Quantum for All

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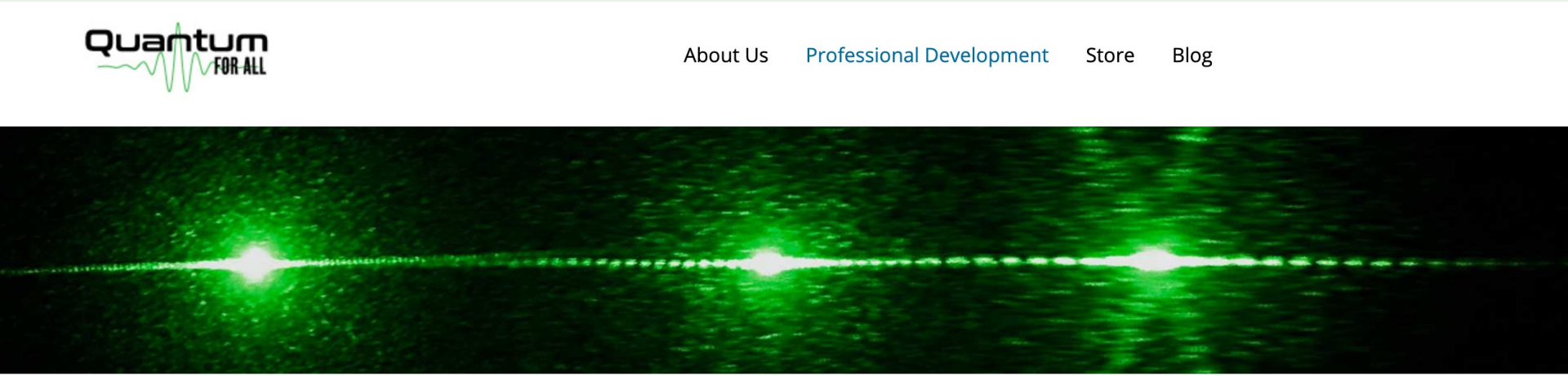
https://quantumforall.org/



Professional Development

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Quantum Education

Quantum
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Project Overview

- Content emphasis on quantum information science (QIS) and **integrated STEM lessons.**
- Science components include physics, chemistry, and computer science, technology includes **applications and coding, engineering design** is woven throughout the interventions, and math is addressed as it relates to quantum concepts such as probability, vectors, and matrices.
- Focus on **underserved students** and school systems (not all teachers have background to teach quantum)
- Sustainability through **classroom implementation**, support, and vetted resources

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Summer 2022

- 4 sites and camps + UWRF
- 4 days of working with teachers (Tues-Friday), weekend off, 4 days of student camps (Mon-Thurs). This gives Monday and Friday as travel days.
- Teacher workshops 8:30-3:30, Camps 9-3 for students, 8:30-4:00 for teachers
- Each site has same schedule/agenda
- Teachers will work with partners to teach sessions in camps. Practicing just as we have students practice in class
- Graduate credit available (will discuss more as time nears)
- Participants will be eligible to host a camp in their district in 2023

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- If you have a question, someone else probably does too, so ask questions or write them on sticky notes and we will address them
- The schedule will be fast because of so much that we want to cover, but we are always glad to stay and discuss anything. We are honored that you are using your valuable time to come and we will respect the times we have.
- Bring a laptop, chromebook, iPad, or all 3 ☺
- Make sure you are on the main email list (comes from kmatsler@uta.edu) AND the site google group email.
- Make sure you have filled out the site information document
- CHECK email regularly. Emails from UTA to set up payment, from leaders about logistics, or peers about social events or questions

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If you did not attend last summer

- Watch videos from last summer's sessions. On YouTube Channel
- We are going to revise schedule to review some of topics from last summer so if you are new it will help bring you up to speed, but we will also offer some sessions after 3:30 where/when/if needed
- There is a vital research component to this grant. You will be asked to sign release forms (IRB).
- Don't get frustrated if it takes more than once to figure it out and it takes time to assimilate and process.
- Don't give up, ALL of our students need these opportunities

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Background of U.S.A. Efforts

- Dec. 2018 U.S. Congress passed National Quantum Initiative Act to advance quantum technology and computing
- Jan. 2019 National Quantum Initiative Program signed into law https://www.quantum.gov/
- Aug. 2020 NSF, OSTP initiative to expand to HS and MS
- Dec. 2020 National Q-12 Partnership kickoff
- Presently developing key concepts for HS QISE https://q12education.org/

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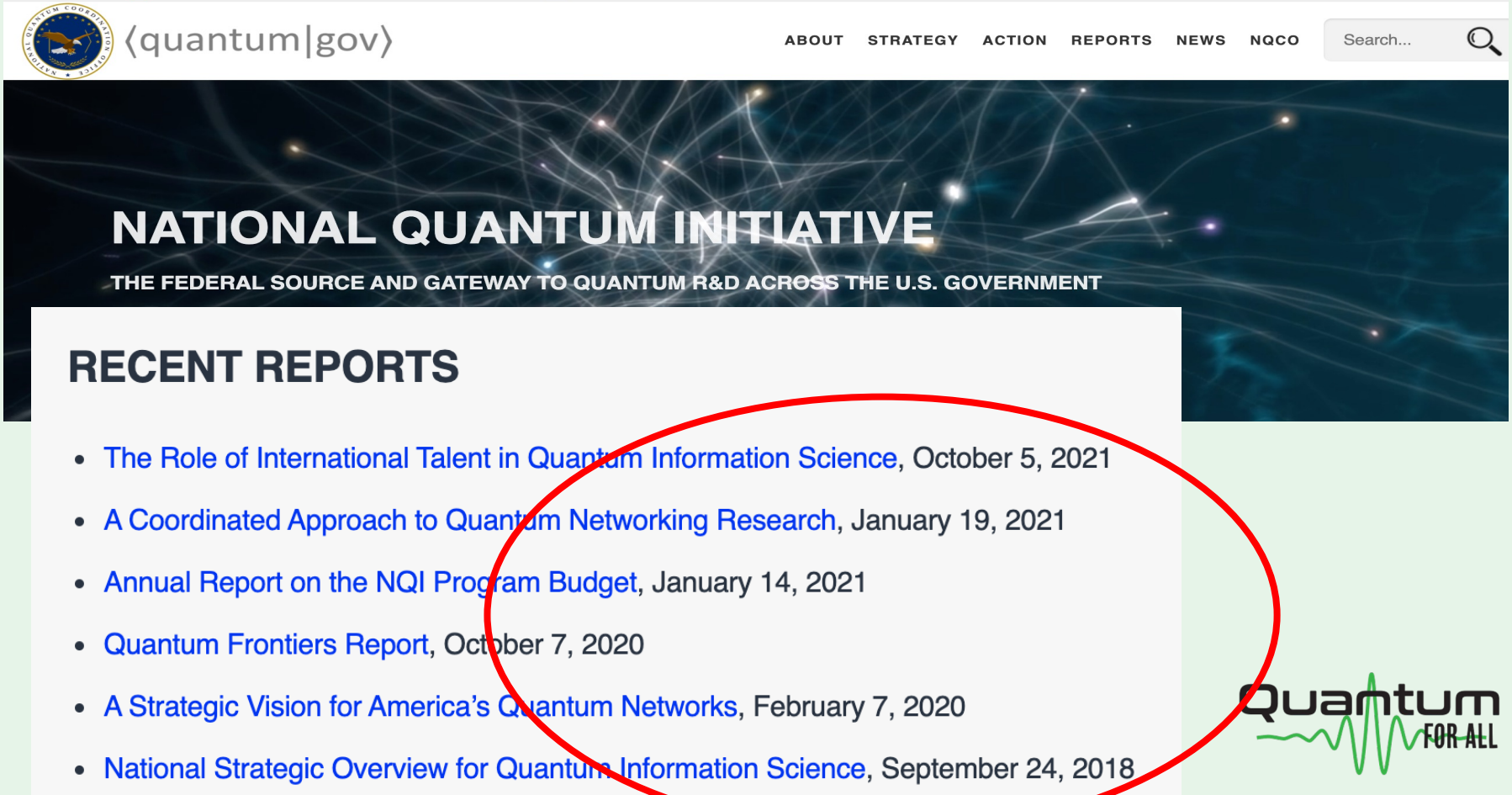
Quantum Initiative (quantum.gov)



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Quantum Key Concepts for HS—SAMPLE

3. MEASUREMENT

Description: In general, the outcomes of quantum measurement are not predetermined. The probabilities of each outcome depends on the quantum state and choice of measurement basis.

Expectation: Students will be able to calculate the probability of obtaining different measurement outcomes, and describe how that probability changes when the measurement basis changes.

Learner Outcomes

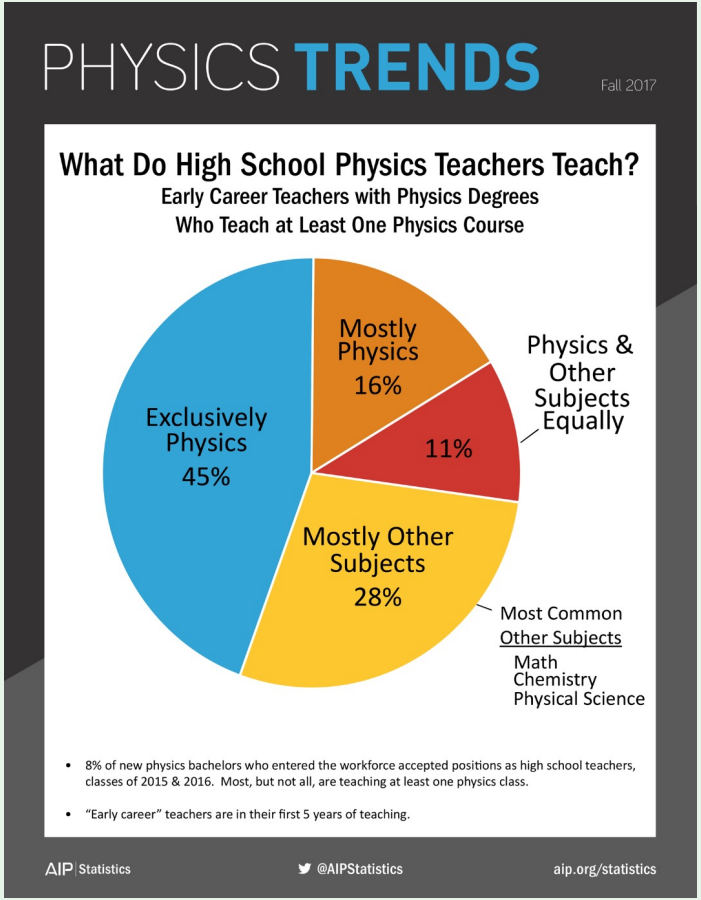
1. Students will be able to contrast classical and quantum measurements.
    a. Example: Repeated classical measurements give the same result, but quantum measurements on identically prepared systems can give random results with probabilities dictated by the quantum state.

4. Students will describe situations where a quantum measurement changes the quantum state.
    a. Example: A photon is blocked by two perpendicular polarizers. Inserting a third polarizer between them at a different angle will allow the photon to pass through all three polarizers with some probability due to the additional measurement.

Equity

One logical venue for exposure to quantum is a physics course. However, according to the American Institute of Physics (AIP), nearly 100,000 students attended schools where physics was not even offered.

Quantum for All Students is providing opportunities for students to learn about quantum, regardless of whether they take a physics class by integrating into other courses and providing camps.



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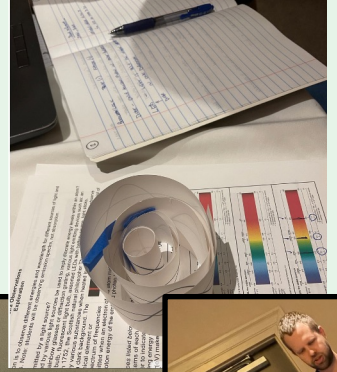
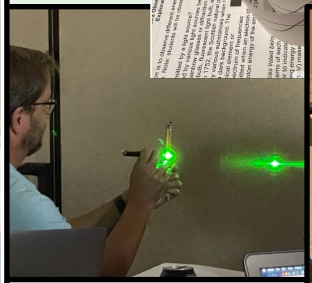
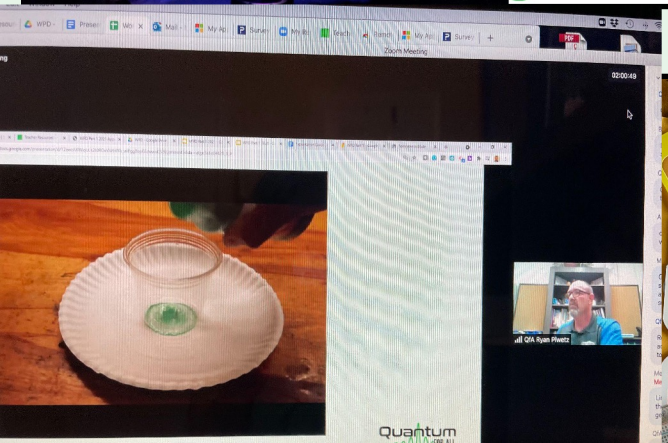
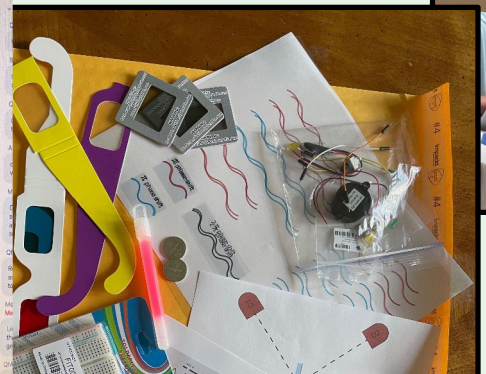
Preparing Secondary Teachers and Students for Quantum Information Science #2048691

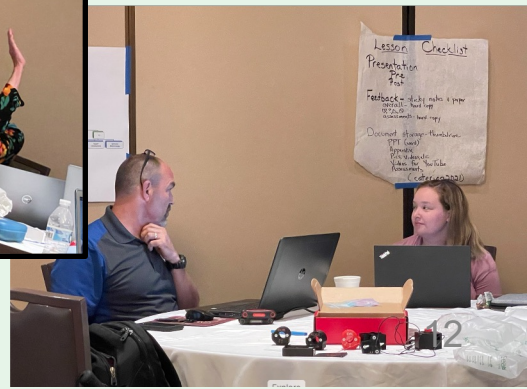


Day	Time	
Saturday, July 17	1:00 PM	Introductions, welcome by Dean of Scienc Stanbaugh, Emily Edwards
	2:00 PM	Quantum Connections
	4:10 PM	Bohr to Quantum
	6:30 PM	Debrief, Dinner
Sunday July 18	7:30 AM	Golden Rules
	9:45	Wave Particle Duality (pt 1)
	11:45 AM	Lunch (working)
	12:30 PM	Wave particle Duality (Mach Zehnder)
	2:45 PM	Heisenberg Principle
	4:45 PM	Malus' Law, Polarization
	6:45 PM	Dinner
	8:00 PM	group time to work on ppts, discussions, r
Monday, July 19	8:00 AM	Review, questions, 2022 plans









NSF

Challenges of teaching quantum to pre-university students

- Teachers do not have background for content or context
- Lack of resources appropriate for K-12
- Lack of guidance for curricular connections
- Limited accountability in standards

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Content

Identify available resources and stakeholders

Learn content and connections

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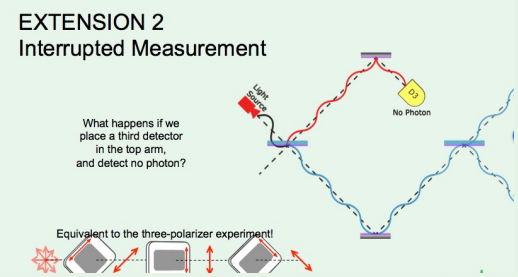
Recognize Gaps: Lack of…

- Understanding why quantum concepts are relevant or priority
- Background in quantum information science by K-12 teachers
- Opportunities to connect relevance of QIS and ICT
- Lack of age appropriate resources (lessons)
- Affordable equipment for hands-on learning experiences
- Classroom support

Veritasium Video :Is This What Quantum Mechanics Looks Like?



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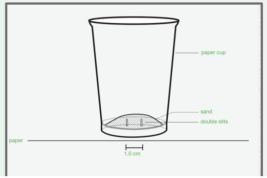
Engage: Activity 1- Sand Through Double Slits

- Describe what you think will happen if sand drops from a cup through two slits as shown.
- Draw your prediction.



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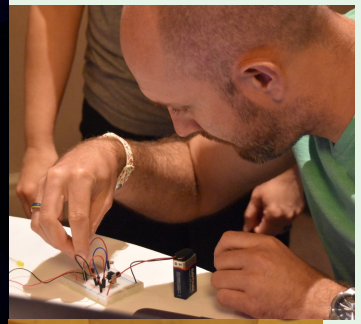
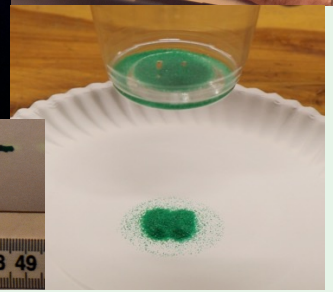
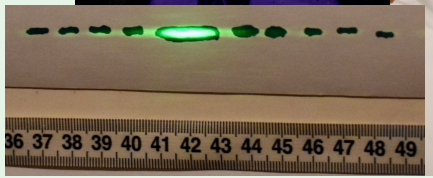
PERIMETER INSTITUTE FOR THEORETICAL PHYSICS

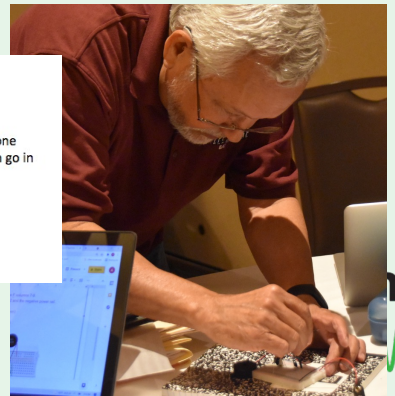
Create Appropriate Resources

- Pedagogical Content Knowledge (PCK) on quantum information science (QIS)
- **S**= physics chemistry
- **T**= technology including applications (i.e. sensors) and coding (Glowscript)
- **E**= engineering design is woven throughout the interventions
- **M**=Probability, vectors, matrices









Heisenberg Principle

In kit: lasers, purple and yellow diffraction glasses

Not in kit: 2 wooden pencils (not mechanical) and 2 small rubber bands, AAA batteries

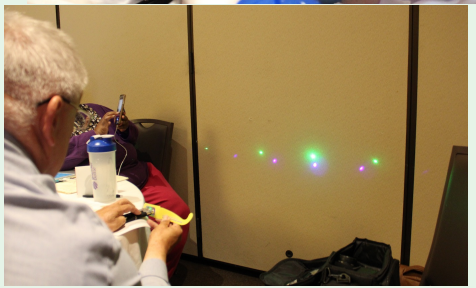
rubber bands and the pencils, make a homemade slit pictured below. Note, at one a rubber band go in between the pencils, and at the other end do not have them go in the pencils.

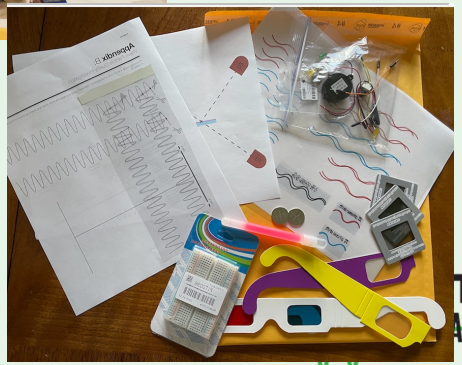
Teacher Tip

There are multiple ways to have students see the double slit experiment. Some make the slits or print on transparencies. Others use commercial slits. The least expensive

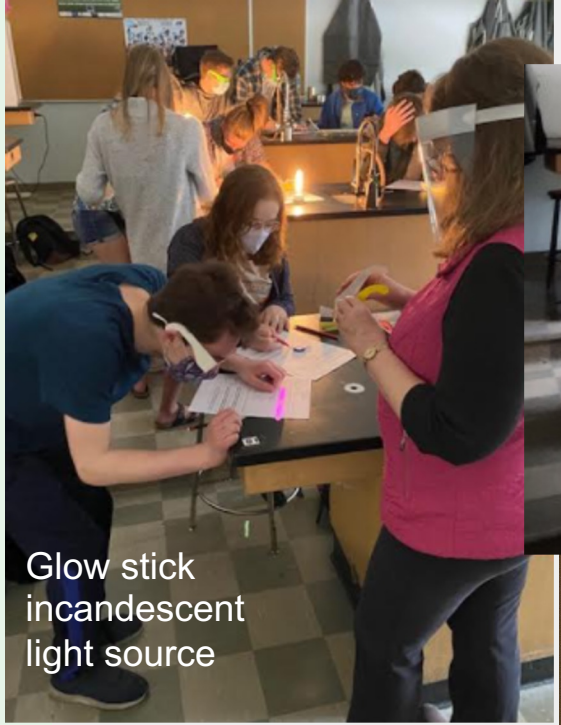
Test and Evaluate

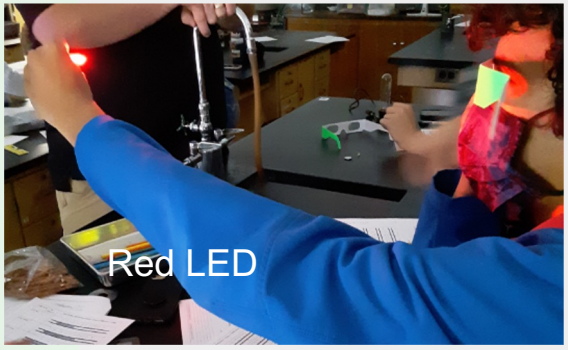
- Peer evaluation
- Virtual
- Classroom
- Camps





What does it look like in the classroom?





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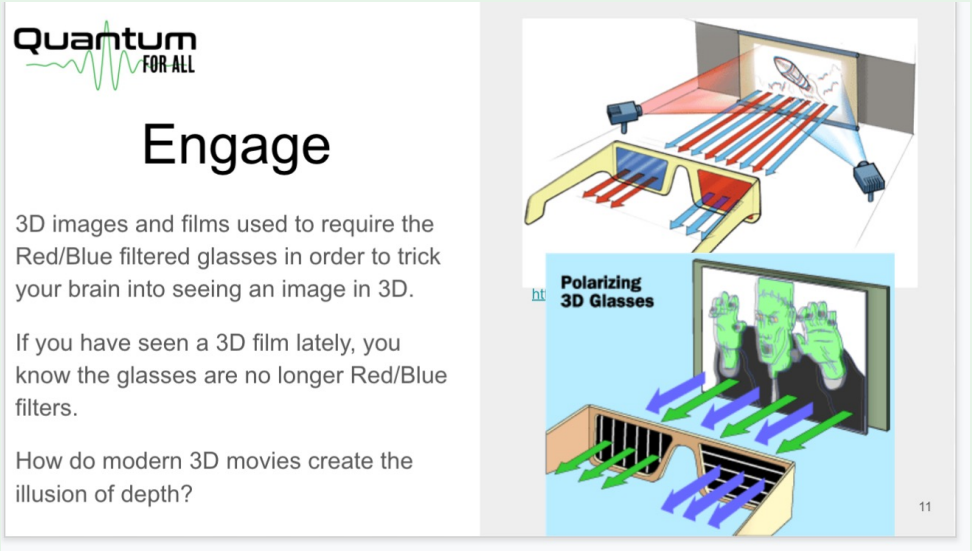
Sample Lesson Topics

- Quantum Connections
- Bohr to Quantum
- Golden Rules
- Wave Particle Duality
- Mach Zehnder
- Heisenberg Uncertainty
- Polarization, Malus' Law
- Quantum Cryptography



Start with the familiar and build lessons that integrate quantum concepts

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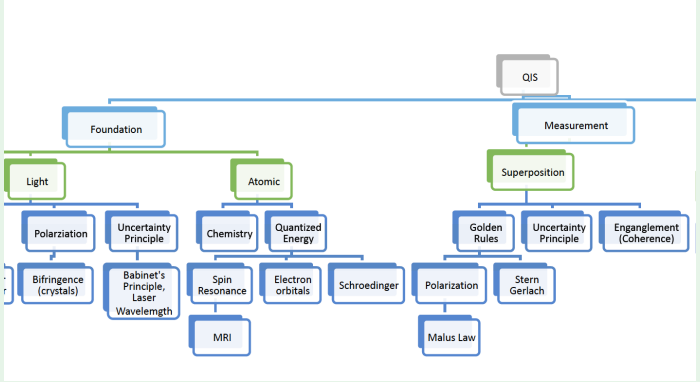
Lesson Development

- Baseline is current content using extensions to address and introduce quantum
- Learning cycles utilizing multiple resources
- Integration of STEM
- Age appropriate for all HS students (not just accelerated)
- Readily available resources for classroom use
- Flow chart for implementation and prior knowledge
- Appendix to guide students
- Short videos for students (w or w/o teacher guidance)
- Correlated to standards (ISTE, NGSS, Quantum, etc.)



Session Outline

Introduction--Review
Engage (laser patterns)
Explore (comparing multiple patterns)
Explain (momentum, equation, vectors)
Extend/Relevance (sound, optics)
Evaluate

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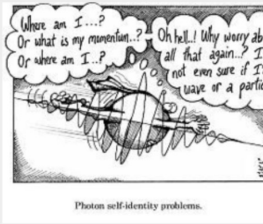
Photo Credit IQC Institute for Quantum Computing



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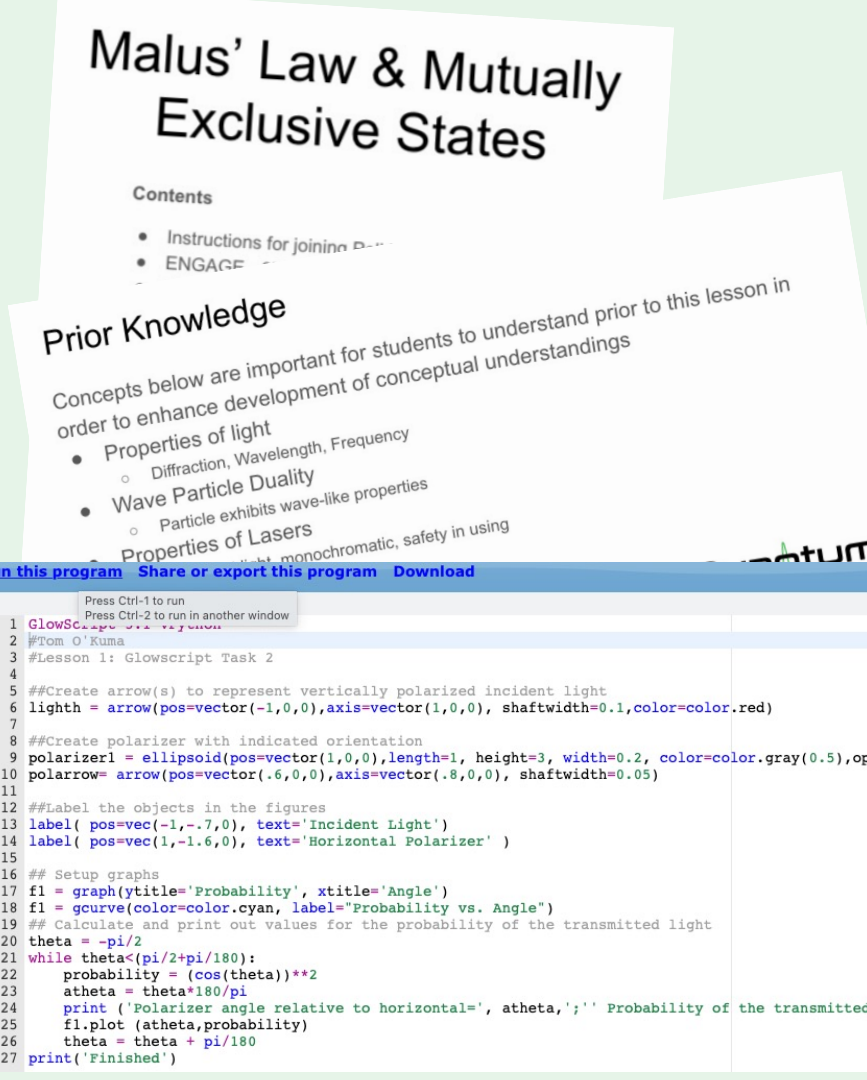
Sample Lesson Components

- Science Concepts
  - Polarization, superposition, Heisenberg's Principle, Malus' Law, Wave Particle Duality
- Technology
  - Glowscript, Quantum Key Distribution
- Engineering
  - Computer aided design in 3D printing, career opportunities, engineering design, TinkerCAD
- Math
  - Vectors, probability, matrices



Are we crazy?

TBD

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