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What your Mother….*er*….Advisor Never Told You: The Other Stuff you Need to Know (and Teach!)

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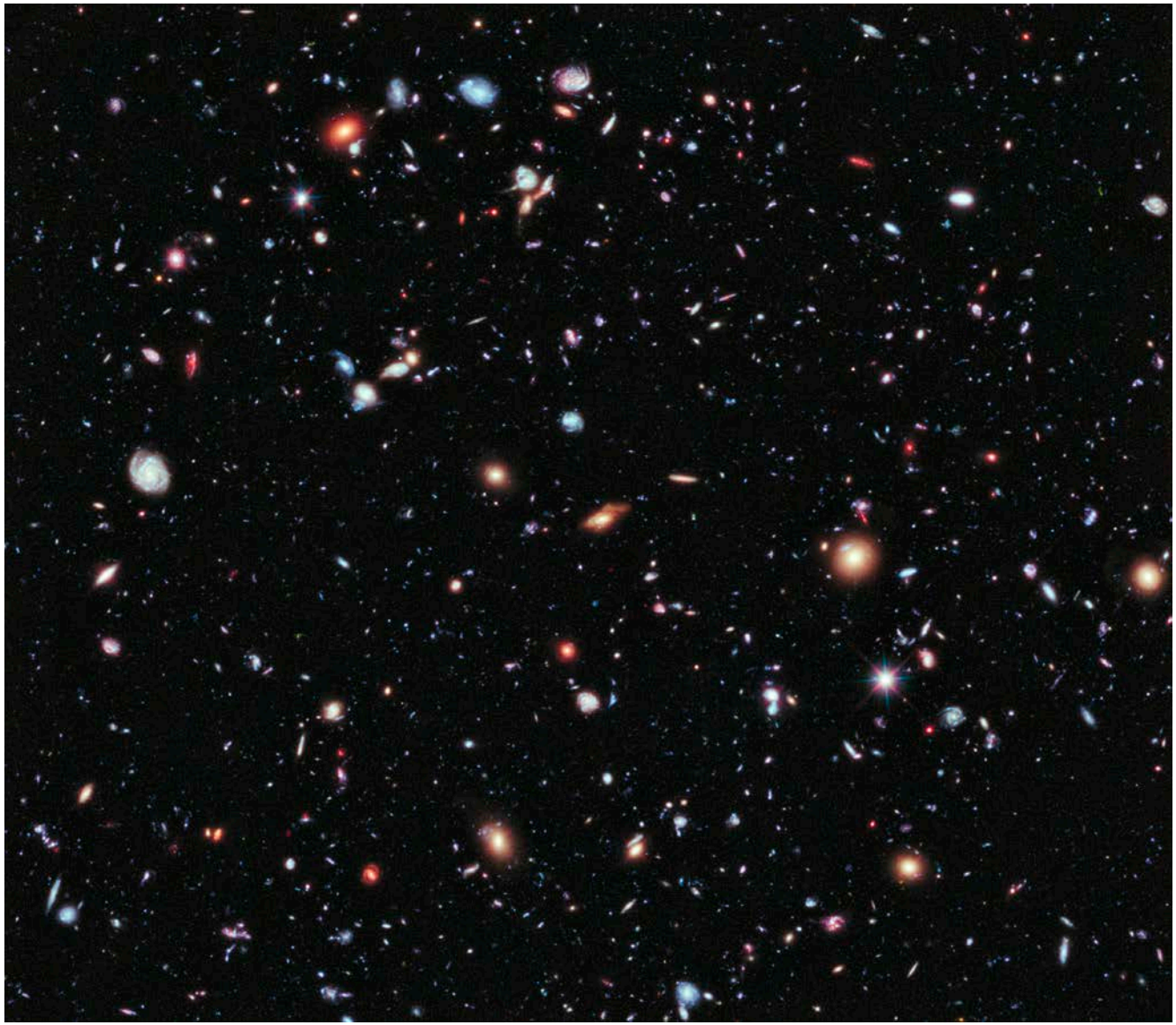
We Love Physics:
The Universe is Fascinating



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Physics – A Path to Prosperity (?)

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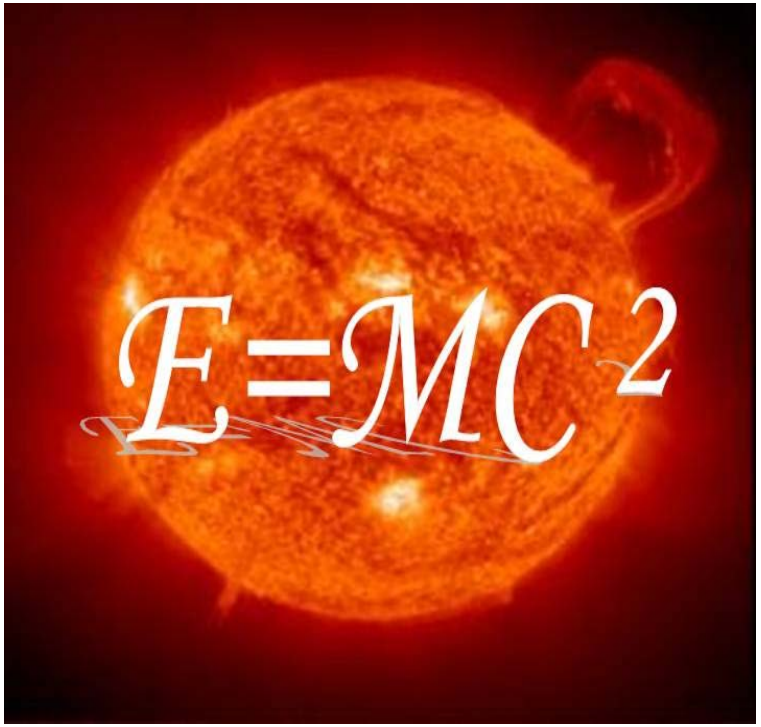
Doing Physics is NOT being a "Physicist"*



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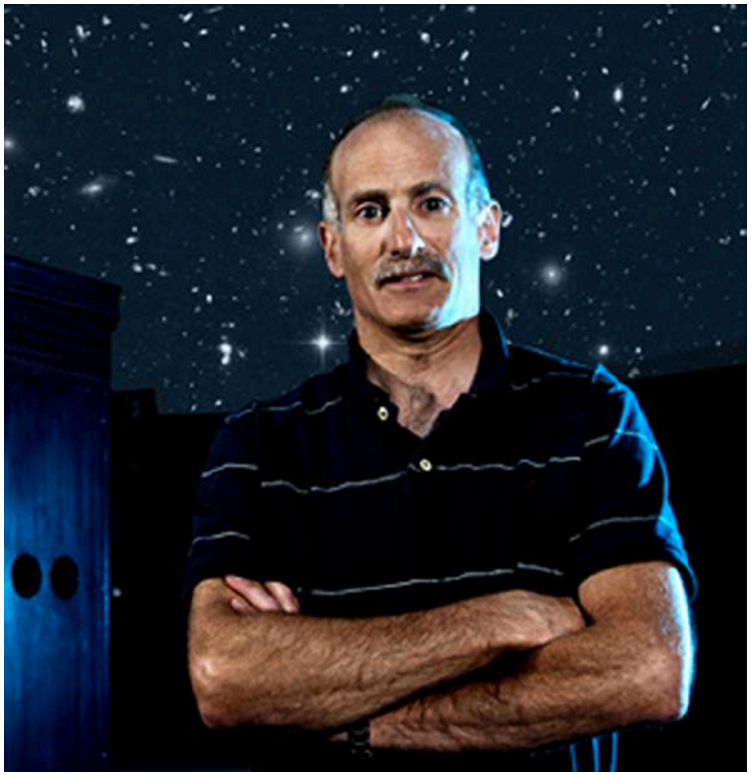

* Also true for *Every* field of study
(Oh, and what *IS* a physicist, anyway?)

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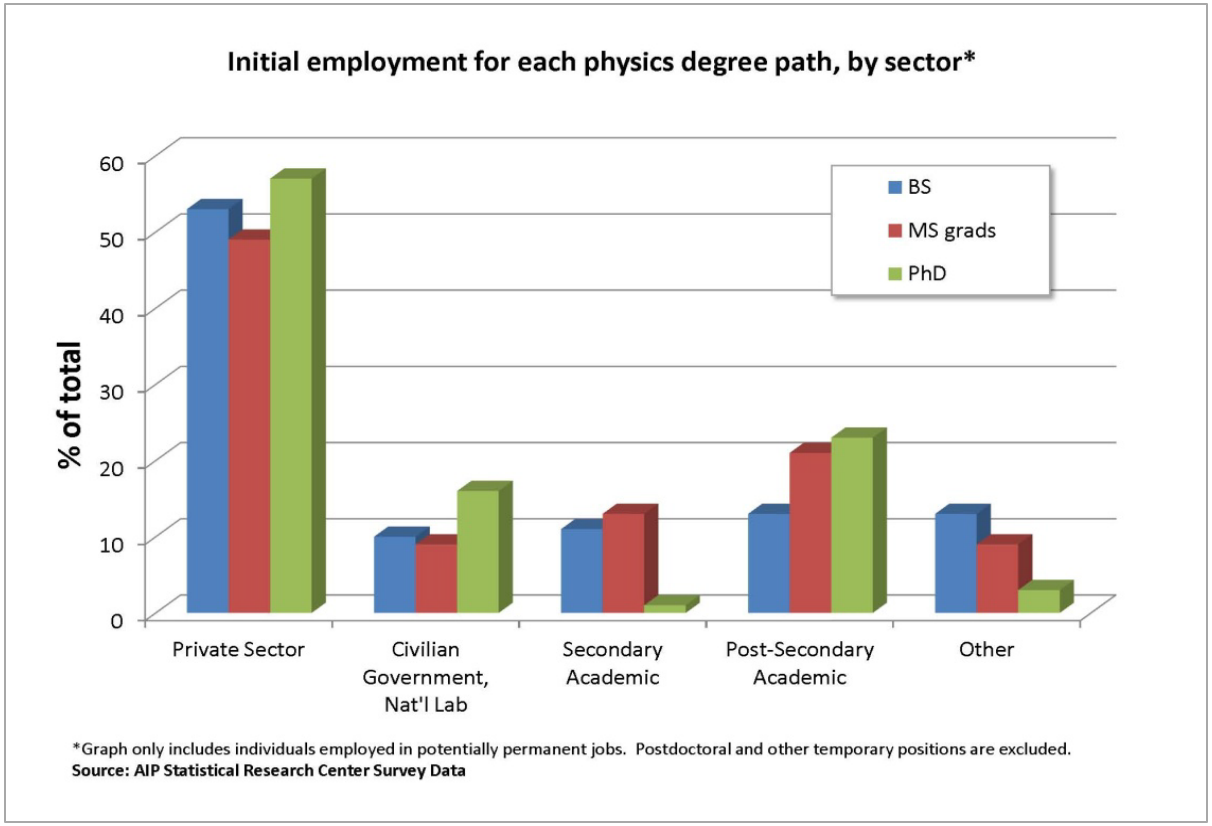
Since….

Most physics students won't become '*physicists*'



…and especially, not *faculty!*

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Physicists can do (nearly) anything!!

but

Succeed *despite* preparation, not *because* of it

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There are BAD Ways to Get Career Skills

CONGRATULATIONS!

Chateau Montelena
Cabernet Sauvignon

≠

Even as Academics, What has been Your Experience?

- What skills and knowledge do you wish you had *before* you started your professional career?
  - Aren't those skills universal… applicable to any career?
- What was it like to learn 'on the job'?
- Is the school of 'hard knocks' the best way to prepare for a career?
- Are there opportunities that may have passed you by?

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The Case to be Made: Two Necessary Elements

Career Development

Give everyone the skills/knowledge/attitudes needed for success

Opportunity Recognition

Leverage *all* of the steps in physics research to create/improve products and services

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Have you read the newspaper lately?

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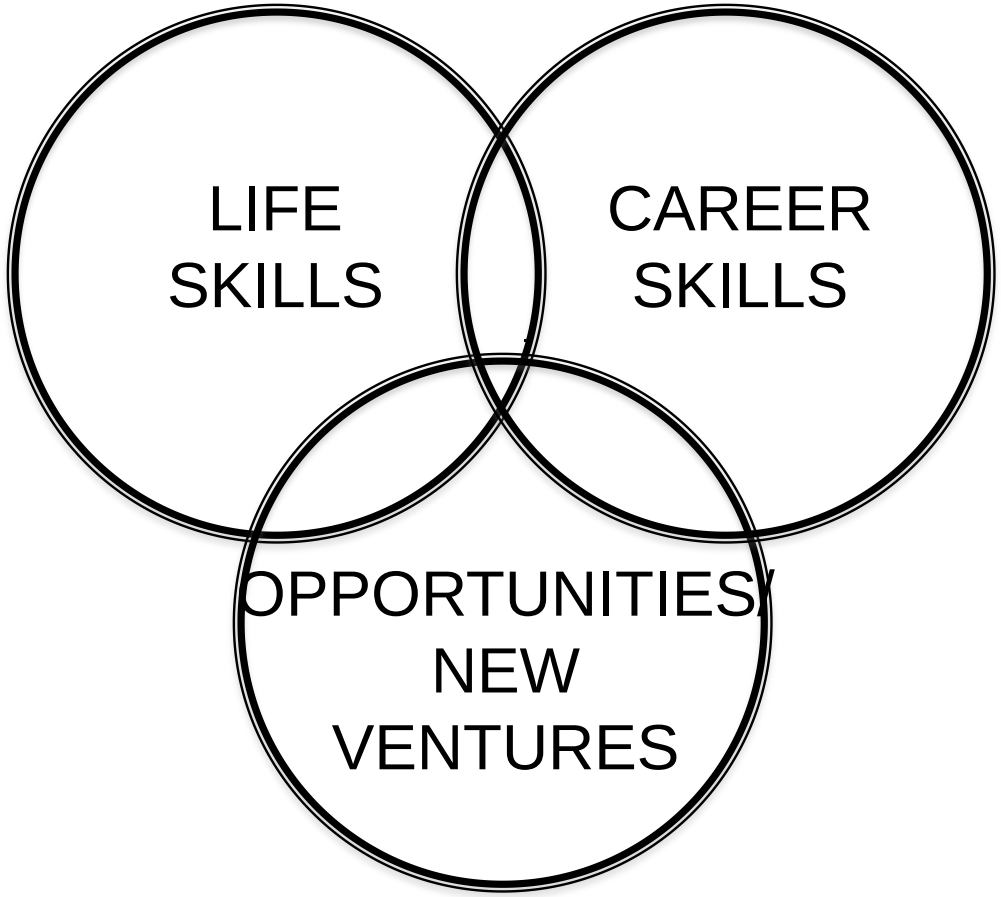
Entrepreneurship and Innovation Education: The Niche it Fills



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Academic

ENTREPRENEURIAL

Non-Profit

For Profit

INTRAPRENEURIAL

NGO

Government

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What is Available for the 'General' Population?

- 'Bridge' Programs
  - Tuck Business Bridge Program (Dartmouth)
  - MiddCORE Program at Middlebury College
  - Various summer 'Entrepreneurial' Workshops
- MBA Programs
  - Entrepreneurship concentrations are now common
  - Technical content added to MBAs
    - Example: *Lab to Market* program at Univ. of Maryland
- Business Majors and Minors
  - What some parents see as the 'right answer'

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Where is Technical Entrepreneurship Happening Now?

- Primarily in *Engineering Programs*
  - Freshman and Senior Design courses now typically include entrepreneurship
  - Career skills built into ABET standards
- Joint programs between Engineering schools and Business schools
  - Typically organized on ‘large’ campuses
  - Often integrated into graduate programs
- Supporting organizations: ASEE and VentureWell/NCIIA (More on this later…)

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For *Physicists*, What is Being Done?

- Undergraduate entrepreneurship programs
  - Carthage *ScienceWorks* program
  - UC-Denver innovation program (Randall Tagg)
- Professional Science Master's Degrees (PSM)
  - Case Western Reserve University started the paradigm
  - Masters degree combining Physics and Business
    - Business plan thesis
  - 14 Programs around the US

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What we're NOT asking for:

Not asking to change the physics you teach

Not asking physics to give up basic research

What we ARE asking for:

Provide professional development and innovatio
education to students

Expand research efforts to promote
commercialization

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One Example: *ScienceWorks* at Carthage and A Little History

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ScienceWorks Entrepreneurial Studies Program Layout

Junior Courses → **Supporting Coursework**

ESNS 310/320:
Core Business Content and Skills
[Total: 8 Credit Hours]

Accounting/Finance/Marketing
Ethics
GIS
Public Speakin
ESNS 325 (J-Term)
Commercial Technolog
g

Senior-Level Business Plan Courses

ESNS 410/430
Full-fledged Business Plan
- New Product
- New Business/Spinoff
- SBIR/IR&D Proposal

Defended before Advisory Board of Experts
[Total 8 Credit Hours]

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A Wide Breadth of Topics

- Goals and Plans
- Technology/Innovation
- Writing/Correspondence
- Entrepreneurs/characteristics
- Marketing Principals
- Product Lifecycle
- Project Management
- Financial Needs
- Marketing and Sales
- Business Intelligence
- Speaking/Presentations
- Listening
- Information Systems
- Web Design/Social Media
- Economics
- Budgeting: Personal and Business
- Business Plans
- Stocks and Bonds
- Investing/Retirement
- Resumes and Interviewing
- Creativity and Ideation
- Business Models
- Incorporation and Business Organization
- Management and Team Skills
- Intellectual Property
- Accounting and Financial Management
- International Business and Cultures
- Legal and Regulatory
- Geographic Information Systems
- Finance and Funding
- Taxes
- Bankruptcy
- Ethics
- Bid and Proposal
- Contracts/Subcontracts/Purchasing
- Insurance/Risk Reduction

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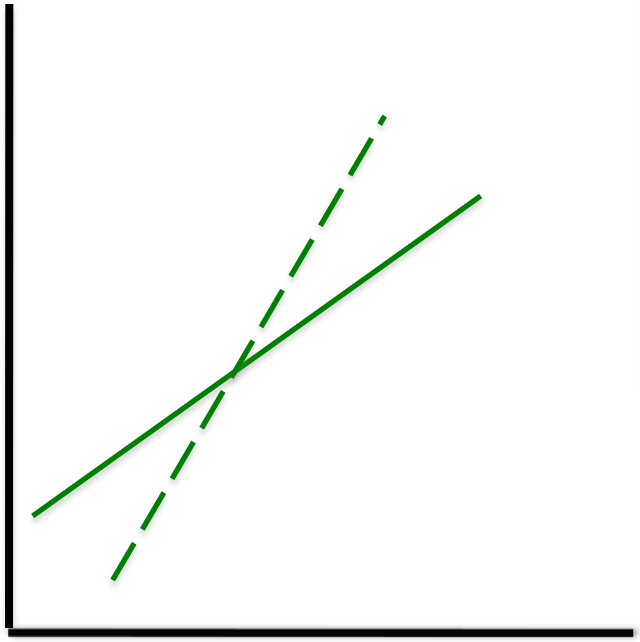
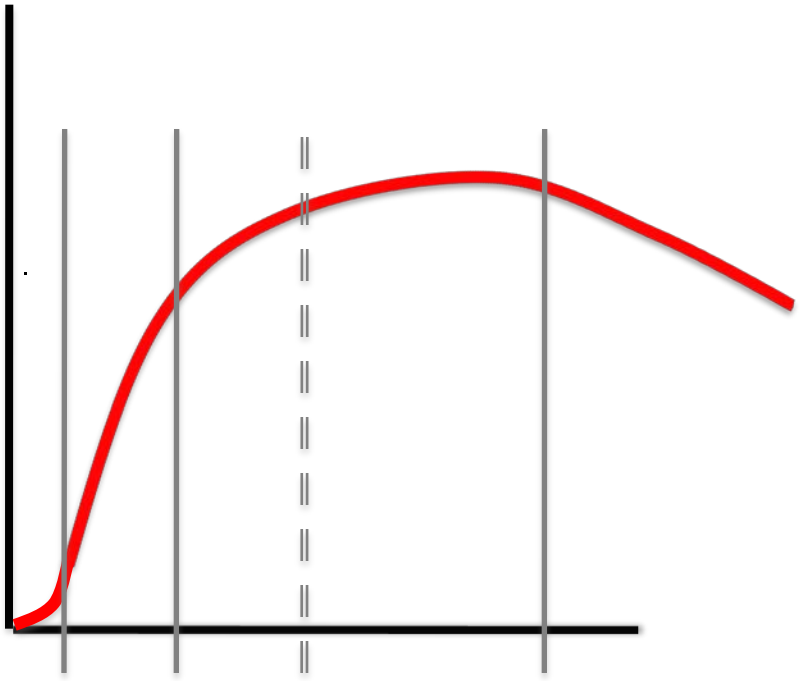
Some Really Cool Stuff

- Product Lifecycle Theory
- Pricing Strategy





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Does our Program Work?

- *ScienceWorks* has helped Carthage science students succeed
  - Jason Benes: $1.1M Royalties from Nike
  - Matija Maretic: Marvelsoft - Paris, London, Zurich – Million dollar deals
  - Liz Zona: Abbott Labs
  - Brian Jones: Medical administration executive
  - Chris Duffy: Epic Systems
  - Melissa Lowe: Ortho McNeill
  - Keith Kobelt: Marsh and McClennan finance
  - Charlie Staniger: Walgreen's management

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Assessment Results

- Carthage *ScienceWorks* graduates are the most successful produced by the college
- More rapidly hired
- More rapid promoted
- More accepted into graduate schools
- More highly rated by employers and advisers

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This seems intimidating, but….

You can do this!

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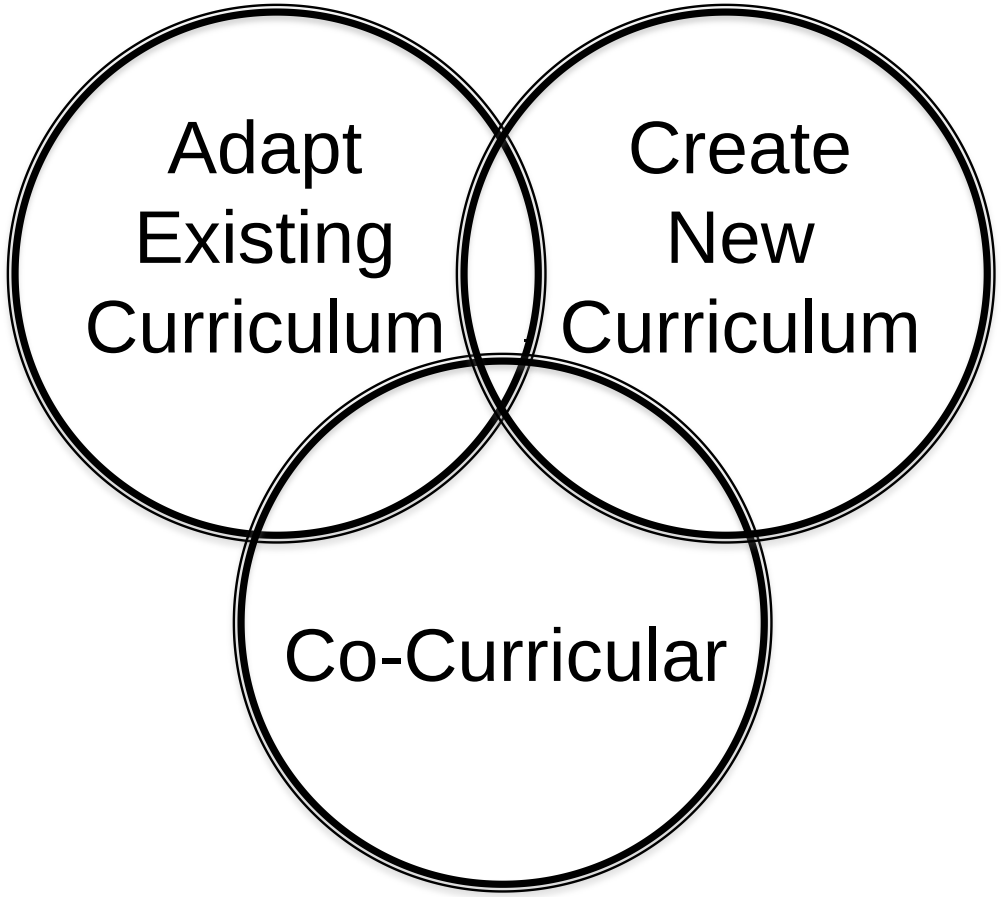
Implementation Methods



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New Curriculum/Shared Curriculum

- Expand elective offerings
  - Speaking, business, ethics, writing
  - Topical courses in other disciplines
- Career Services offerings
- Team-taught courses
  - Advanced lab course with business input
- Dedicated courses on entrepreneurship (minor?)
- Online Homework/Experiences
  - TED.com

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Building the Staffing Skill Set

- Hire 'Professors of Practice'
  - Started by UT-Austin as a staffing model
- Take advantage of National Collegiate Inventors and Innovators Alliance meetings and resources/publications
  - Large body of information, curriculum, documentation, roadmaps, etc., already available
  - A great community looking to work together
- Revise sabbatical standards
  - Industrial positions vs. traditional research positions

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Career Building Events

- Networking events
  - Alumni speakers, breakfast/lunch
  - Board of Trustee Members
    - Build constituency while getting input
  - Industry advisory board
    - Create your own!
- Site Visits/Field Exercises
  - Local/regional industries

Class Projects/Senior Thesis: Commercially-inspired Projects

- Examples:
  - Applied Laboratory Technology:
    - Gas sniffers to check for leaks in meat casing
  - Research Projects
    - Historical background of technology development
    - Reverse-engineer a product (e.g., a drill)
    - Develop product improvements

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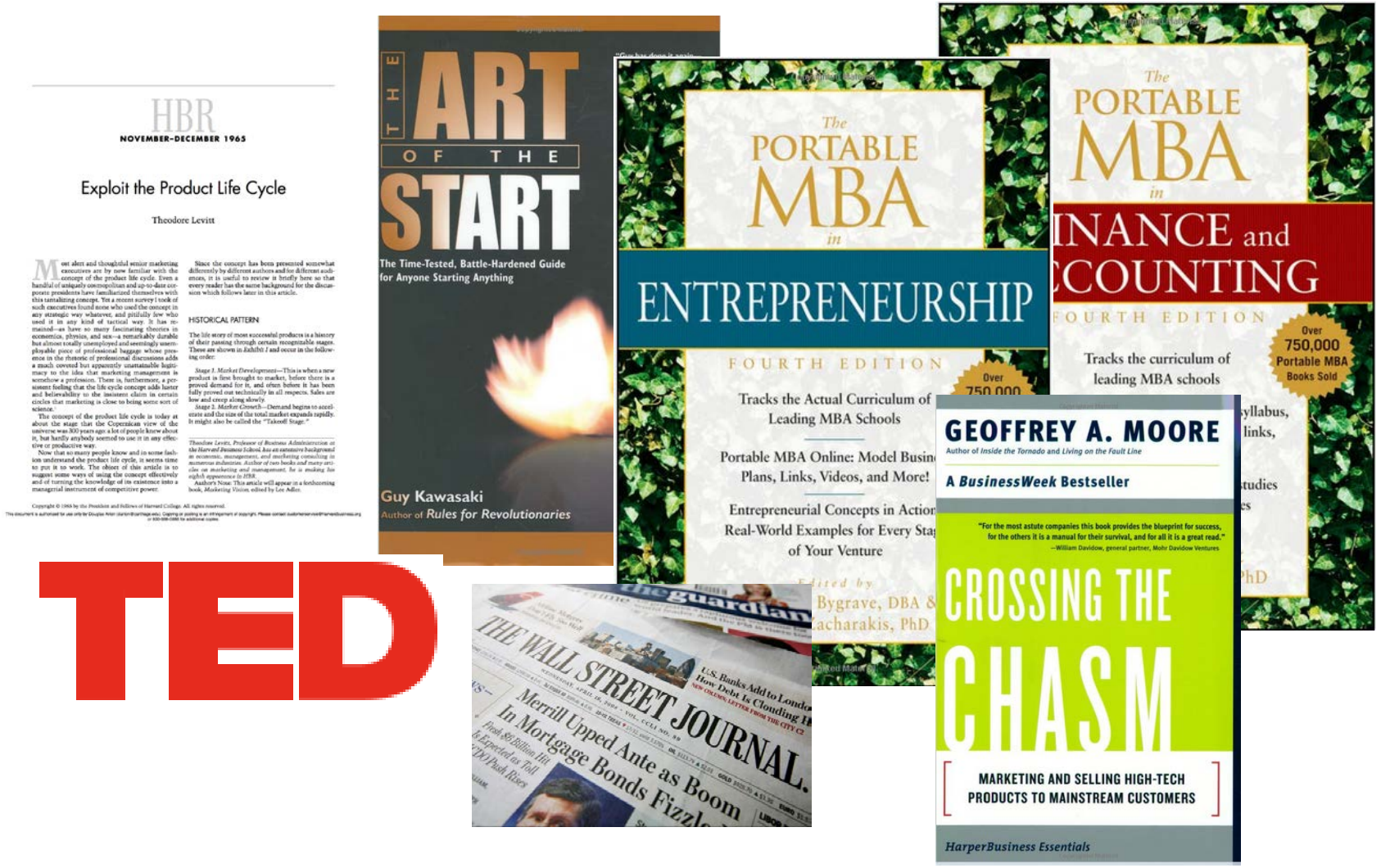
Sources and Materials



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Innovation from Physics Research

Innovation vs. Invention vs. ‘Research’

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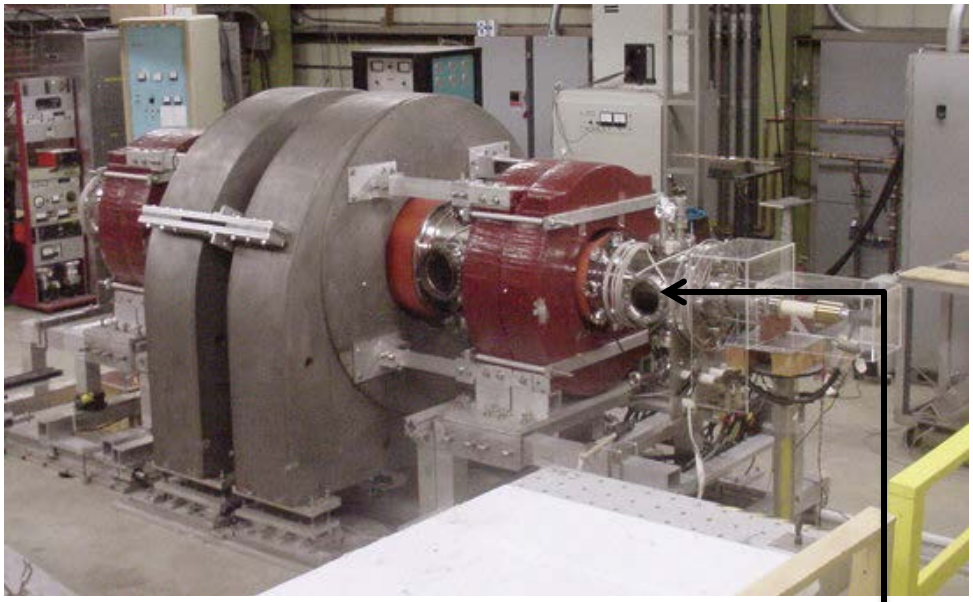
Where do ideas come from?



- Every step in the research process could result in innovation
- Research has an *end goal* in mind
  - But the innovation may be an *intermediary step*
- Utilize *Ideation Theory* to identify opportunities

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What Needs to Happen? A Shift in Mindset

- How could my research have *commercial value?*
  - *Directly or Indirectly?*
- Can I recognize *opportunities?*
- Can I answer '*Who needs it*?'
- Do I document/record to allow me to *protect my ideas*?
- Can I develop *partnerships* and *linkages* to bring products and processes to market?

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What Can Be Done?

- Step One: Implement *innovation and Creativity* as an attitude
  - In research
  - In teaching and education (Examples to follow…)
- Step Two: Look at every step in the process as an opportunity to develop viable products or services
  - Take appropriate IP precautions
- Step Three: Seek out expertise!
  - Community of entrepreneurial faculty and organizations
- Step Four: Promote student creativity at all levels
  - Young creativity is *Powerful*
- Finance, inventory control, order tracking - it's all just *data!*

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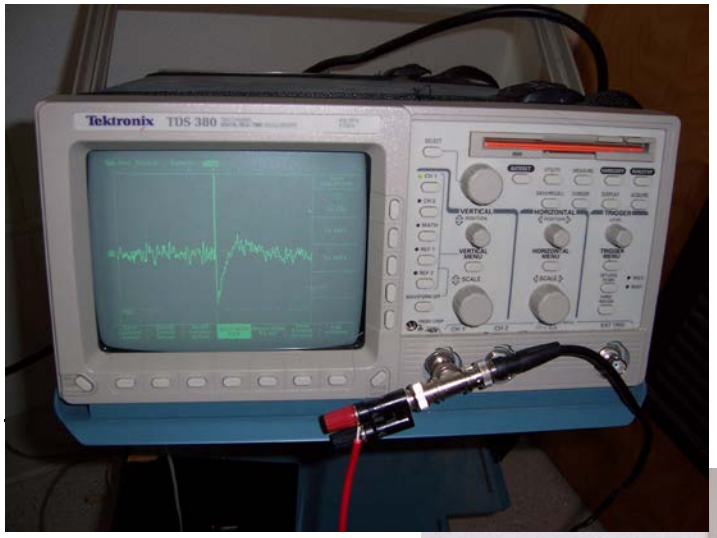
Experiential/Co-Curricular

- Internships/Co-Ops
- Site Visits
- Cross-disciplinary projects
  - Talk to unrelated researchers
    - Not necessarily in the *sciences*
  - Example: Fiber optic neuroprobe



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Genisys

- Leverage patented technology for injector
- Senior student business plan for an all-electric compressor system
  - Key concept: AC compressor for hybrid/electric vehicles
- Worked with auto manufacturers
- Key product line for new company

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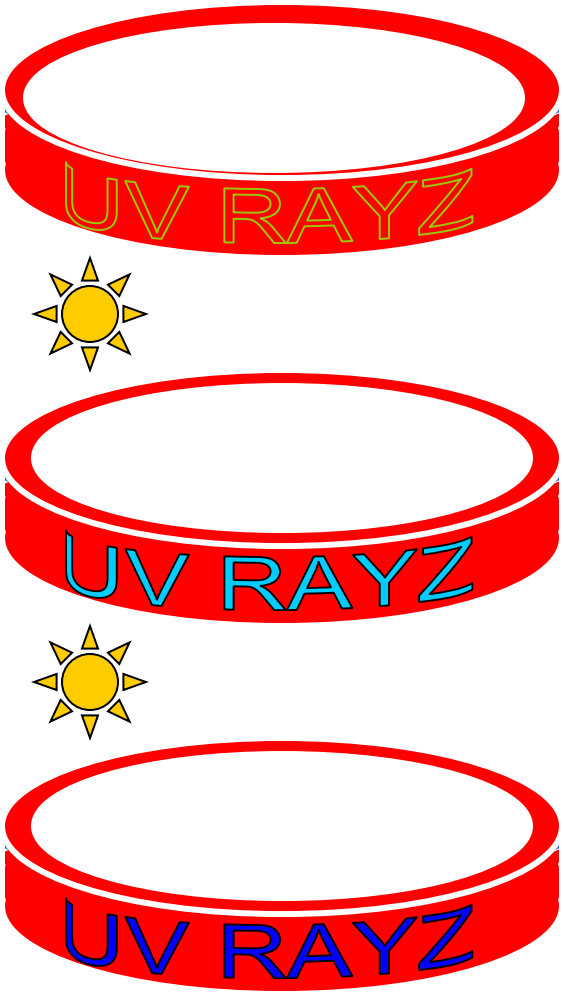
UVRayz Sun Sensing Bracelet



- Ideate patent from International Specialty Products for UV-sensitive color changing compound
- Idea: Sun Sensing Bracelet based on the ‘affinity bracelet’ model
  - Medically viable product with a significant promotional element:
    - Hotels, theme parks, sports, cruises, etc.
- Links molding, printing, distribution companies

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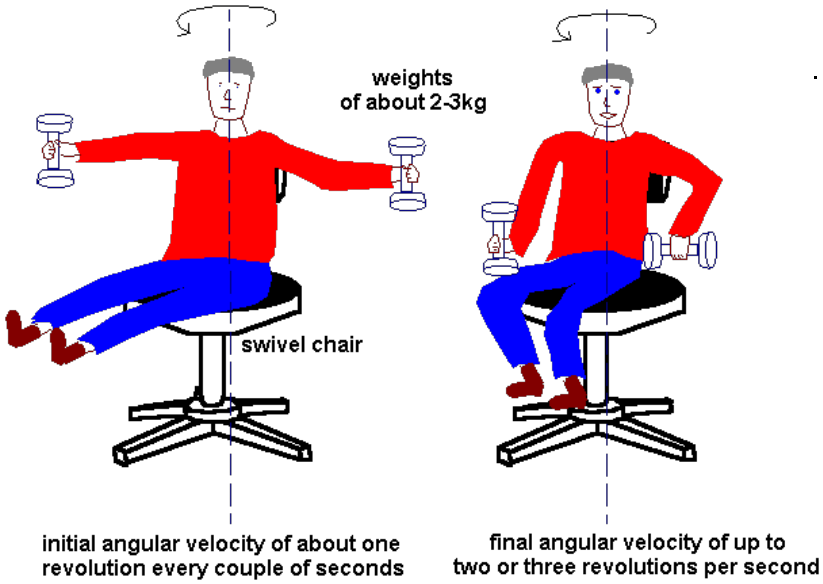
Innovation and Commercialization in Intro Labs

- Example: Angular Momentum Lab



Reaction Wheels: Steering Spacecraft

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‘Modern Physics’: Absorption and Diffraction

- Applications: Medical imaging, Security screening, crystallography
- Use 3D Model (high-Z) and lab radiation sources to simulate Computed Tomography
  - Use multiple energies to explore Photoelectric and Compton regimes
  - Create a ‘contest’ – Who can best guess what’s inside the box?
- Microwave diffraction
  - Hidden object in styrofoam container
  - Rescale to X-rays

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In a ‘Canon’ Course

- E&M: Inductance calculation
- What is the real impedance of a lightning arrestor?
- What potential exists between the building and ground?
- Architecture applications

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Implications for the Academy

- Changes needed in goals/outcomes/assessments
  - What is the right set of assessable outcomes for students and faculty?
  - Do 'traditional' curricular structures achieve these goals?
  - Do 'traditional' delivery methods work in this environment?
- A shift in the traditional research process
  - Grant supported research with other than 'predictable' outcomes
- Changes in academic IP policies
  - Technology Transfer offices can be a help or hindrance

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Ancillary Benefits

- Recruiting!!
  - Prospective students are more interested in physics *if* career preparation included
  - PARENTS are particularly positive
- Alumni engagement
  - More successful alumni reflect back and contribute to department success
- Competition
  - Physics viewed as a career path – like (or even better) than engineering

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I&E Resources

- United States Association of Small Business and Entrepreneurship (USASBE)
- American Society of Engineering Education (ASEE)
- Collegiate Entrepreneurs Organization (CEO)
- Foundations: Coleman, Kauffman

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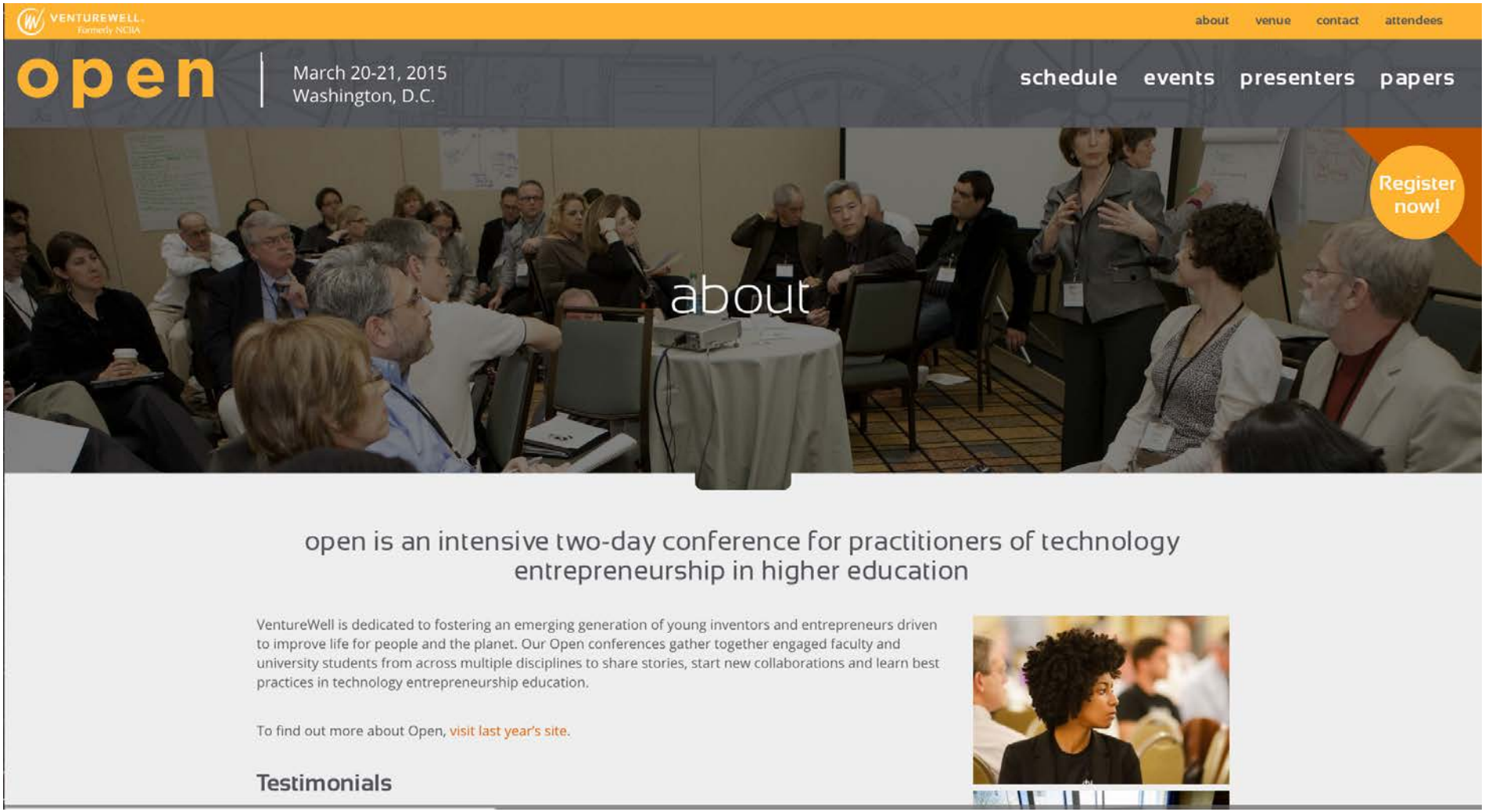
VentureWell/National Collegiate Inventors and Innovators Alliance

www.venturewell.org

Conferences, Resources, Grants



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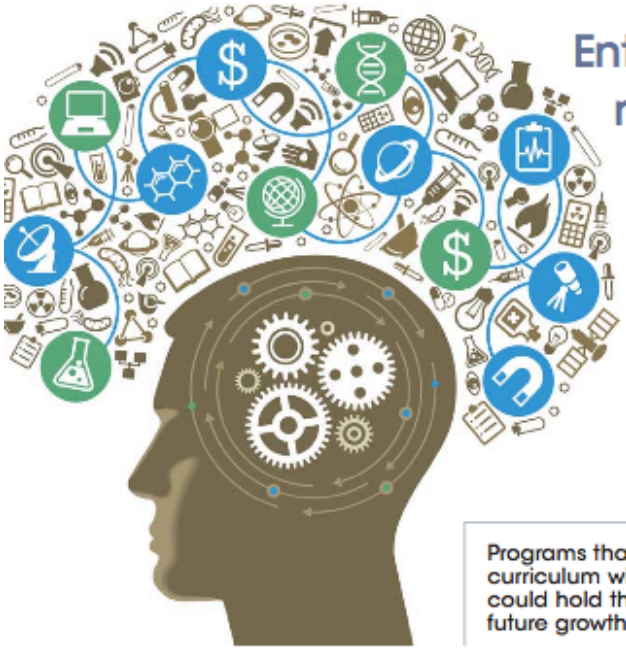
Things your adviser never told you:

Entrepreneurship's role in physics education

Douglas N. Arion



Programs that augment the core physics curriculum with real-world business skills could hold the key to the discipline's future growth.

Somehow or other, we got hooked on physics—hooked enough to study it and to be readers of PHYSICS TODAY. Many of us became physicists and now practice the discipline either directly or indirectly in our chosen careers. Some of those careers involve the traditional academic positions of faculty or research staff, others are in industry or government, and still others are in fields less directly tied to physics, but in which physics education and training are extremely valuable nonetheless. All those career outcomes have something in common: None of us received formal academic preparation for them. Doing physics and working as a physicist are not one and the same.

We who are physics professors often recruit students by telling them that the discipline is great preparation for virtually any career—and we genuinely believe that to be true. The traditional physics education, however, is designed for creating faculty, even though most students will never find a permanent academic position.

Consider that in 2011 approximately 6000 bachelor's degrees and 1600 PhDs were conferred in physics, yet only 400–500 faculty positions are filled annually, and most of those are part-time or short-term positions. The funnel effect is apparent: In 2010 just 37% of bachelor's degree recipients went on to graduate school in physics or astronomy and 32% of recipients reported that their ultimate goal was to end up on the faculty at a college or university; in all likelihood, only about 10% will actually become professors.[1]

Where do the rest go? Figure 1 shows the employment-sector breakdown of professionals reporting a physics background. Most work in the private sector, with many applying their physics ed-

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The Train is Leaving the Station

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Thank you

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Specifics

- Uvic: IDEAFEST, Medical, Materials/Condensed Matter
- UBC: PER program, “APPLIED” physics program
- SFU: Optical, Materials, Biophysics