

# Creating Rewarding Careers in Industrial Physics and Physics Education

**UCSD  
Physics Colloquium**

**February 15, 2024**

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Technical Fellow  
General Atomics Aeronautical Systems, Inc.**

**[www.ga-asi.com](http://www.ga-asi.com)**

**President/Chair**

**General Atomics Sciences Education Foundation**

**[www.sci-ed-ga.org](http://www.sci-ed-ga.org)**

# Outline

- **Part 1: Career in industry**
- **Part 2: Education path**
- **Part 3: APS involvement**

*Limited highlights reel – range, fun*

- **What does an industrial physicist do?**
- **Can you get involved in physics education in industry?**
- **What is the best way to prepare undergraduate physics students for careers?**
- **How can APS play a major role in your professional life?**
- **How are these questions related?**

# Part 1: My technical career in 4 snapshots

- PhD UCSD, “Low temperature heat capacity of magnetic superconductors,” Prof. Brian Maple 1980
- Post-doc at Exxon Research, 1980-1982
- Hired as solid state physicist at General Atomics (GA) in 1982 to help develop non-nuclear programs.
- At GA, GA-ASI for 41 years – mostly materials R&D



*Every story and perspective of life in industry is unique and changes depending on the stage of one's career*

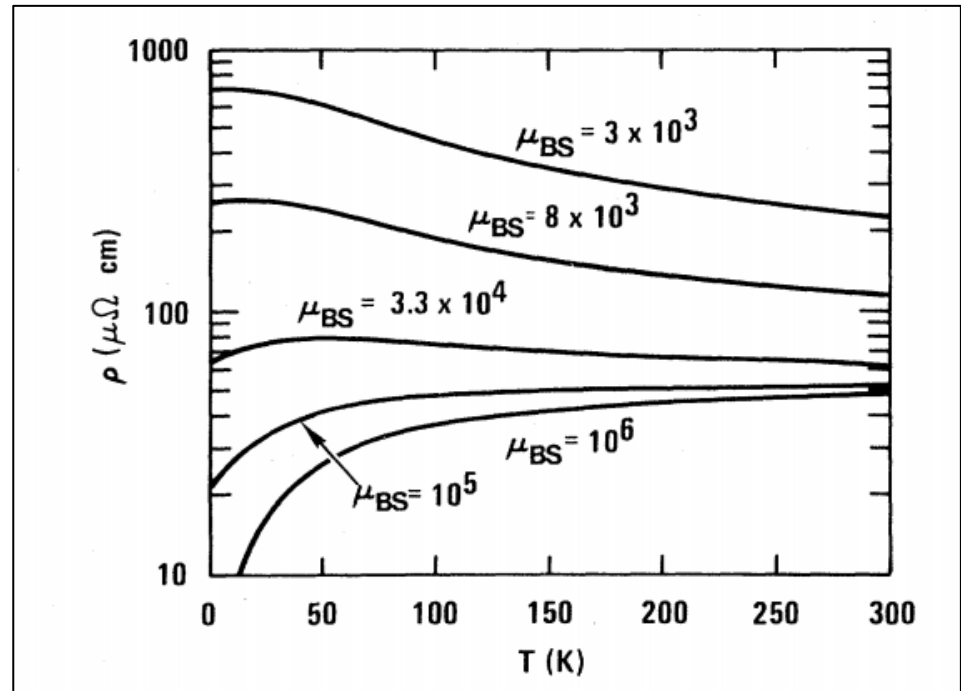
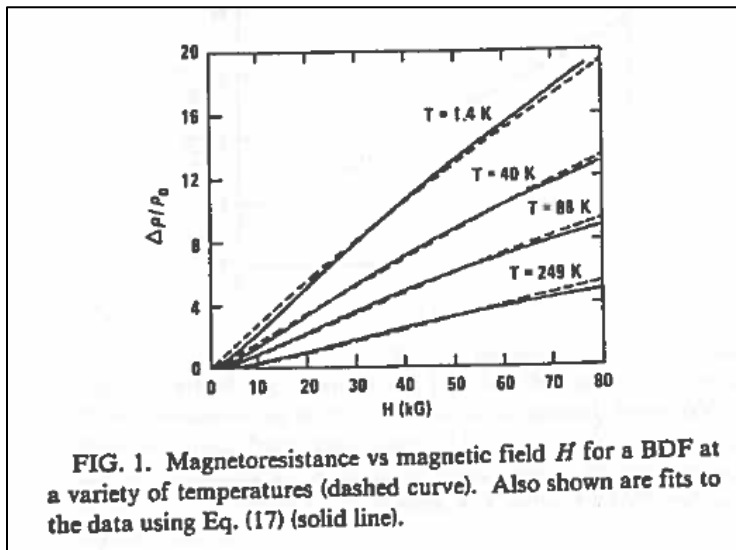


# Investigate 2-D Structures: Graphite Fibers

Used graduate school knowledge to set up low temperature high H lab to measure magnetoresistance →



<https://www.sho.espci.fr/sip.php?article48&lang=fr>



PHYSICAL REVIEW B

VOLUME 30, NUMBER 2

15 JULY 1984

Electrical transport properties of benzene-derived graphite fibers

L. D. Woolf, J. Chin, Y. R. Lin-Liu, and H. Ikezi  
GA Technologies, Inc., P.O. Box 85608, San Diego, California 92138  
(Received 28 December 1983)

# Model thermophotovoltaic (TPV) energy conversion systems and test cells – space nuclear power

High temperature materials + optical properties →

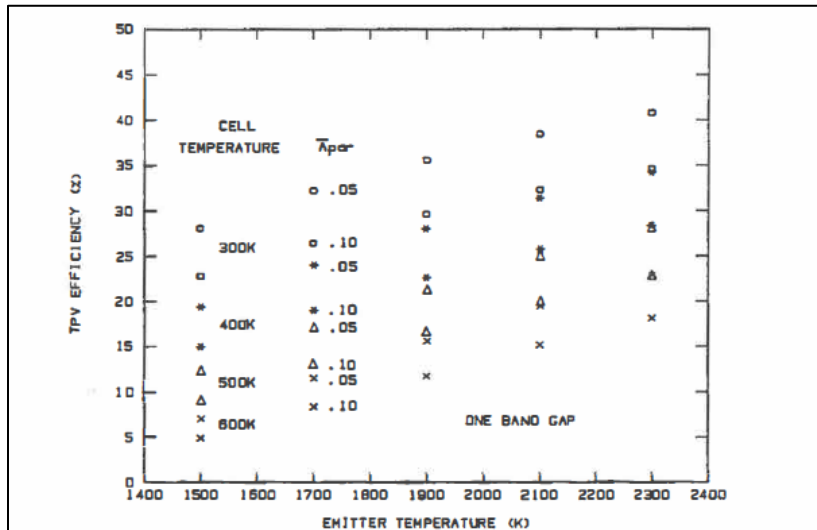
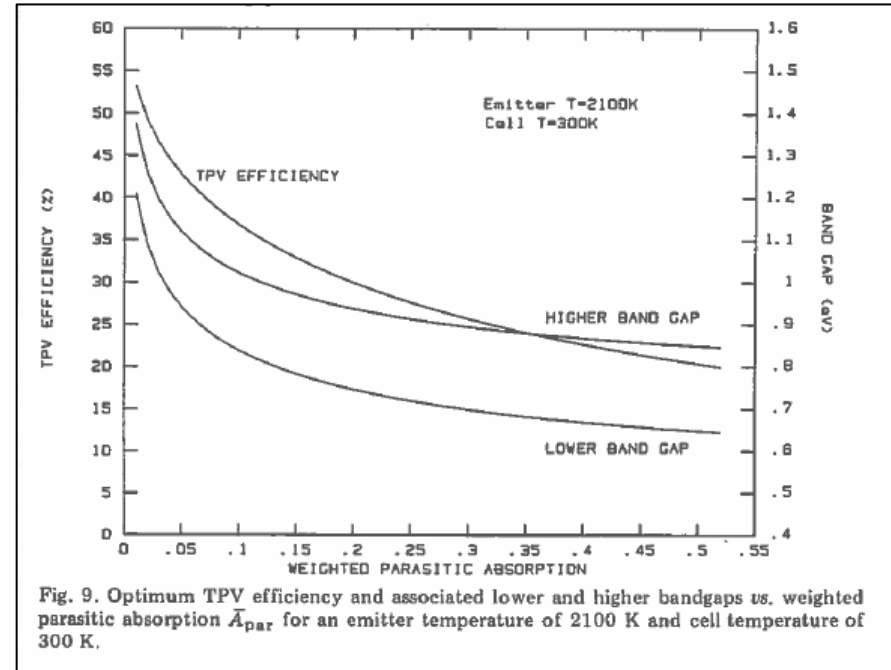
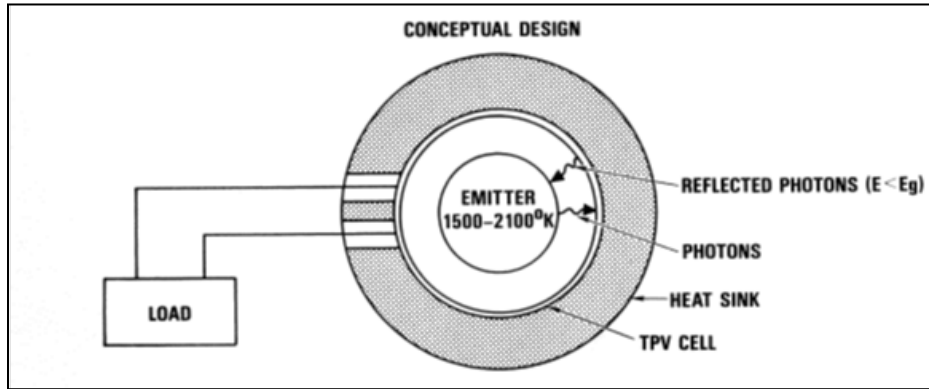


Fig. 1. Maximum TPV efficiency of a single bandgap cell as a function of emitter temperature for selected values of cell temperature and weighted parasitic absorption  $\bar{A}_{par}$ .

*Solar Cells*, 19 (1986 - 1987) 19 - 38

19

**OPTIMUM EFFICIENCY OF SINGLE AND MULTIPLE BANDGAP CELLS IN THERMOPHOTOVOLTAIC ENERGY CONVERSION**

L. D. WOOLF

GA Technologies Inc., P.O. Box 85608, San Diego, CA 92138 (U.S.A.)

(Received October 3, 1985; accepted in revised form December 23, 1985)



# HTS discovered: Led high temperature superconducting (HTS) wire development project

Graduate school + ceramic materials + thick film coatings →

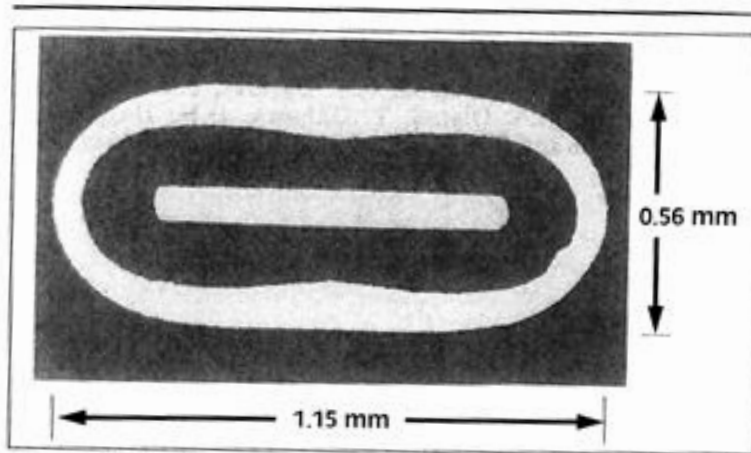


Fig. 4. Polished transverse cross section of an as-coated silver and superconductor coated silver tape.

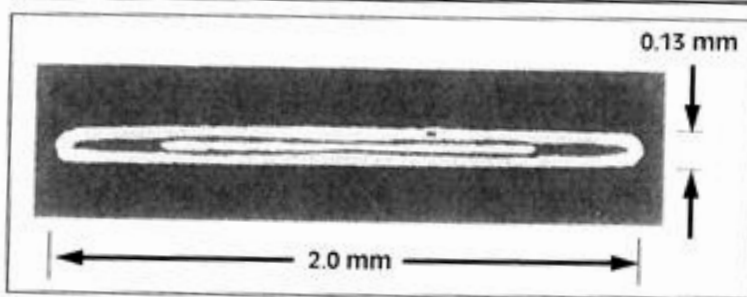


Fig. 5. Polished transverse cross section of a fully processed silver and superconductor coated silver tape.

- 7 years, papers, patents, presentations
- Effort was commercially unsuccessful
- Motivated education activities

Journal of Electronic Materials, Vol. 24, No. 12, 1995

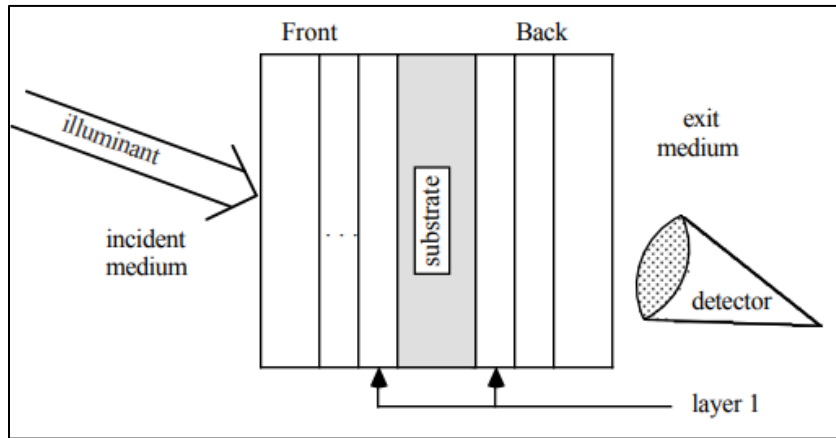
Special Issue Paper

Fabrication of Long Length Bi-2223 Superconductor Tape Using Continuous Electrophoretic Deposition on Round and Flat Substrates

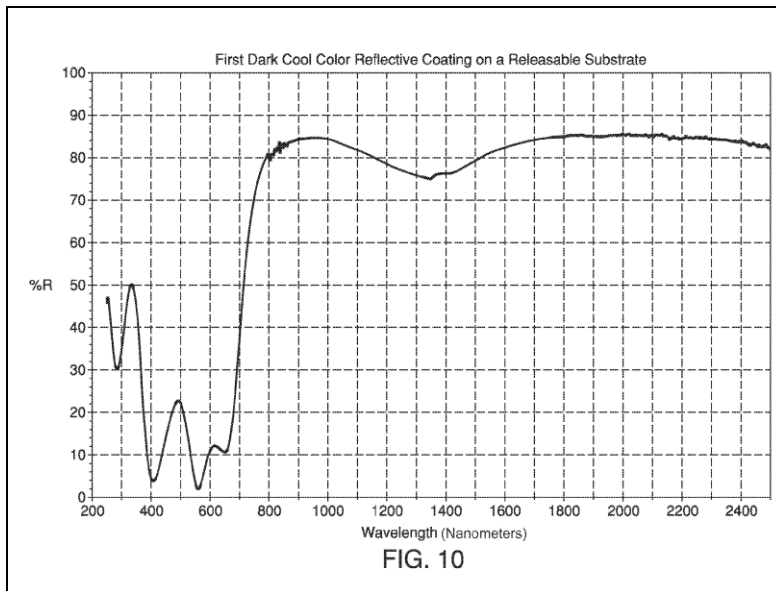
L.D. WOOLF, T.L. FIGUEROA, R.A. OLISTAD, F.E. ELSNER, and T. OHKAWA

Pacific Superconductors Division, General Atomics, San Diego, CA 92186

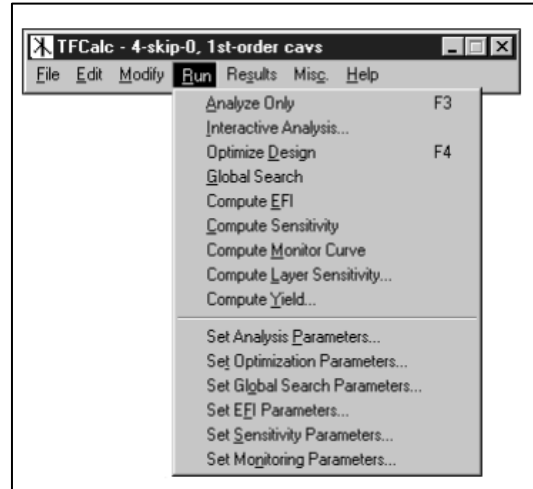
# Thin film coatings



[https://sspectra.com/files/win\\_demo/manual.pdf](https://sspectra.com/files/win_demo/manual.pdf)



Self taught: thin film coating design, development, fabrication, testing → (2001-present)



(12) **United States Patent**  
Woolf

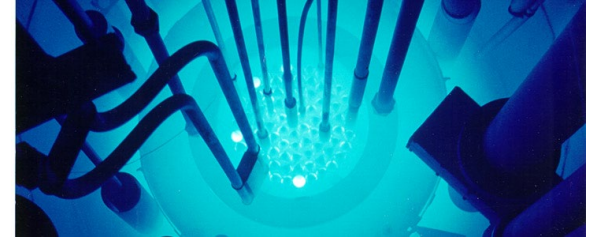
(10) **Patent No.:** US 8,932,724 B2  
(45) **Date of Patent:** Jan. 13, 2015

(54) **REFLECTIVE COATING, PIGMENT, COLORED COMPOSITION, AND PROCESS OF PRODUCING A REFLECTIVE PIGMENT**

6,699,313 B2 3/2004 Coulter et al.  
7,455,904 B2 11/2008 O'Keefe  
2009/0087553 A1 4/2009 O'Keefe

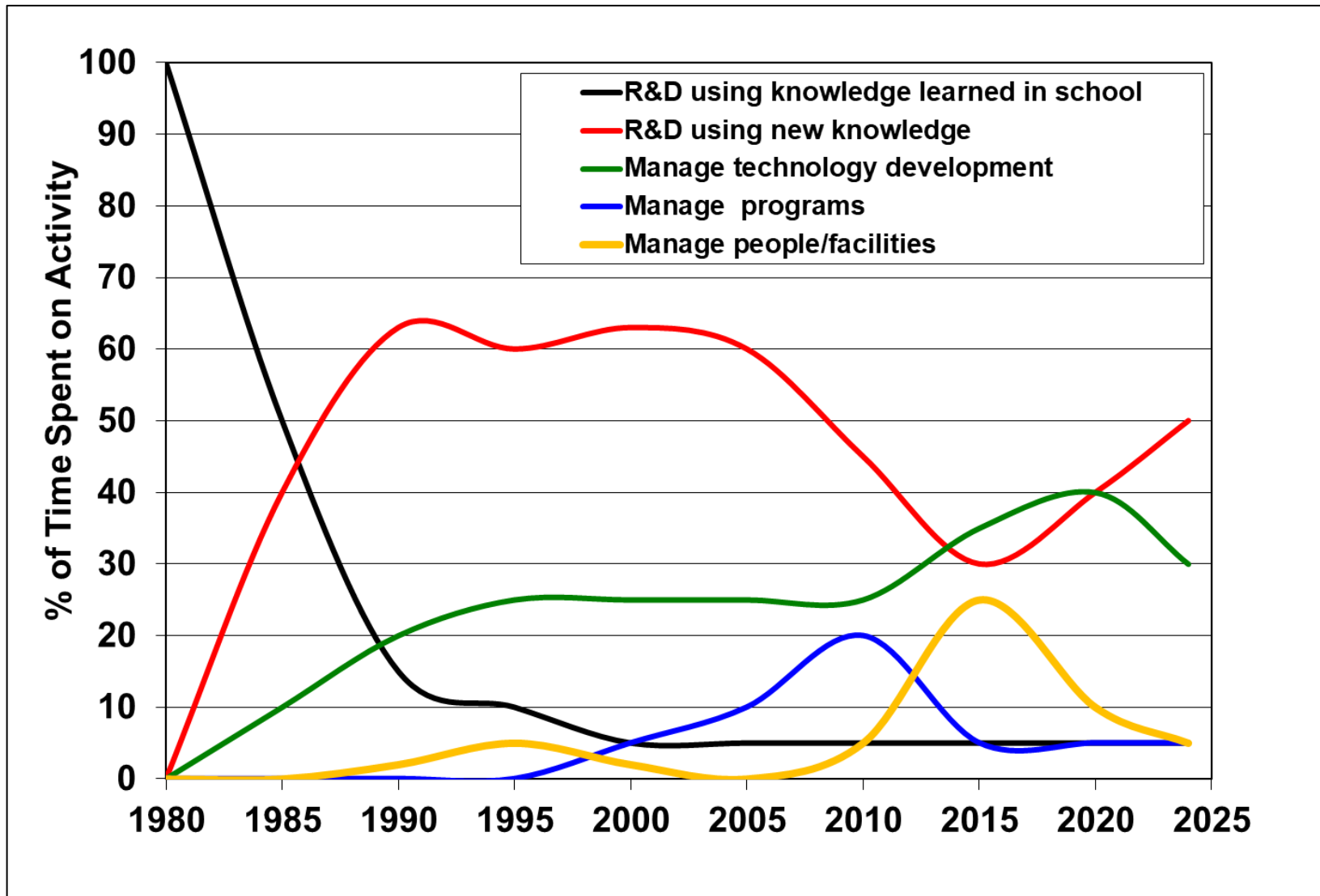
# Other fun stuff I've worked on or still work on

- **Past (1980-1993)**
  - **Neutron transmutation doping of Si:  $\text{Si} + n \rightarrow \text{P}$** 
    - Neutron fluence, annealing, measurements
  - **Materials for Nuclear Thermionic Space Power**
  - **Very high temperature electrical insulators for Nuclear Thermoelectric Space Power (1300K/100V/10 mils/7-years)**
- **Present**
  - **Coordinate intellectual property**
  - **Set up innovators internal research program**
  - **Review/revise company social media posts**





# Evolution of job responsibilities over time



# Advantages of Careers in Industry

- **Goal is development of a product**
- **Satisfaction of seeing your efforts make a difference**
- **Opportunities for patents, business development**
- **Challenge of not just doing science, but applying science to technology, then figuring out how to manufacture it in dynamic marketplace**
- **Challenge of learning how to perform R&D and scale-up under schedule, cost, equipment, quality, personnel, facilities constraints**
- **Varied career opportunities: science, technology, manufacturing, program or project management, group management, quality**
- **Many different projects; constant learning and agility needed**
- **Pay, bonus pool, stock options**

# Disadvantages of Careers in Industry

- Often minimal publications/presentations and interactions with non-company peers due to proprietary aspects, export controls, security issues
- Reduced likelihood of being recognized for your achievements from an academic perspective, e.g. awards, fellowships
- Focus on a defined goal (NOT curiosity driven)
- Limited freedom to pursue your personal interests
  - (caveat – see next part of talk!)
- (Almost) No sabbaticals, no tenure
- Need to rapidly reinvent yourself as technologies and business areas change

## Part 2: Education activities are possible in industry

- Outreach program started at GA in 1992
- Many companies have education outreach programs
- Details and funding are highly dependent on the company, management support, and the initiative and desire of the individual scientist
- **Why was I motivated to get involved and then more involved?**
  - **Opportunities, curiosity, frustration**
  - **7-year unsuccessful effort to develop high Tc superconducting wire**

# 1992-2003: Education modules, posters, presentations, reviews

## “The journey of a thousand miles begins with one step” Lao Tzu

- 1992: GA education outreach program started
- 1993: Co-author: An Exploration of Materials Science Module; workshops
- 1996: Author: The Line of Resistance Module; presentations
- 1996: Author: Seeing the Light: Physics and Materials Science of Incandescent Light Bulb Module; presentations
- 1997: APS Teacher Scientist Alliance 5-day workshop K-6 science
- 1997: Author: It's a Colorful Life Module; workshops
- 1997: GA Sciences Education Foundation web site
- 1997: Reviewer for NSF Instructional Materials Development (IMD) panel
- 1998: Co-Author: Chromatics: The Science of Color
- 1998: Reviewer for LHS FOSS Electronics middle school unit
- 1998: Testified about state science standards to CA State Board of Education
- 1999: Presented 4 workshops at NSF sponsored workshop in U Wisconsin
- 1999: Wrote and managed science education petition to improve state science standards
- 2001: Presented 3 workshops at AAPT winter meeting in San Diego
- 1999-2004: Color, Light, Seasons posters
- 2001: Presented workshops at High School Teachers Day March & April APS
- 2002: LHS FOSS middle school unit on Force and Motion – design/review
- 2002: Chair – COV Review Panel for NSF IMD program
- 2003-2008: Reviewer for BSCS inquiry based high school science curriculum

Start

Catalyst

GA

APS

NSF



# 2004-Present: NSF/APS National Panels, FEd & COE chair, Phys21, EP3 GA Sciences Education Foundation president/chair

- 2004: Testified to CA state board of education on draft criteria for K-8
- 2004: NSF site review of GEMS Seeds of Science/Roots of Reading – LHS
- 2004-2007: APS Forum on Education
- 2005: Chair: review of Nat. Center for Learning/Teaching in Nanoscale S/E
- 2007: NSF site reviews of SRI Nanosense program
- 2007-present: President/Chair GA Sciences Education Foundation
- 2007: Steering committee: NSF Materials Education Workshop
- 2008-2011: Elected to 4-year chair line, APS Forum on Education
- 2010: Org. committee: 2nd workshop on graduate education in physics
- 2010-2012: APS Committee on Education
- 2012: NSF review panel for Cornell High Energy Synchrotron Source
- 2014: NSF review panel for National High Magnetic Field Laboratory
- 2014-2015: APS/AAPT Joint Task Force on Undergraduate Physics Programs-Phys21
- 2016-2018: APS Development Advisory Committee
- 2016-2022: APS Effective Practices for Physics Programs (EP3)
- 2019-2020: APS Excellence in Physics Education Award selection committee
- 2020-2024: IUPAP Working Group 16: Physics and Industry, US Member
- 2022-2024: APS Committee on Education (2023 Chair)
- 2023-2026: APS EP3 Editorial Board (2025 Chair)
- 2023: APS Working Group on Vision/Mission/Values
- 2023-2024: Member-At-Large-U.S. Liaison Committee for the IUPAP

GA

APS

NSF

# Moral

- **Stay open to opportunities**
- **Never say no (some of my peers disagree!)**
- **Do what you say you will do**
- **Do a good job**
- **If motivated/annoyed, then create/solve**
- **Utilize your unique skills and knowledge**
  
- **Let's look at some education highlights - posters**
  - Multiple representations
  - Relationships
  - Synthesize complex concepts into simple visible form

# Color mixing - misconceptions

Curiosity Driven!

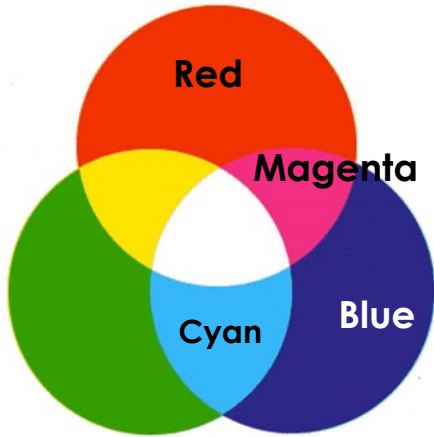
## Confusion about primary colors



<https://www.aps.org/publications/apsnews/200007/teachers-day.cfm>

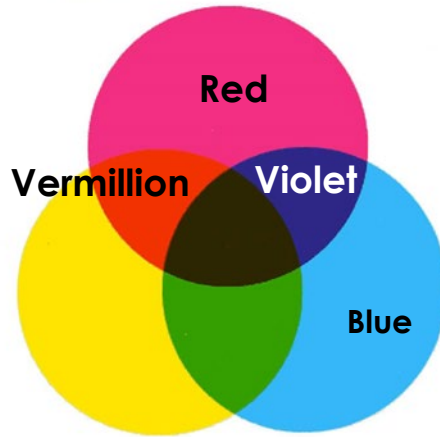
The result of mixing light colors together.

- White is the result of superimposing the three beams of light, green, red, and blue, the primary light colors.
- The projection of two of these colors produces the secondary light colors: yellow (the result of superimposing green and red), magenta (the result of superimposing red and intense blue) and cyan blue (the result of superimposing intense blue and green).

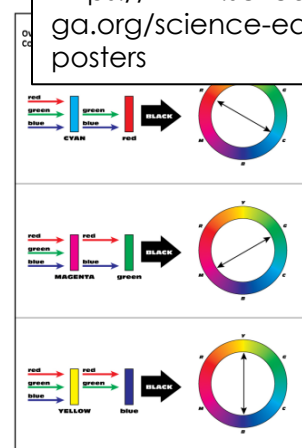
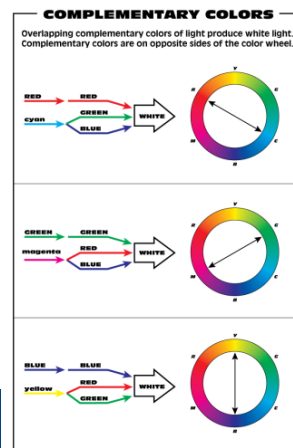
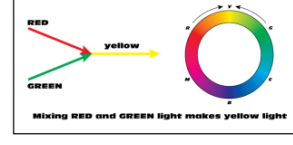
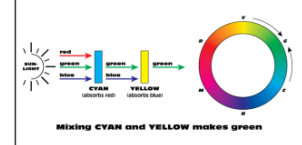
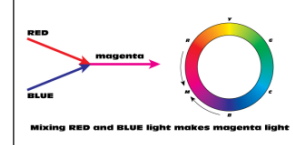
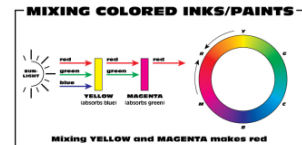
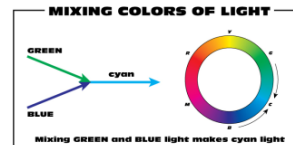
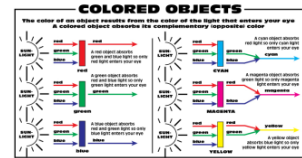
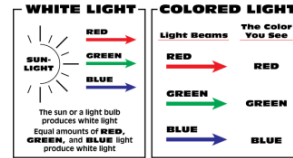
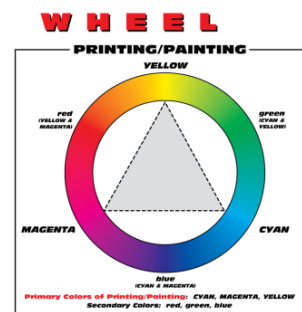
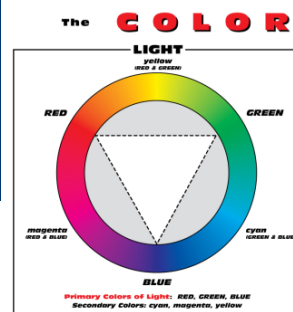


The result of mixing pigment colors together.

- Black is the result of superimposing the three primary colors: yellow, red, and blue.
- Mixing yellow and red together produces vermilion.
- Red plus blue gives us violet.
- By combining blue with yellow we get green.

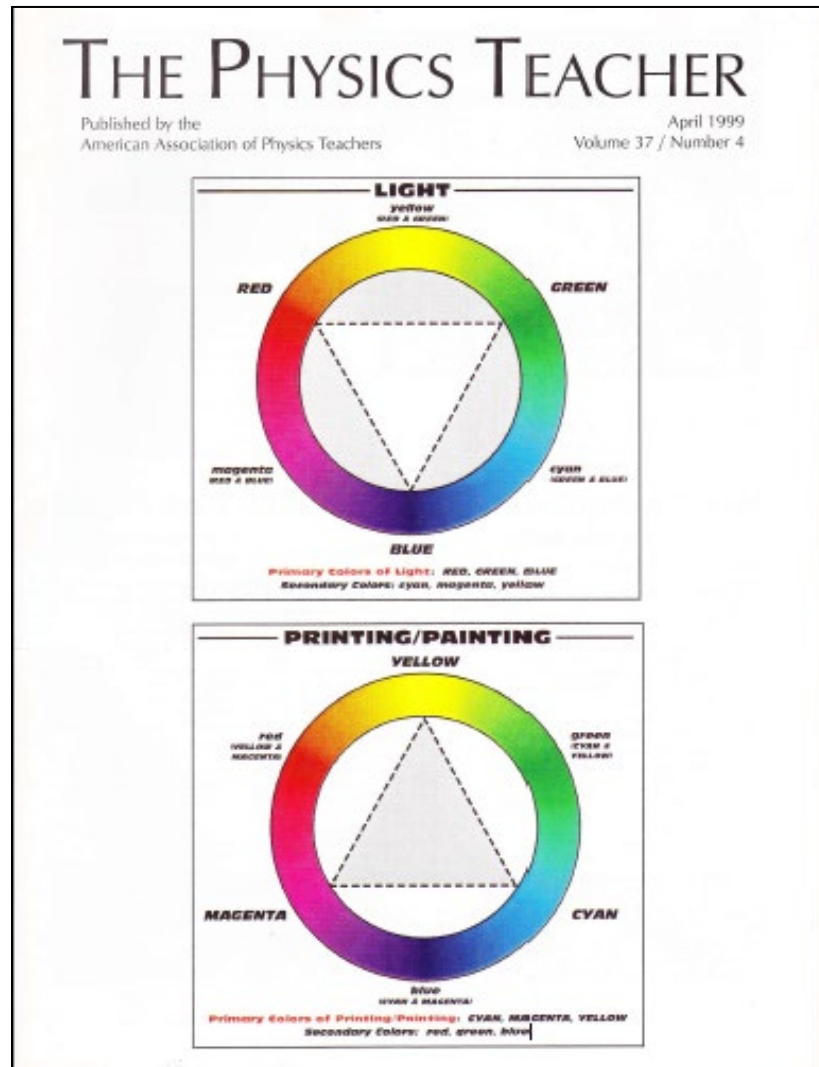


Barron's Art Handbooks: Mixing Colors 1. Watercolor



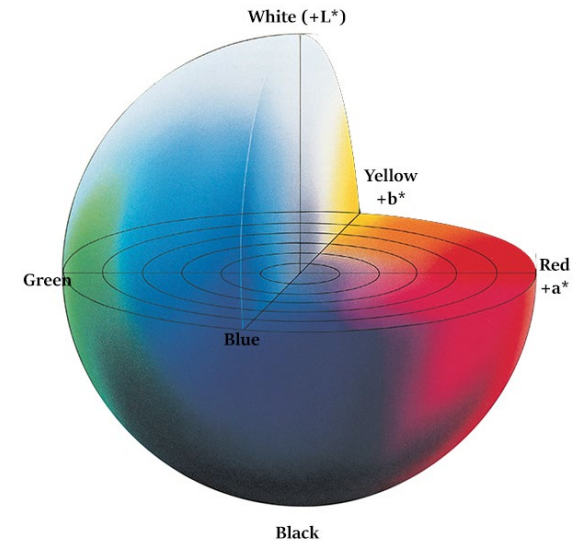
<https://www.sci-ed-ga.org/science-education-posters>

# Publicity for the correct color wheels from the color wheel poster ...

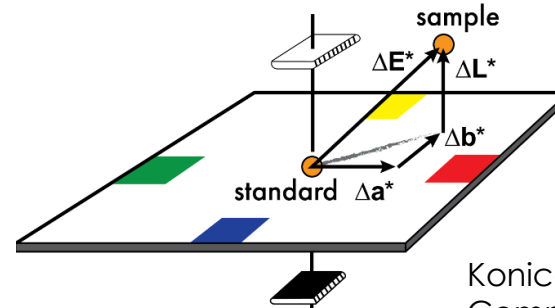


“Confusing Color Concepts Clarified,” L. D. Woolf, The Physics Teacher 37, p.204 (1999)

Education informs industrial work!



$$\Delta E_H = [(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2]^{1/2}$$

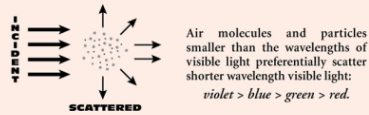


Konica Minolta “Precise Color Communication” booklet

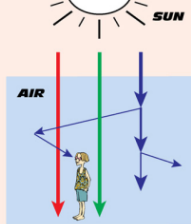


# Light Matters Poster: More physics than color wheel poster

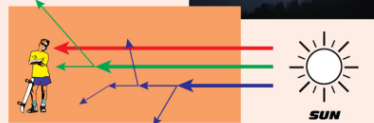
## MOLECULES AND SMALL PARTICLES SCATTER LIGHT



When sunlight passes through the atmosphere, the shorter wavelength components are preferentially scattered. So when we look away from the sun, we see the blue sky. When we look toward the sun, we see unscattered light. Why isn't the sky violet? See the details section below for a hint and reference 3 for a complete explanation.



**SUNLIGHT**  
Short Path at Noon  
Long Path at Sunset



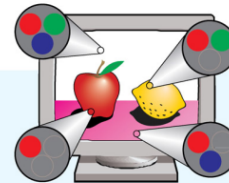
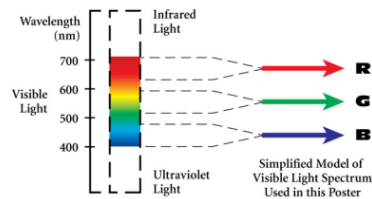
Sunlight passes through a longer length of atmosphere at sunset than at noon, which leads to increased scattering. When we look toward the sun at sunset, we see the unscattered light that is enriched in light of longer wavelengths. This results in a yellow or orange or even red sun.

### Some Details and Clarifications

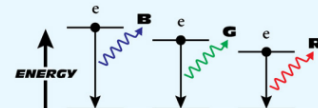
- Light is not colored. Color is a human visual response that depends on the spectrum of visible light entering our eyes - the color that we observe then depends on the responsiveness of the long, middle, and short wavelength sensitive cones in our eyes and the processing of these signals by the brain.
- The color of an object seen by reflected light depends on both the light spectrum illuminating the object as well as the reflectance spectrum of the object. This is why the color of clothes changes with illumination conditions.
- Light of a single wavelength corresponds to a definite perceived color. Most perceived colors can be evoked by a large number of different light spectra entering our eyes.
- For further details about and limitations of the explanations given in this poster, consult the references.

# L I G H T M A T T E R S

## LIGHT EMISSION

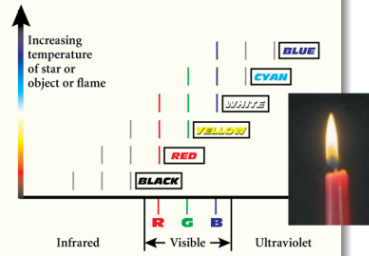


A computer monitor uses R, G, B phosphors to generate colors.



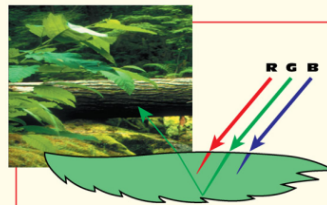
In these phosphors, the energy lost by an excited electron (e) results in light emitted with that energy.

## HOW COLOR CHANGES WITH INCREASING TEMPERATURE



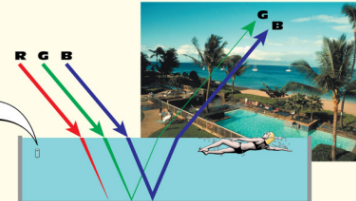
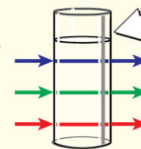
Objects emit light over a wide continuous range of wavelengths. At each temperature, this range can be approximated by three separated wavelengths. The rules for additive color mixing can then be used to predict how the color of hot objects changes with increasing temperature.

## ABSORPTION



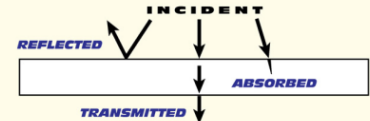
Leaves are dark green because they absorb almost all of the red and blue part of the visible spectrum and much of the green; they reflect a small portion of the green. Much of the absorbed light is used for photosynthesis; the remaining absorbed light heats the plant.

Water in a glass does not appear colored because the short path of light through the glass of water results in almost no light absorption.

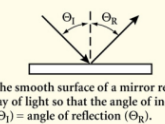


Deep water appears blue because absorption of visible light by water is gradual as well as selective: greatest at the red end of the spectrum, least at the violet and blue end.

## BULK MATTER REFLECTS, TRANSMITS, AND ABSORBS LIGHT



### REFLECTION



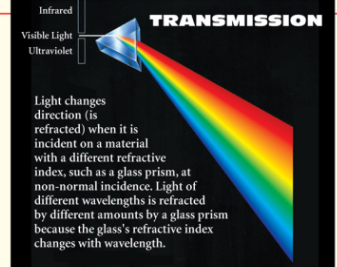
The smooth surface of a mirror reflects a ray of light so that the angle of incidence ( $\theta_i$ ) = angle of reflection ( $\theta_r$ ).



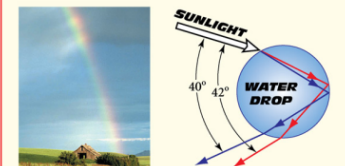
The surface of a white piece of paper diffusely reflects the incident light because the surface is optically rough at visible wavelengths.



### TRANSMISSION



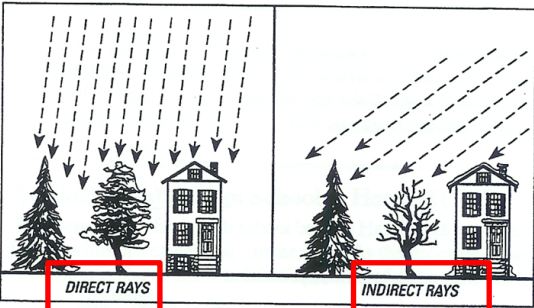
Light changes direction (is refracted) when it is incident on a material with a different refractive index such as a glass prism, at non-normal incidence. Light of different wavelengths is refracted by different amounts by a glass prism because the glass's refractive index changes with wavelength.



Part of the incident light undergoes refraction as it enters a water drop, then reflection at the back surface, then refraction as it exits the drop. The index of refraction of water is different for different wavelengths, causing the incident sunlight to separate into a rainbow of colors. Only shown are the rays corresponding to the angle at which scattering is a maximum. See Reference 1, chapter 21 for further details.



# Misconceptions about seasons: scale, words

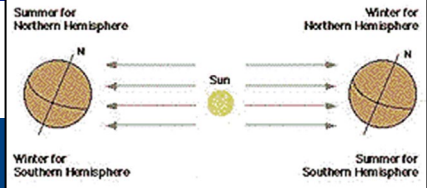
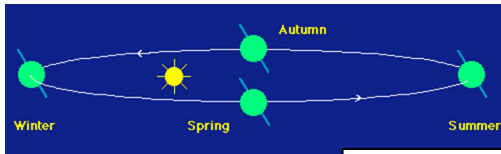


Two factors resulting from the tilt of the Earth's axis account for seasonal weather changes. First, in summer the Sun shines higher in the sky and its rays beat more directly down, warming the surfaces they contact. In the winter when the Sun is lower in the sky, its light reaches the ground at a lower angle, spreading out its warming ability. This is the phenomenon sometimes referred to as "indirect rays."

## Variations in the Length of Daylight

The second factor contributing to the seasons is the length of the daylight period. Because of the tilt of the Earth's axis, daylight lasts longer in the summer than in the winter. The farther you travel from the equator, the more extreme this contrast becomes. So not only is the Sun's warming light less effective in the winter but there are fewer hours of it. Also, the Earth's surface has more time to cool off at night in winter than in summer.

From: A Private Universe Teacher's Guide, p. 18



# THE SEASONS A TALE OF THE SUN, EARTH, AND TWO CITIES

**At any time, half of Earth's surface is heated by sunlight, while the entire surface is cooled by Earth's emission of infrared light.**

**Some Details and Clarifications**

The tropics receive roughly constant solar heating throughout the year. As a result, they essentially have no seasons.

At the tropics, the annual solar radiation absorbed by Earth exceeds the annual infrared radiation emitted. At the mid-latitudes, the annual radiation absorbed by Earth is approximately equal to the annual energy infrared emitted. At the poles, the annual infrared radiation emitted by Earth exceeds the annual absorbed solar radiation.

In most scientific literature, the angle of the Sun is measured with respect to the zenith, not the horizon as is done in this poster. The angle of the Sun measured from the zenith is called the zenith angle.

*Created by Dr. Lawrence M. Wood, Sonoma State University, Rohnert Park, California 94928*  
For additional information, your instructor, or see [www.earthlink.org/~lwood/seasons/seasons.html](http://www.earthlink.org/~lwood/seasons/seasons.html)

The seasons are almost entirely a consequence of the yearly changes in daylight hours and the angle between the Sun's rays and Earth's surface. Small variations in the Earth-Sun distance over a year are mostly irrelevant. The top half of the poster illustrates the seasons in the Earth-Sun distance over a year as mostly irrelevant. The bottom half compares daylight hours, maximum daily Sun altitude, daily solar energy, and temperature data from a northern hemisphere city (New York City - 40° north latitude) and a southern hemisphere city (Wellington, New Zealand - 40° south latitude). The data analysis shown confirms these

**ALL OBJECTS EMIT ELECTROMAGNETIC RADIATION. HIGHER TEMPERATURE OBJECTS EMIT AT SHORTER WAVELENGTHS.**

Earth emits mostly infrared radiation in all directions.

The Sun emits radiation in all directions. Only less than half of this radiation is emitted as visible light.

The sun's rays that strike Earth are mostly parallel. For the other diagrams, we drew the rays perfectly parallel.

This figure shows the size of Earth, the size of the Sun, and the Earth-Sun distance at approximately the correct scale.

The length of the line of latitude in daylight (x) divided by the total length shown (x+y) indicates the percentage of daylight hours at that latitude.

Count the number of the Sun's rays between:

- A - B
- B - C
- C - D
- D - E
- E - F

The greater the density of rays, the greater the solar heating, resulting in higher temperatures.

**JULY**  
Summer in North America  
Winter in South America

**JANUARY**  
Winter in North America  
Summer in South America

When the Sun is at an angle  $\theta$  above the horizon, the concentration of sunlight on Earth's surface is reduced by a factor of  $\sin(\theta)$  compared to the concentration when the sun is directly overhead.

Local Zenith

Local Zenith

**Quantitative Model Matches Data!**

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SCIENCE EDUCATION FOUNDATION  
www.science-ed.com

# A guest appearance on The Big Bang Theory ...



# And another

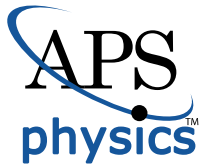




...and another



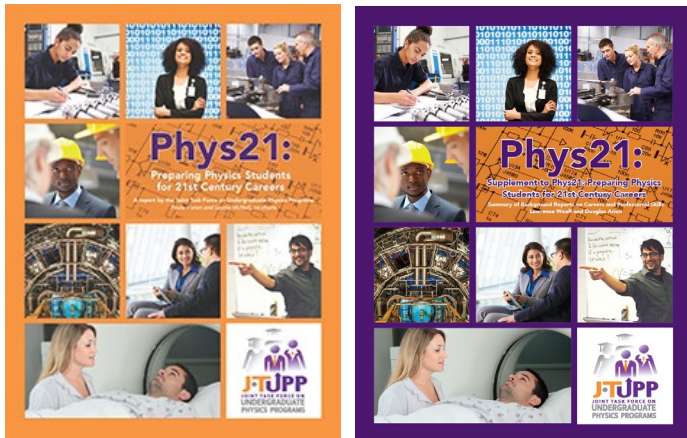
# Part 3: APS Involvement



## Joint Task Force on Undergraduate Physics Programs (J-TUPP)

*What skills and knowledge should the next generation of undergraduate physics degree holders possess to be well prepared for a diverse set of careers?*

[compadre.org/phys21](https://www.compadre.org/phys21)



Report

Supplement

Some slides include text from Prof. Laurie McNeil's talk at the 2017 APS March Meeting

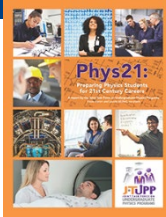
<https://www.compadre.org/JTUPP/docs/MarchMtg17.pptx>



# J-TUPP MEMBERSHIP

**Paula Heron, co-chair, *University of Washington***

**Laurie McNeil, co-chair, *University of North Carolina, Chapel Hill***



**Douglas Arion, *Carthage College***

**Walter Buell, *The Aerospace Corporation***

**S. James Gates, *University of Maryland***

**Sandeep Giri, *Google Inc.***

**Elizabeth McCormack, *Bryn Mawr College***

**Helen Quinn, *Stanford Linear Accelerator Center***

**Quinton Williams, *Howard University***

**Lawrence Woolf, *General Atomics Aeronautical Systems, Inc***

## **Society liaisons**

**Ted Hodapp, *APS***

**Renee Michelle Goertzen, *APS***

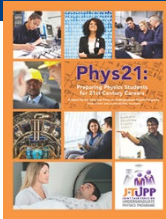
**Beth Cunningham, *AAPT***

**Bob Hilborn, *AAPT***



# A FEW FACTS (changes year to year)

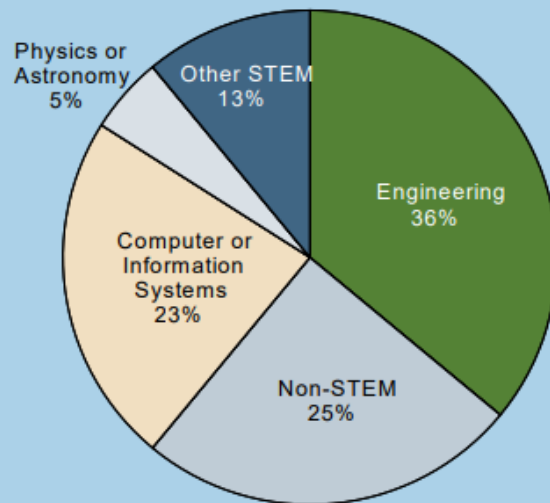
- 7,500 people graduate with bachelor's degrees in physics each year
- 350 people are hired as physics faculty members each year
- **5% of all physics bachelor's eventually end up as physics professors**
- **40% of bachelor's graduates enter the workforce immediately**
  - **61% work in the private sector**
  - 13% work in colleges and universities
  - 8% work in high schools
  - 6% work in the military
  - 5% work in civilian government or national laboratories
- **35% of physics PhDs work in 4-year academic institutions**
  - **65% do not**



Various reports, AIP Statistical Research Center

# Physics Bachelors Employment

Field of Employment for Physics Bachelors in the Private Sector, Classes of 2013 & 2014 Combined

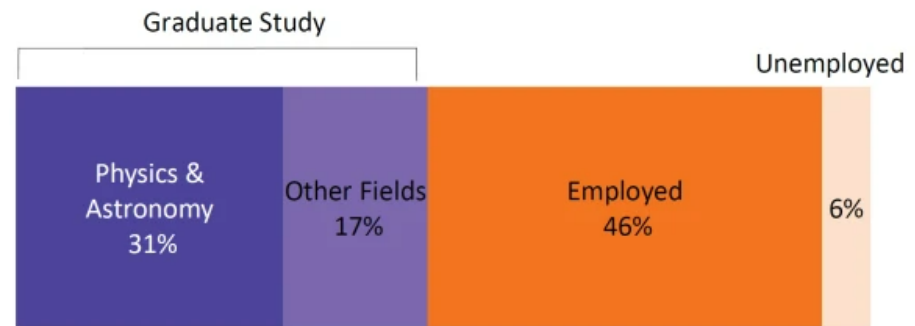


STEM refers to natural science, technology, engineering, and mathematics.

Figure is based on 1,141 responses

[www.aip.org/statistics](http://www.aip.org/statistics)

Status of Physics Bachelors One Year After Degree, Classes of 2019 and 2020 Combined



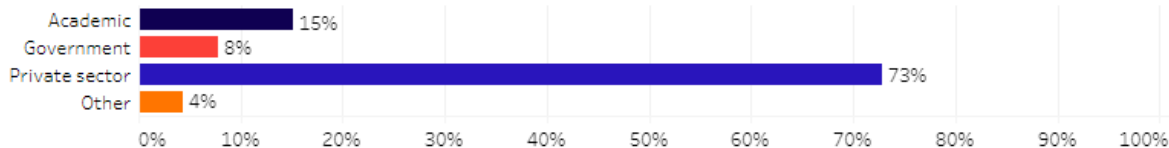
<https://ww2.aip.org/statistics/status-of-physics-bachelors-one-year-after-degree-classes-of-2019-and-2020-combined>

# New Physics PhDs Holding Potentially Permanent Positions

Employment Fields for New Physics PhD Recipients Holding Potentially Permanent Positions



All Employment Sectors:



<https://ww2.aip.org/statistics/whos-hiring-physics-phds>  
Classes of 2016-2020

# Common Job Titles of Physics Bachelor's Recipients

## Computer Hardware and Software

- Software Engineer
- Programmer
- Web Developer
- IT Consultant
- Systems Analyst
- Technical Support Staff
- Analyst

## Research and Technical

- Research Assistant
- Research Associate
- Research Technician
- Lab Technician
- Lab Assistant
- Accelerator Operator
- Physical Sciences  
Technician

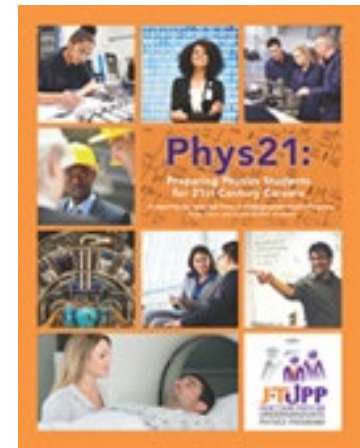
## Education

- High School Physics  
Teacher
- High School Science  
Teacher
- Middle School  
Science Teacher

## Engineering

- Systems Engineer
- Electrical Engineer
- Design Engineer
- Mechanical Engineer
- Project Engineer
- Optical Engineer
- Manufacturing  
Engineer
- Laser Engineer
- Associate Engineer
- Technical Services  
Engineer
- Application Engineer
- Development  
Engineer
- Engineering  
Technician
- Field Engineer
- Process Engineer
- Process Technician
- Product Engineer
- Product Manager
- Research Engineer
- Test Engineer
- General Engineer

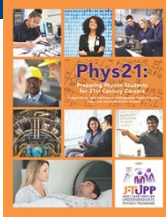
This list is composed of common job titles identified by an AIP Statistical Research Center survey of physics bachelor's degree graduates from the classes of 2009 and 2010.





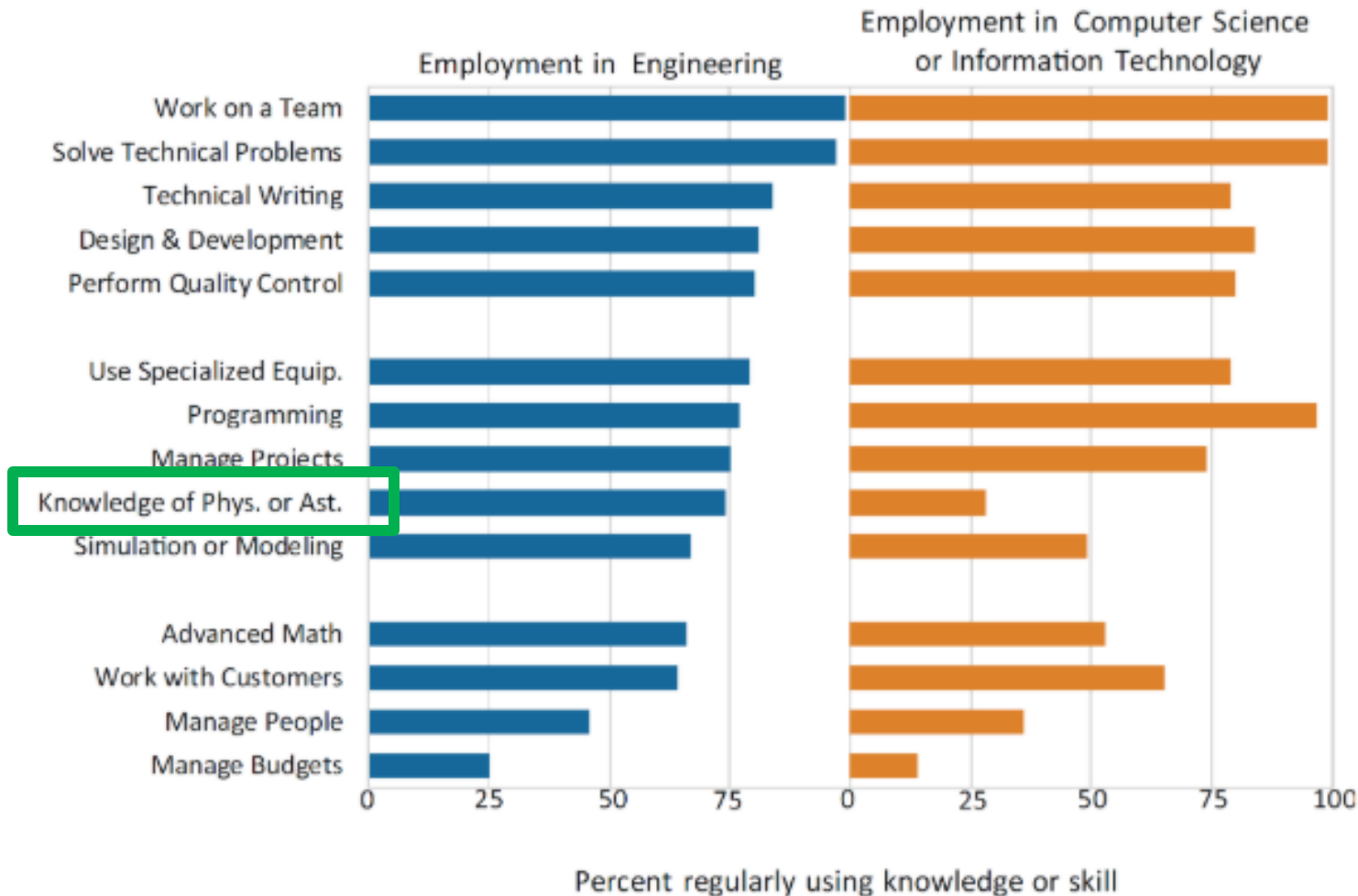
# THE CHALLENGE FOR PHYSICS DEPARTMENTS

- To better prepare students for diverse careers, *does not* mean
  - abandoning the rigorous technical education that makes a physicist a physicist
  - regarding your program as providing only vocational training
- It *does* mean evaluating whether your department is doing its best to prepare students to compete with graduates in other fields (such as engineering) for desirable employment and career options
- It *does* mean that we should consider reframing education in the context of how it is used by our students

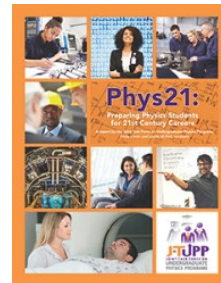


From Prof. Laurie McNeil's talk at  
the 2017 APS March Meeting

# Knowledge and Skills Regularly Used by New Physics Bachelors Employed in the Private Sector, Classes of 2015 & 2016 Combined



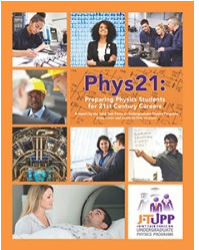
Percentages represent the physics bachelors who indicated they use a knowledge or skill "daily," "weekly," or "monthly" on a four-point scale that also included "never or rarely."



# Phys21 LEARNING GOALS FOR PHYSICS PROGRAMS: 1 of 2

## Physics-specific knowledge, e.g.

- Apply basic laws of physics
- Solve problems involving multiple areas of physics
- Solve multidisciplinary problems that link physics with other disciplines
- Investigate how physics concepts are used in modern technology



p. 19-21

## Scientific and technical skills, e.g.

- Solve both well-posed and ill-posed problems through experiments, simulations, models
- Determine follow-on investigations
- Identify resource needs
- Competencies: instrumentation, computation, industry standard software, coding, data analytics



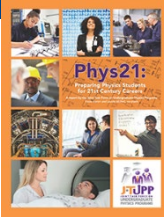
# Phys21 LEARNING GOALS FOR PHYSICS PROGRAMS: 2 of 2

## Communication skills, e.g.

- Communicate orally and in writing with audiences with a wide range of technical or non-technical backgrounds
- Organize and communicate ideas using words, mathematical equations, tables, graphs, pictures, diagrams
- Listening, discussing, persuading, assessing, understanding, teaching

## Professional/workplace skills, e.g.

- Collegiality and collaboration in diverse teams
- Critical life skills: time management, listening, optimism, responsibility, perseverance, ethical behavior
- Awareness of career opportunities and pathways for physics graduates
- Awareness of standard practices for effective resumes and job interviews

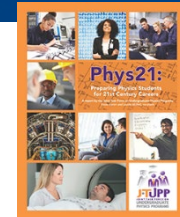


p. 19-21



# How to Become a Successful Physicist

- Carl Wieman, “The Nature of Physics Problem Solving”
- [Physics Today 75 \(9\) 46-52 \(2022\)](#)
  - “29 sets of questions that students and physicists need to ask themselves during the research process. The answers at each step allow them to make the 29 decisions needed to solve a physics problem”
    - Selection and Planning (1-9)
    - Decisions that establish the specifics needed to solve the problem (10-15)
    - Analysis and Conclusions (16-26)
    - Decisions about the significance of the work and how to communicate the results (27-29)



# Origin of the EP3 Guide



## Genesis of the EP3 Guide

### ***Charge from the APS Council:***

*Provide a **living** physics-community-based resource to assist programs in developing a culture of continuous self-improvement, in keeping with their individual mission, context, and institutional type*

APS Council approved formation of the Best Practices for Undergraduate Physics Programs (BPUPP) Task Force in 2015 to create this Guide



# EP3 Task Force Members



## Task Force & Leadership



**David Craig**  
Leadership Team, Task Force Co-Chair, and Community Engagement  
Oregon State University



**Noah Finkelstein**  
Task Force Member  
University of Colorado Boulder



**Robert Hilborn**  
AAPT Liaison  
American Association of Physics Teachers Society



**Theodore Hodapp**  
Leadership Team  
Moore Foundation



**Michael Jackson**  
Leadership Team and Task Force Co-Chair  
New Mexico Institute of Mining and Technology



**Courtney Lannert**  
Task Force Member, Assistant Editorial Director, and Department Toolkit Consultant  
Smith College and University of Massachusetts Amherst



**Ramon Lopez**  
Task Force Member  
University of Texas Arlington



**Sam McKagan**  
Editorial Director, Leadership Team, Community Engagement, and Website Design Team  
McKagan Enterprises



**Willie Rockward**  
Task Force Member  
Morgan State University



**Gay Stewart**  
Task Force Member  
West Virginia University



**Gubbi Sudhakaran**  
Task Force Member  
University of Wisconsin La Crosse



**Kathryn Svinarich**  
Task Force Member  
Kettering University



**Carl Wieman**  
Task Force Member  
Stanford University



**Lawrence Woolf**  
Task Force Member  
General Atomics Aeronautical Systems, Inc.

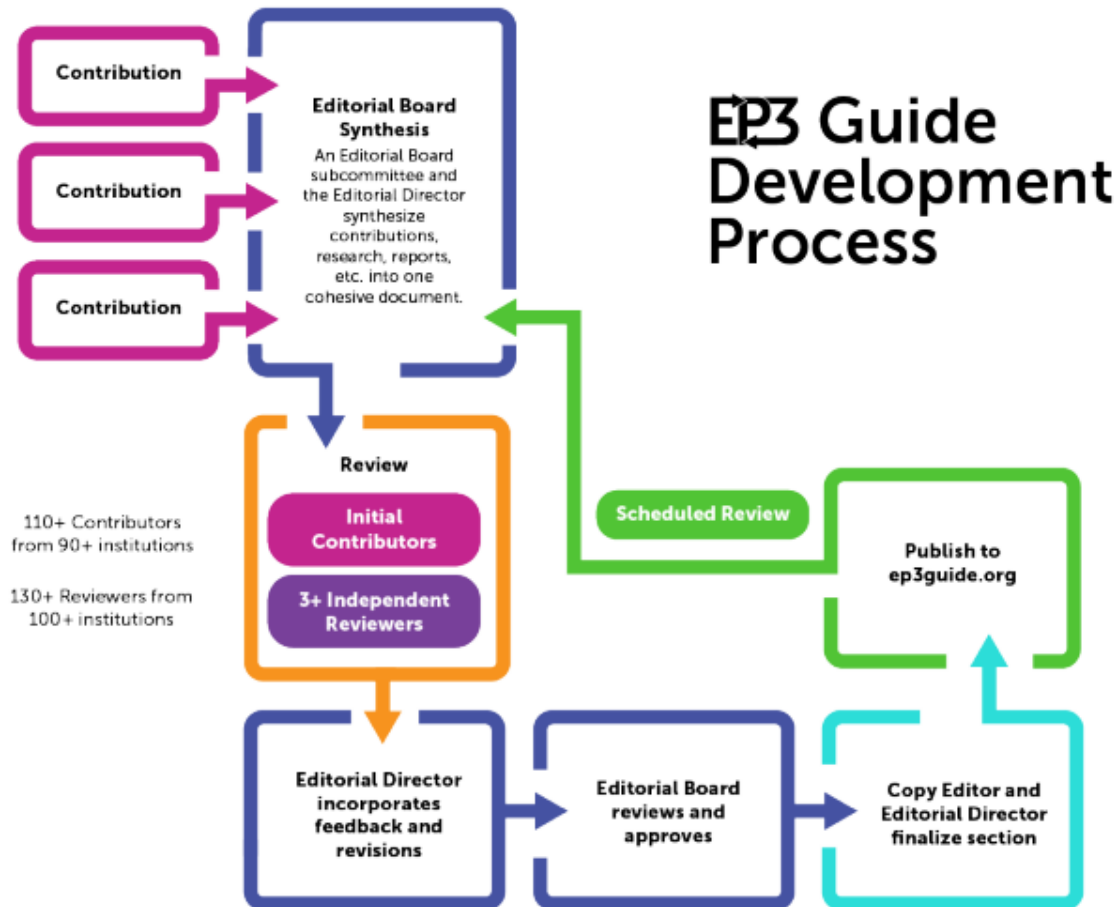


**Michael Wittman**  
Leadership Team and APS Liaison  
American Physical Society

# EP3 Process



## Section Development



# Effective Practices Guide Sections

Developed and reviewed by experts in the physics community, these sections have been approved by the task force. They address a wide range of topics relevant to ensuring a thriving physics program, including actionable practices and implementation strategies.

Recruiting of Undergraduate Physics Majors	Retention of Undergraduate Physics Majors	Advising and Mentoring of Students	Career Preparation
Preparing Students for Graduate School in Physics and Related Fields	Undergraduate Research	Internships	Capstone Experiences
Introductory Courses for STEM Majors	Introductory Courses for Life Sciences Majors	Upper-Level Physics Curriculum	Courses for Non-STEM Majors
Instructional Laboratories and Experimental Skills	Computational Skills	High School Physics Teacher Preparation	Degree Tracks
Dual-Degree Programs	How to Be an Effective Chair	How to Select and Use Various Assessment Methods in Your Program	How to Create and Use a Strategic Plan
How to Create and Use Foundational Documents	Departmental Culture and Climate	Equity, Diversity, and Inclusion	Ethics
How to Undertake an Undergraduate Program Review	How to Serve as an Undergraduate Program Reviewer	The Physical Environment: Encouraging Collaboration and Learning	7 more sections by the end of 2024

# EP3 Guide – Career Preparation Section Themes and Effective Practices

Description	Benefits	<u>Effective Practices</u>	Assessments	Resources	Evidence
		<b>3. Provide students with off-campus learning experiences that explicitly teach skills and knowledge relevant to future careers</b>			
	<p>1. Communicate to and educate students about a variety of career options</p> <p>2. Provide students with on-campus experiences that explicitly teach skills and knowledge relevant to future careers</p> <p>3. <u>Provide students with off-campus learning experiences that explicitly teach skills and knowledge relevant to future careers</u></p>	<p>A. Create connections between your physics program and employers, professionals, and alumni &gt;</p> <p>B. Create infrastructure that will allow students to take part in summer research experiences and/or internships in local companies &gt;</p> <p>C. Engage foundations, non-profits, government entities, and your development or fundraising office to promote student innovation &gt;</p>			

## 3 Themes

1. Communicate to and educate students about a variety of career options
2. Provide students with on-campus experiences that explicitly teach skills and knowledge relevant to future careers
3. Provide students with off-campus learning experiences that explicitly teach skills and knowledge relevant to future careers

### 3. Provide students with off-campus learning experiences that explicitly teach skills and knowledge relevant to future careers

- A. Create connections between your physics program and employers, professionals, and alumni >
- B. Create infrastructure that will allow students to take part in summer research experiences and/or internships in local companies >
- C. Engage foundations, non-profits, government entities, and your development or fundraising office to promote student innovation >



# EP3 Guide – Career Preparation Section

## Implementation Strategies for 1 Effective Practice

### A. Create connections between your physics program and employers, professionals, and alumni

- i. Connect local physics and technology professionals with faculty to provide opportunities for student internships.
- ii. Pair students with mentors in private-sector careers, e.g., see the IMPact program under [Resources](#).
- iii. Provide students and faculty with opportunities to take tours of local companies and other places of employment.
- iv. Support students applying for jobs, especially students from [marginalized groups](#), in finding workplaces where they will be supported.
- v. Invite alumni to interact with current students as informal or formal mentors, e.g., by serving as colloquium speakers, attending departmental events, inviting students to visit the alumni's workplace, or judging student posters or presentations.
- vi. Educate members of the private sector about things physics students can do, technical skills and knowledge students gain from a physics degree, and ways students' problem-solving abilities can benefit companies, e.g., by visiting their businesses, hosting department open houses, or creating industry advisory boards.

**6 Implementation Strategies**  
(menu of options)

# Career Preparation Resources

- **Phys21 Report and Supplement**
  - [www.compadre.org/JTUPP/](http://www.compadre.org/JTUPP/)
- **EP3 Guide**
  - <https://ep3guide.org/>
- **AIP Career Pathways Project**
  - [www.spsnational.org/career-resources/career-pathways](http://www.spsnational.org/career-resources/career-pathways)
- **APS Careers in Physics**
  - [www.aps.org/careers/index.cfm](http://www.aps.org/careers/index.cfm)
- **How to become a successful physicist, Carl Wieman**
  - [Physics Today 75 \(9\), 46-52 \(2022\)](#)
- **International Career Resources**
  - <https://iupap-corporate-associate-members.web.cern.ch/node/4>



# Questions?

- What does an industrial physicist do?
  - Lots of interesting challenging work
- Can you get involved in physics education in industry?
  - Yes, just begin the journey
- What is the best way to prepare undergraduate physics students for careers?
  - Purposely. Consider the many resources available such as Phys21 and EP3
- How can APS play a major role in your professional life?
  - By providing opportunities to make an impact, and work with interesting people (in addition to providing a forum for talks)
- How are these questions related?
  - Cross-fertilization