




Infrared sensor development for applied sciences

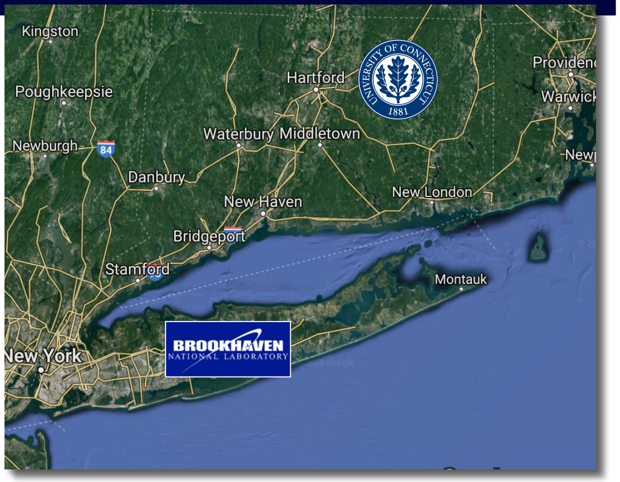






COVID-era filtration material evaluation

Facility-based materials research



- Frequent user and advisor to DOE supported facilities
- Expertise in X-ray experiments in many modes
  - Resonant inelastic X-ray scattering from electrons
  - Non-resonant inelastic X-ray scattering from phonons
  - Diffraction for structural studies
  - X-ray transmission imaging

JNH Synchrotron-related Science Service record

- Proposal Review Panelist and Chair, *Inelastic X-ray Scattering* panel, APS, ANL 2015-2019
- Proposal Review Panelist and Chair, *Soft x-rays, photoemission, and infrared* panel, NSLS-II, BNL 2018-2022
- Lecturer, US DOE National School and Neutron and X-ray Scattering, 2018-present
- Beamline advisory team, Soft inelastic X-ray scattering beamline (SIX), NSLS-II, BNL 2015-present
- Beamline science advisory committee, Inelastic Scattering Group, APS, ANL 2009-present
- Scientific Review Committee, Inelastic X-ray Scattering Beamlines, APS, ANL, 2016
- Program committee Inelastic X-ray Scattering 2019, June 23–28, 2019, Stony Brook, NY
- Organizing committee International Conference on Low-Energy Electrodynamics in Solids, Miami, FL, 2020

NextGenCT

- Passed in 2012 by CT assembly
- $1.7B to upgrade UConn infrastructure
- Goal: Develop STEM education and research to in CT through UConn

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A-Z

Budget, Planning and Institutional Research

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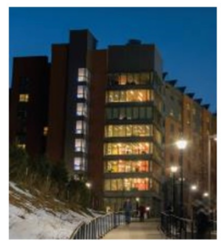
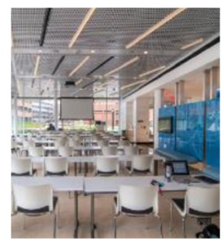
Next Generation Connecticut (NextGenCT)

Major UConn Projects Completed

UConn Hartford Campus
$139M
3 bldgs. 215,000 square feet
Completed August 2017



Werth Residence Hall
$95.8M
212,000 square feet, 730 beds
Completed August 2016



Engineering and Science Building
$92.5M
115,000 square feet
Completed October 2017

Student Recreation Center
$97.1M
191,000 square feet
Completed August 2019

Gant Building Renovation Phase I-II
~$170M
200,000 square feet
Completed August 2019, May 2021

Fine Arts Production Facility
$35.5M
30,000 square feet
Completed April 2020

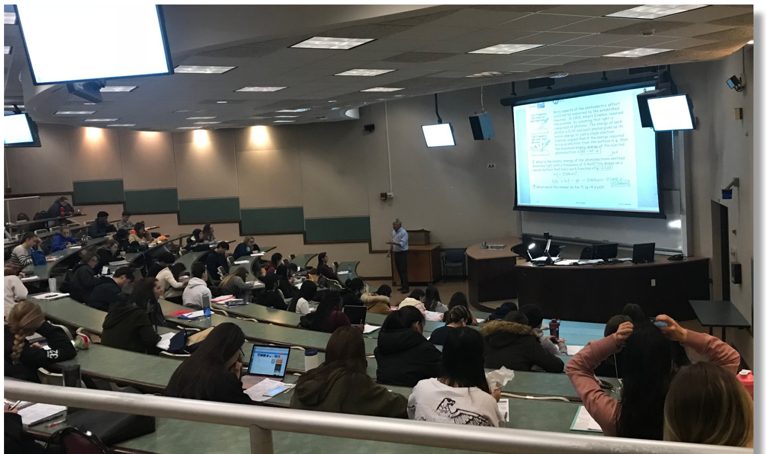
Monteith Building Renovation
$23.7M
73,000 square feet
Completed August 2016

Putnam Refectory Renovation
$18.7M
42,000 square feet
Completed August 2016

Supplemental Utility Plant
~$67M
40,000 square feet
Completed November 2022

STEM Research Center Science 1
~$220.1M
200,000 square feet
Est Completion FY23

Prof. Hamilton's traditional 1010 class in P36



Prof. Hancock's active learning 1601 class in P103B

Introductory Physics Sequences

Sequence	Majors	Math level
Phys 1601/2	Physics	
Phys 1501/2	Engineering	
Phys 1401/2	Life sciences	
Phys 1201/2	General physics	Algebra-based
Phys 1010	Non-science	Conceptual

Massive effort to convert all calculus-based physics classes to active learning model 2017-2021

High impact ~2000 students/yr

Promotes inquiry-based learning
Integration of theory and experiment

Some components of active learning in calculus-based physics

- ***Delivery*** students seated, instructor/TAs at centralized control center, others observing, kept to a minimum
- ***Demo*** students seated, instructor/TAs at centralized control center, others observing or helping, often uses ceiling/side doc cam
- ***Discussion/individual work*** students seated working on problem sets, instructors/TAs walk the room peering over shoulders, answering questions, offering help as needed, individual and wall-mount whiteboards used
- ***Discussion/group work*** students standing or seated working on problems together, instructor/TAs walk the room to discuss problem approaches, offering help as needed, individual and wall-mount whiteboards used
- ***Activities*** small equipment sits on tables, accessible to each student or groups of three students, instructors/TAs ask questions and are around to help, individual and wall-mount whiteboards used
- ***Quantitative Lab*** larger, more quantitative equipment sits on corner of each table with students around, instructors/TAs assist development of theory, collection of data, advanced analysis, coding, and presentation preparation, individual and wall-mount whiteboards used

Overview of studio physics project

1st course conversion begins → F17

8 semesters

6th course conversion completes → S21

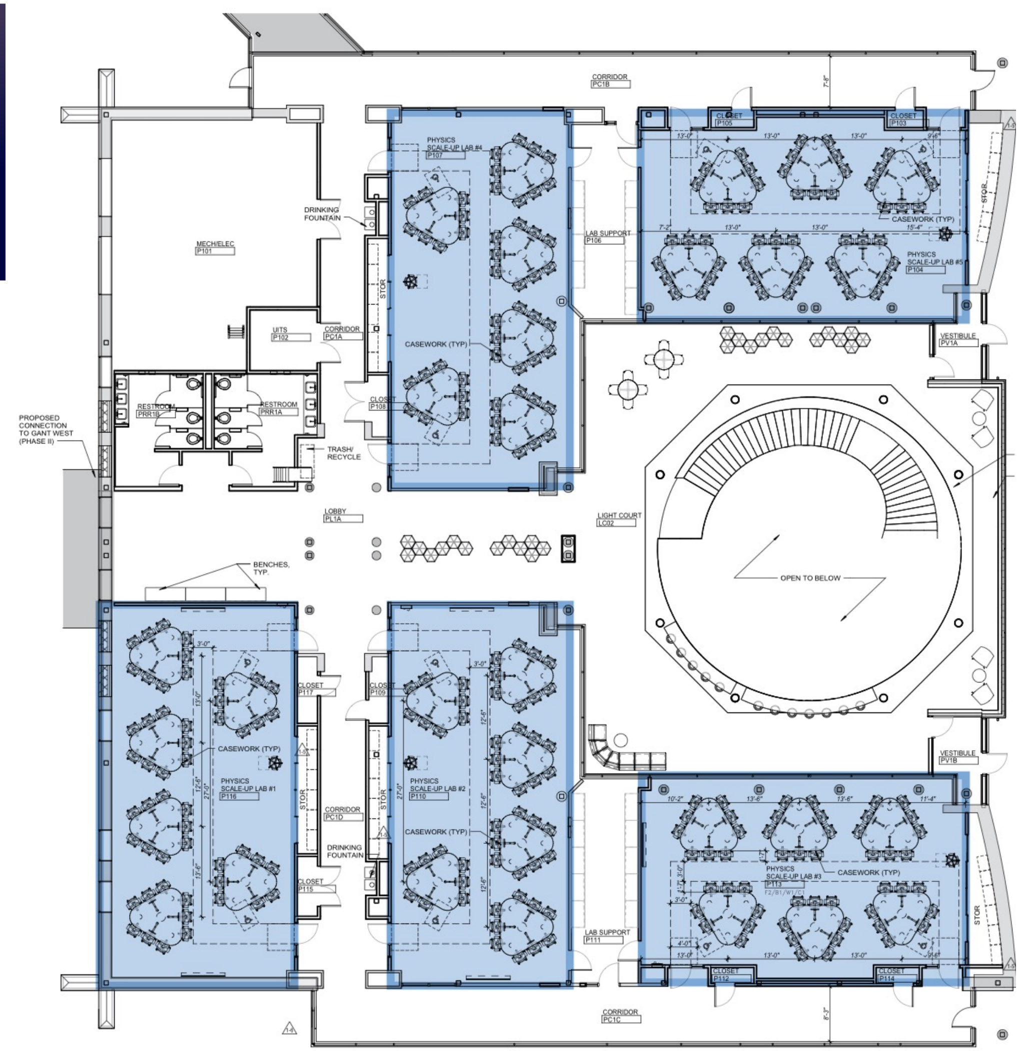
	Physics majors ~36 seats/AY		Engineering majors ~1512 seats/AY		Life-science majors ~648 seats/AY		
Semester	**1601**	**1602**	**1501**	**1502**	**1401**	**1402**	**Studio space**
F16	-	Sinkovic	Wu, Wu, Valente	Wells, Valente	Dulli	Dulli	None
S17	Valente	-	Fernando, Sinkovic, Valente	Wells, Valente	Dulli	Dulli	None
F17	-	Valente	Ordaz, Sinkovic	McCarron, Ordaz	Wu	Wu	**Babbidge+Gant**
S18	Hancock	-	Joo, Ordaz, Ordaz	Valente, Wu, Joo	Wu	Wu	**Physics P103B** 
F18	-	Valente	Phelps, Khosravi, Sinkovic	McCarron, Ordaz, Ordaz	Wu	Wu	
S19	Hancock	-	Bastami, Ordaz, Ordaz	Valente, Sainju, Joo	Wu	Wu	
F19	-	Valente	8S Hancock CC XW,NG,ST,MP,EC	Sainju, Ordaz, Ordaz	Wu	Sainju	Gant Plaza GP1xx 
S20	Sinkovic	-	7S Ghimire CC ST,XW	8S Valente CC	Wu	Sainju	
F20	-	1S	8S	5S	4S Wu CC	Sainju	
S21	1S	-	7S	8S	2S	4S Sainju CC	
F21	-	1S	8S	5S	4S	2S	

S=studio section, 54 seats **T**=Traditional lab section, 18 seats

Project impacts >2000 seats/yr

Physics Learning Labs
Gant plaza

- 5 physics active learning spaces, 54 students each in Gant plaza
- Phys 1601Q, 1602Q, 1501Q converted to studio style, 1502Q, 1401Q, 1402Q convert in coming semesters
- Many awards to faculty, graduate students
- Organized course shown to be effective
- Teaching assistants widely gain experience teaching side-by-side with experienced instructors



first floor - Plaza Building

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Week 5: Work and Energy

Sp19 = 2/18-2/22
Fa19 = 9/23-27

ppt section
Activity
Demo
Tutorial
Assessment
Staff mtg/deadline

Su 12mid Adaptive Release wk5 | Su 10pm RA Wk5 - Work and Energy | W 10pm Prelab 4 – Bouncing and work | Th 10pm HW Wk5 - Forces and free body diagrams

NO LAB REVIEW DUE | T 3pm TA train 5.3 Bouncing,6.1,6.2 | T MT1 1st draft due to IoRs | F 12n Dev mtg wk7

Learning objectives

- ✓ Apply the work-energy theorem to objects moving in one and two dimensions
- ✓ Isolate the components of force that do work
- ✓ Describe the difference between conservative and non-conservative forces

- ✓ Apply the relationship of Hooke's law to determine the work done by a spring
- ✓ Identify conditions under which mechanical energy is conserved
- ✓ Apply conservation of mechanical energy for a conservative system at two different times
- ✓ Determine the potential energy from a force function or a graph of potential energy vs. position

- Quantify work done by three forces (g,magnetic,elastic) in test to see which are conservative
- Observe transfer of kinetic and potential energy under gravity
- Empirically assess a law of restitution for elastic and magnetic bouncing

5.1 Work-energy theorem – GK, EC,

Front matter
Dot products
Work-energy theorem
Work and kinetic energy
Graphic work-energy: space
Graphic work-energy: looptyloop
Conservative versus nonconservative
P-5.1.1: Dot products
P-5.1.2 Elevator
P-5.1.3: Cool runnings
P-5.1.4: Ramp into friction
Tutorial Quiz

HRW7

5.2 Potential and mechanical energy – NG, XW, JH

Front Matter
Work-energy review
Mechanical and potential energy
Loopty-loop activity
Unleashing your potential energy
Potential energy properties
Nonconservative forces and energy
P-5.2.1: Ski jump
P-5.2.2: Falling onto a spring
~~P-5.2.3: Spring on an incline~~
P-5.2.4: A problem with a lot of potential
Tutorial Quiz

HRW8

5.3 Quantitative Laboratory #4: Bouncing and work

- Smart cart bouncing on track against magnetic and elastic bumpers
- Measure coefficient of restitution and compare
- Observe conservation of energy when in freefall
- Observe energy missing from KE+grav pot and identify as either elastic or magnetic energy
- Lab Analysis Report

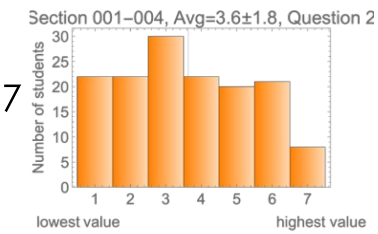
Gear

- Pasco smart cart
- Pasco track, leveling feet, vertical post, track rod adapter, spring+magnet bumper accessory

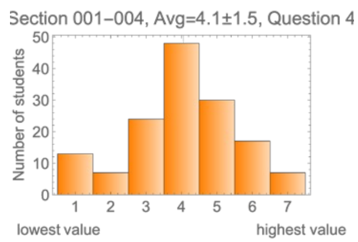
Educational Value Survey, sections 001-004

Please circle a number 1 to 7 to indicate the value of each course component:

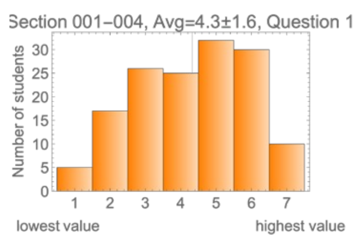
Weekly reading assignments 3.6 ± 1.7



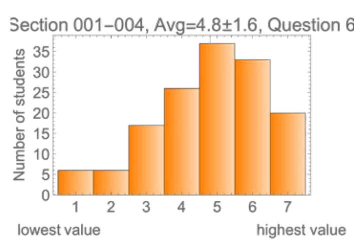
Pre-lab activities 4.1 ± 1.4



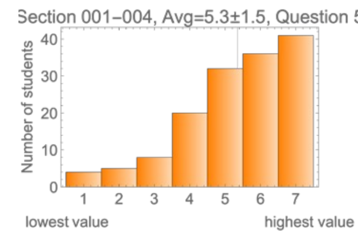
Group work at whiteboards 4.3 ± 1.6



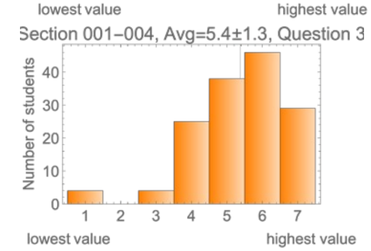
Computer simulations 4.8 ± 1.6



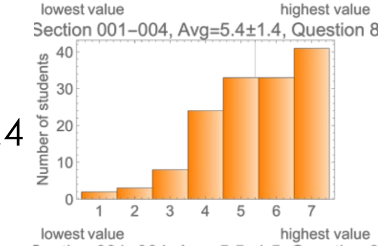
Hands-on activities 5.3 ± 1.5



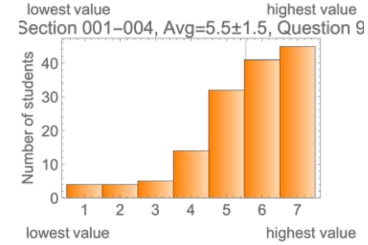
Quantitative labs 5.4 ± 1.1



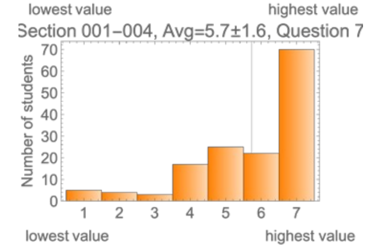
Physical demonstrations 5.4 ± 1.4



Lectures by instructor 5.5 ± 1.5



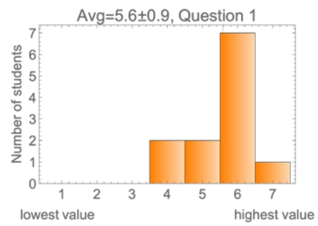
Tutorial problems 5.7 ± 1.6



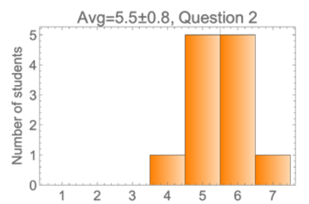
Teaching Assistant Survey, sections 001-008, 12 responses

For each statement below, circle a number that best describes your agreement on a scale that ranges from 1 (**not at all the case**, i.e., completely **DISAGREE**) to 7 (**completely the case**, i.e., completely **AGREE**).
IL = Interactive Lecture, ED: Engaged Discussion, QL = Quantitative Laboratory

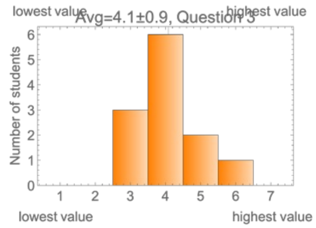
ED: Tutorial problems are presented in a very clear way
5.6 ± 0.9



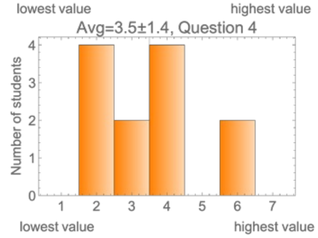
ED: Tutorial problem solutions are presented in a very clear way.
5.5 ± 0.8



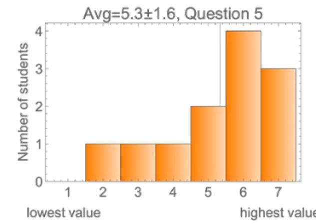
ED: Tutorial problems are very hard to students.
4.1 ± 0.9



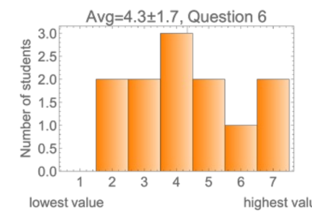
ED: Students engage with working on tutorial problems actively. 3.5 ± 1.4



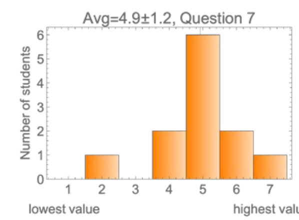
IL: The instructions/questionnaires for hands-on activities and interactive simulations are presented in a very clear way to students. 5.3 ± 1.6



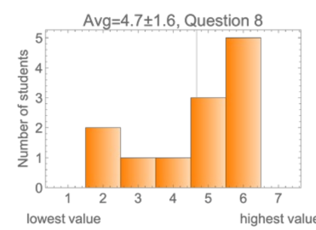
IL: Student engage with group discussion and hands-on activities actively. 4.3 ± 1.7



QL: Students are completely satisfied with group assignments. 4.9 ± 1.2

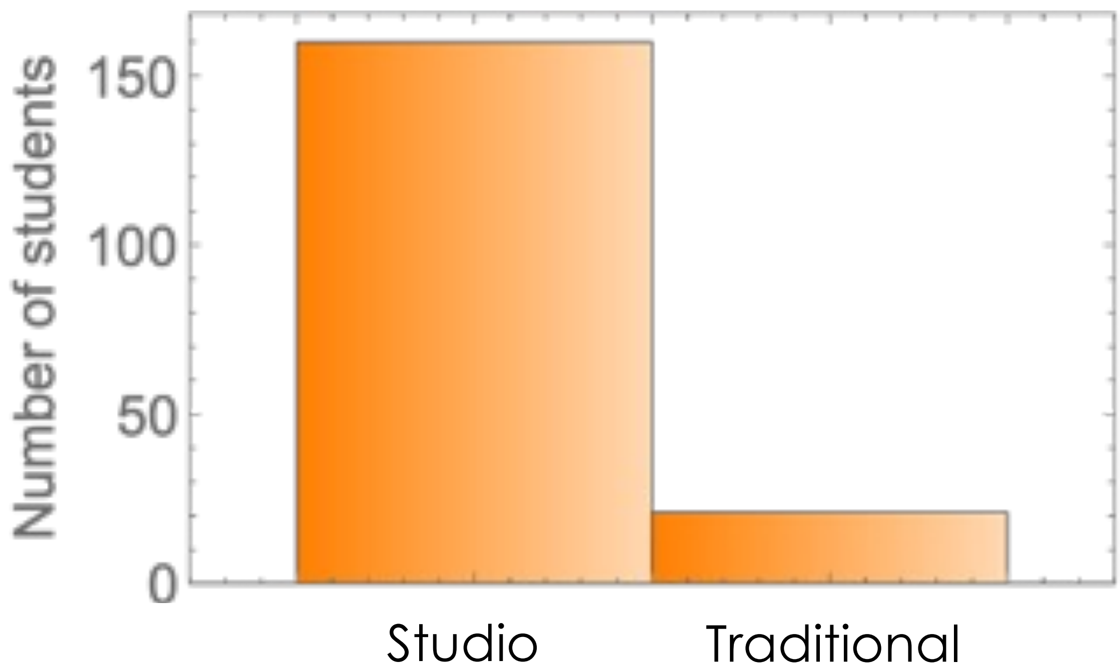


QL: The lab apparatus never has hardware issues. 4.7 ± 1.6



Educational Value Survey, sections 002, 004-008

If you had the option to choose between studio-format 1501 (current format) and traditional-format 1501 (3 hour lab separate from lecture and no tutorial problems or activities in class), which one would you choose?

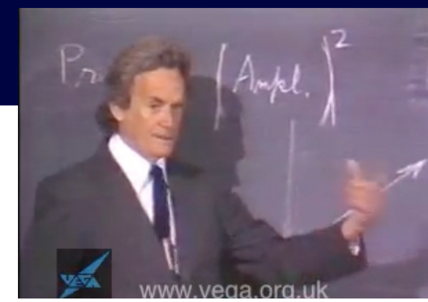


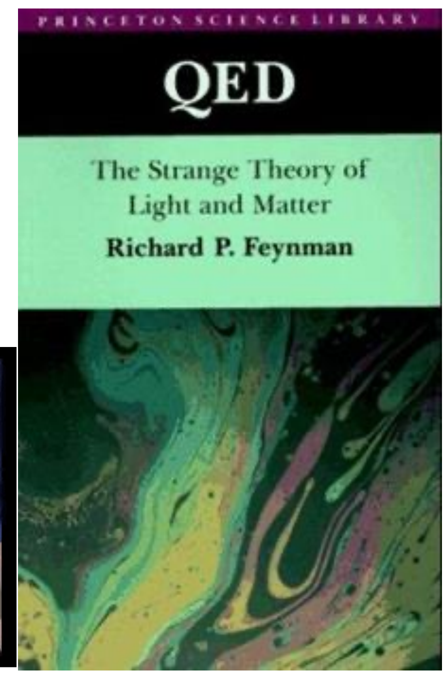
Students choose studio more than 7:1 over traditional in inaugural semester

What does quantum mean?

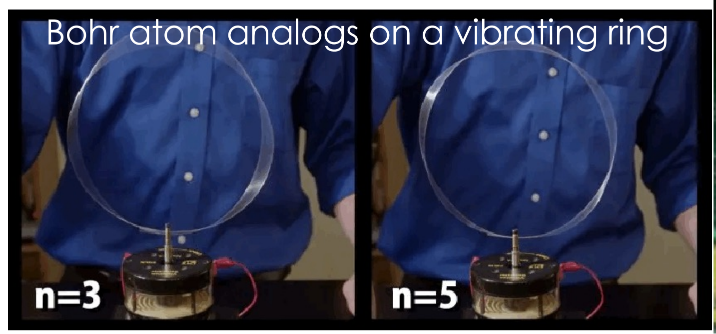
- Examples of *classical* physics concepts:
  - "That pencil is sitting at rest on the table"
  - Force is mass times acceleration
  - The total amount of mass is constant
- Examples of quantum concepts:
  - The state of a system evolves according to the Schrodinger equation
  - Measurement of a quantity puts it in an state of well defined value of the outcome

QEd project: modernizing the physics curriculum





- Two semester sequence covers purely classical physics
  - 1x01: Newton's laws, energy, momentum, angular, fluids, statics
  - 1x02: Electrostatics, magnetostatics, circuits, optics
- Idea: capitalize the organization of studio physics to update quantum-ready curriculum
- Naturally spreads to high schools via ECE program (1201/2)
- Draws inspiration from Feynman's 1979 Auckland public lectures



Bohr atom analogs on a vibrating ring

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QEd project: modernizing the physics curriculum

- Developing plan, proposal due 10/30/23
- Includes funding for graduate Physics TAs to study current curriculum and develop quantum-aligned content for massive course
- Includes small advisory board:
  - School of Engineering
  - Neag School of Education
  - CLAS Sciences
  - Industry
  - …

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