Physics at the Community College

Thomas O'Kuma
Physics
Lee College

- Thank You to
- Forum on Education

- Thank You also to my
- Colleagues, particularly Curt Hieggelke and David Maloney
- Family, particularly my wife Kathy

Outline

- Community Colleges
  - Community Colleges in General
  - Physics Programs at Community College
  - Data on Physics at Community Colleges
- Microcomputer – Based Laboratory (MBL)
  - TYC Workshop Project
  - Developments
- Conceptual Survey of Electricity and Magnetism (CSEM)
  - Development
  - Some Results

Community College – What are They?

- Junior Colleges – academic transfer
  - first two years of a baccalaureate degree
  - Associate Degree – two year degree
- Technical Colleges – preparation for workforce
  - Certificate – one year degree
  - Associate Degree – two year degree
- Community Colleges – multi-purpose
  - Academic transfer
  - Workforce preparation
  - Continuing Education

Community College – Quick Facts*

- Number and Type - 1,177 Community Colleges
  - 988 Public; 158 Independent; 31 Tribal
- Enrollment
  - 11.7 million students; 6.7 million credit; 5 million noncredit
  - Full time – 40%; Part time – 60%
- Demographics
  - Average Age – 29;   21 or younger – 47%
  - Women – 58%;   Men – 42%
  - Minorities – 36%
  - First Generation to Attend College – 39%

*http://www.aacc.nche.edu/AboutCC/Pages/fastfacts.aspx

Community College – Quick Facts* II

- Community College students constitute the following percentages of undergraduates:
  - First-time freshman – 40%
  - Native Americans – 52%; Black – 43%
  - Asian/Pacific Islanders – 45%; Hispanic – 52%
- Employment Status
  - Full-time students employed full time – 27%
  - Full-time students employed part time – 50%
  - Part-time students employed full time – 50%
  - Part-time students employed part time – 33%
- *http://www.aacc.nche.edu/AboutCC/Pages/fastfacts.aspx

Community College – Quick Facts* III

- Average Annual Tuition and Fees
  - Community Colleges (public) - $2,402
  - 4-Year Colleges (public) - $6,585
- 59% of new nurses and the majority of other new health-care workers are educated at community colleges
- Close to 100,000 international students attend community colleges – about 39% of all international students in the United States.
- Degrees and Certificates Awarded Annually
  - Associates Degree – 612,915
  - Certificates – 328,268
- *http://www.aacc.nche.edu/AboutCC/Pages/fastfacts.aspx

Physics Programs at Community Colleges

- Topical Conference on Critical Issues in Two-Year College Physics and Astronomy, Washington D.C., November 1989*
- Critical Issues Identified
  - 1. the feeling of isolation experienced by many TYC physics faculty;
  - 2. the need to network with other TYC faculty;
  - 3. a need to remain current in pedagogical approaches to teaching physics;
  - 4. a need to know how many students take physics at two-year colleges; and
  - 5. what encompasses a physics program at TYCs.

*see *Proceedings of the Topical Conference on Critical Issues in Two-Year College Physics and Astronomy*, AAPT, 1991.

Physics Programs at Community Colleges
Some Initiatives Following the Conference

- TYC21 Project (1993-2000) - addressed Critical Issues 1 & 2 directly
- NSF Funded Projects - addressed Critical Issue 3 directly
  - TYC Workshop Project (1991-2006+)
  - PEPTYC Projects (1991-2005)
  - Others – ICP21, …
- AIP Survey of TYC Physics – addressed Critical Issue 4 directly
- SPIN-UP/TYC Project (2002-2004) – addressed Critical Issue 5 directly

TYC21 - Two-Year Colleges in the Twenty-First Century: Breaking Down Barriers

- Principal Investigators
  - Mary Beth Monroe, Southwest Texas Junior College
  - Marvin Nelson, Green River Community College
- National Advisory Committee
- 15 Regional Networks around the country - conducted 90+ regional meetings over a 3+ period of time
- 3 (+3) National Meetings
  - 1994 - University of Notre Dame
  - 1995 - Post Falls, Idaho
  - 1996 - National Meeting 1 - University of Maryland
  - 1997 - National Meeting 2 - University of Denver
  - 1998 - National Meeting 3 - Arbor Day Farm, Nebraska
  - 1999 - American Airlines Center, Ft. Worth
- Funded by NSF & AAPT

TYC21 II
What was Learned?

- Networking
  - How to establish a network of TYC faculty
  - How to sustain the network
- Isolation
  - Most TYC physics faculty are isolated
  - How to "combat" isolation
- Critical Issues

See *A Model for Reform - Two-Year Colleges in the Twenty-First Century: Breaking Down Barriers*, AAPT, 2000.

TYC Workshop Project (1991 - 2006+)

- Professional Development Workshops designed for TYC physics faculty (in 2001 expanded to include HS physics faculty)
- Principal Investigators
  - Curtis Hieggelke, Joliet Junior College (IL)
  - Thomas O'Kuma, Lee College (TX)
- Funded by NSF through a number of programs, JJC, and LC
- Curtis Hieggelke will discuss this program in the next talk

PEPTYC Project
(1991 – 2005)

- Professional development program designed to provide modern physics experience and pedagogical experience
  - 2 week May Institute
  - 2 academic year follow-ups at TS AAPT/APS/SPS meetings
- Principal Investigators
  - Robert Beck Clark, Texas A&M University
  - Thomas O’Kuma, Lee College
- Funded by NSF, TAMU & LC

Strategic Programs for Innovations iN Undergraduate Physics at Two-Year Colleges

- Principal Investigators
  - Thomas O'Kuma, Lee College
  - Mary Beth Monroe, Southwest Texas Junior College
  - Warren Hein, AAPT
- National Advisory Committee
- Training and Planning Conference, July 25-27, 2002 at Trinity University in San Antonio, TX
- Soliciting and Selecting TYCs to be visited
- Conduct 10 Site Visits
- Writing and Planning Conference, June26-29, 2003 at Sinclair Community College in Dayton, OH
- Post Site Visits
- "Next Step" Meeting, January 8, 2005 at AAPT Winter Meeting in Albuquerque, NM
- Funded by NSF, AAPT, LC & SWTJC

SPIN-UP/TYC Sites Selected

- Estrella Mountain Community College - AZ
- Green River Community College - WA
- Howard Community College - MD
- Rose State College - OK
- Mt. San Antonio College - CA
- Amarillo College - TX
- Delta College - MI
- Gainesville College - GA
- Lord Fairfax Community College - VA
- Miami-Dade College - Wolfson Campus – FL
- *Florence-Darlington Technical College – SC
- *Wake Technical Community College – NC
- *Prince George’s Community College - MD

Common Features of an "Outstanding Two Year College Physics Program"*

- Dedicated Physics Faculty
- A Real and Sincere Interest in Students
- Collegial Relationship with Other Faculty
- Good Working Relationship with Administration

**Strategic Programs for Innovations in Undergraduate Physics at Two-Year Colleges: Best Practices of Physics Programs"*, by Mary Beth Monroe, Thomas O'Kuma, and Warren Hein, AAPT, 2005.

AIP Survey of TYC Physics

- First ever comprehensive study of physics activities at Two-Year Colleges nationwide
- Done in 1996 with publication in 1998*
- A second, less comprehensive survey done in 2001-2002 with publication in 2003#

*_Physics in the Two-Year College_, by Michael Neuschatz, Geneva Blake, Julie Friesner, and Mark McFarling, AIP R-425, October 1998.

#_Physics in the Two-Year College: 2001_-02, by Mark McFarling and Michael Neuschatz, AIP R-436, June 2003.

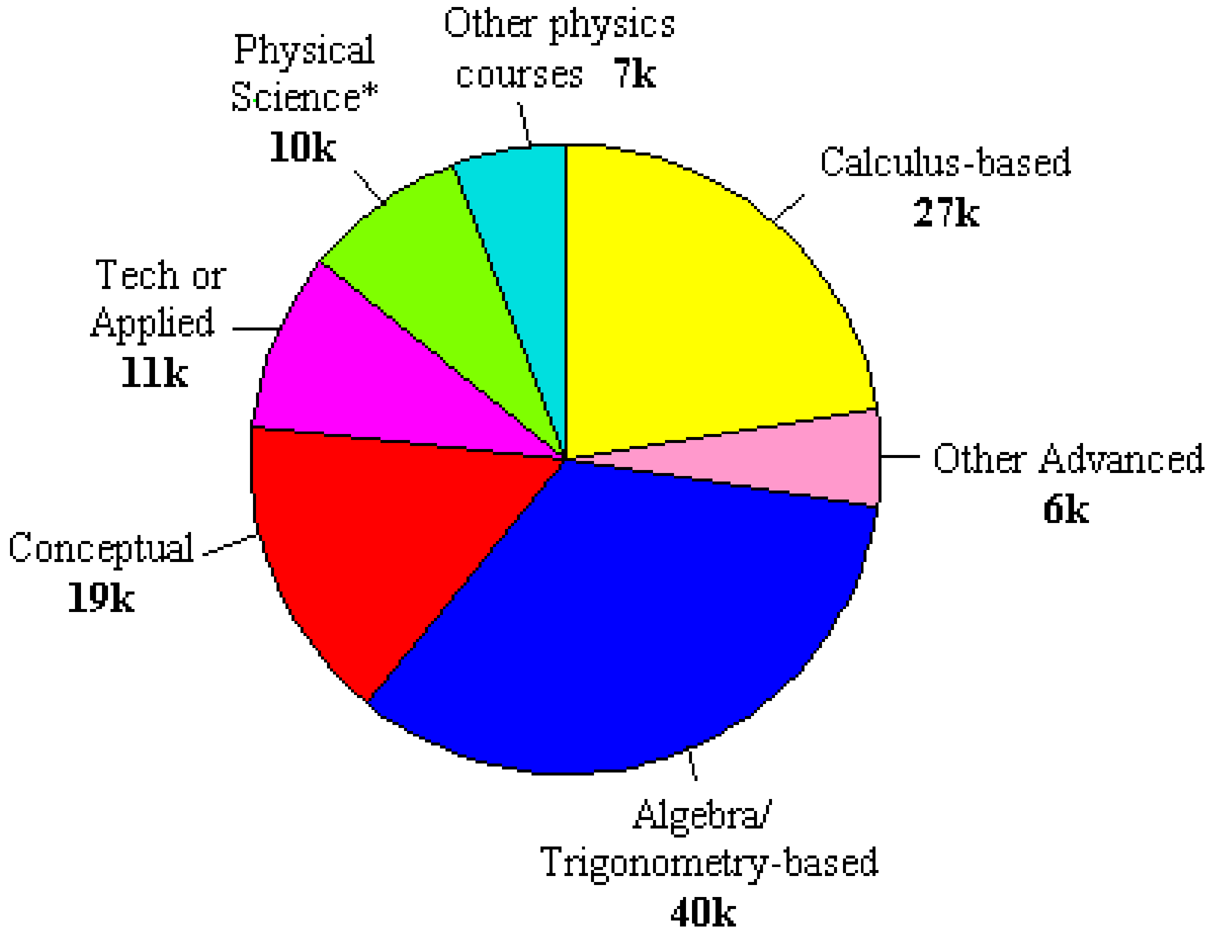
AIP Survey
A Snapshot

- 120,000 students take physics per year at TYCs ~ 25% of all who take introductory physics
- 60% of TYCs who teach physics have 1 or less full-time physics faculty members

- 31% of students taking physics at TYCs are female
- 15% of students taking physics at TYCs are minorities
- 14% of TYC physics faculty are women
- 4% of TYC physics faculty are minorities

- 2,560 faculty – 1638 full-time; 922 part-time
- Curricular changes are implemented reasonably easy

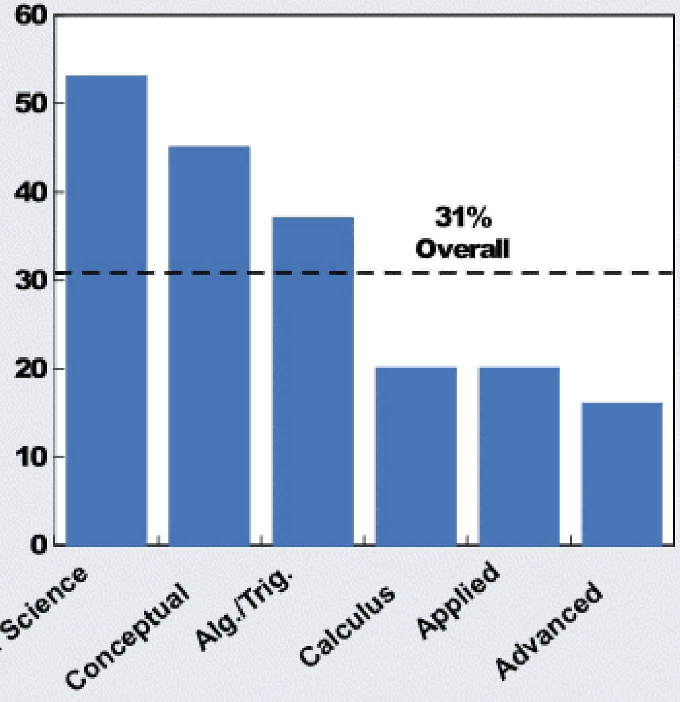
Physics at the Two Year College - 1997



* With at least half the course content in physics

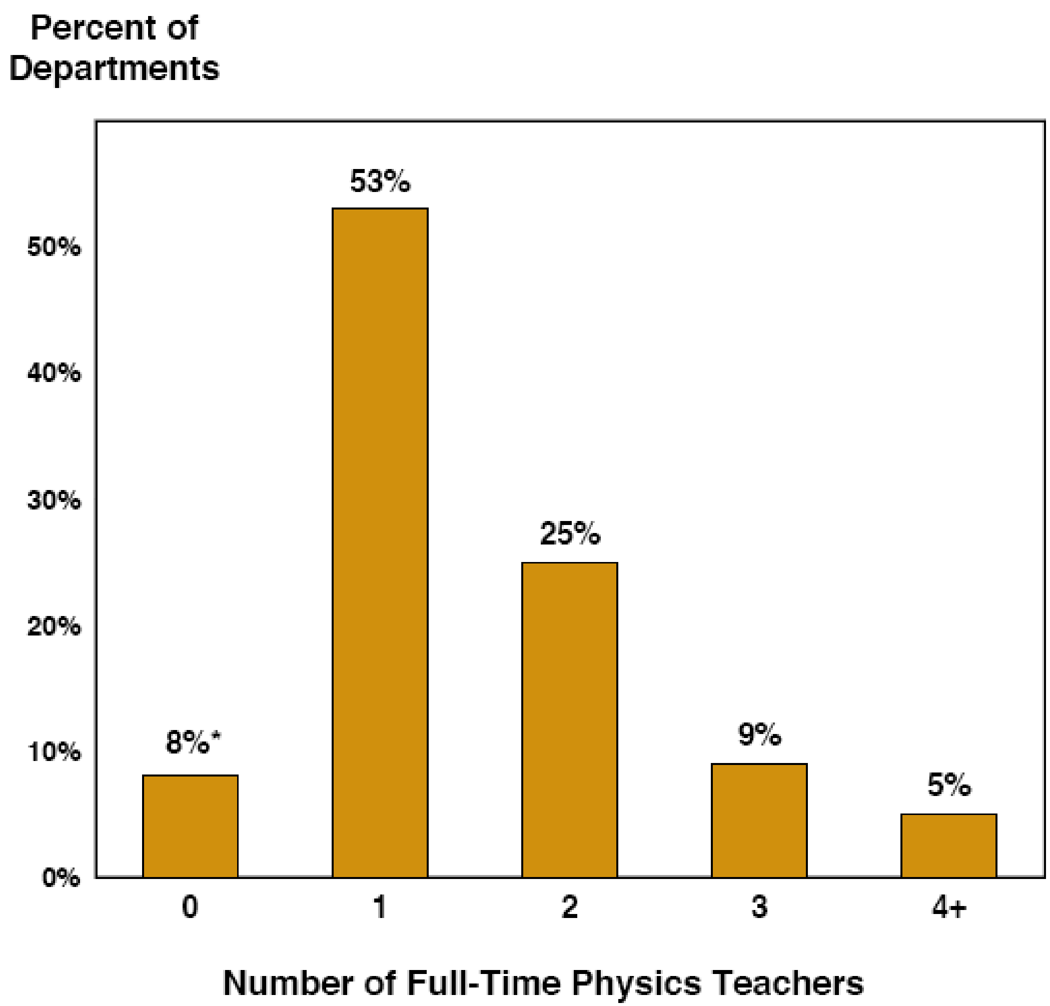
Women Taking TYC Physics

Figure 2. Percent of Two Year College Physics Students Who Are Women, Overall and by Course, 1996



Source: Neuschatz et al., *Physics in the Two Year Colleges*, AIP.

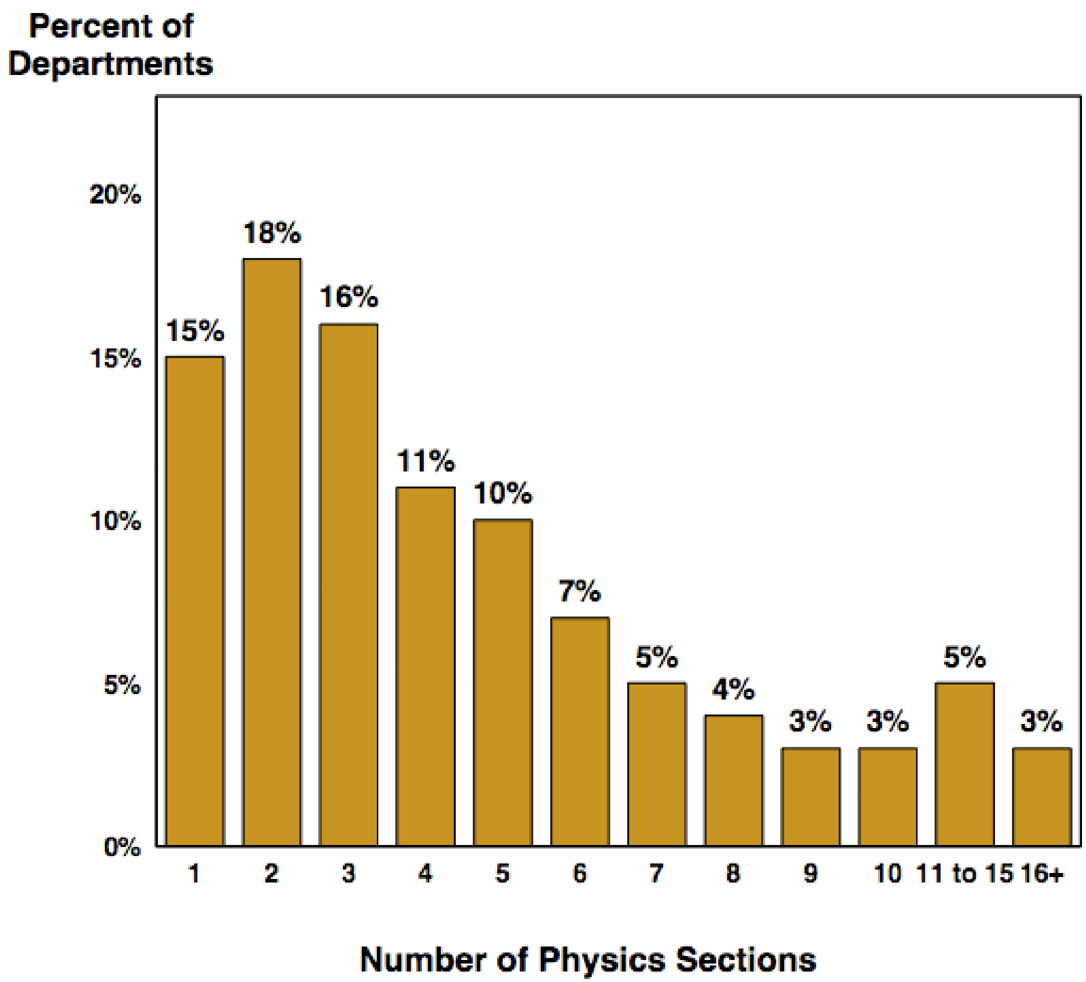
Figure 1. Number of Full-Time Physics Teachers in Departments



*These departments have only part-time physics faculty.

AIP Statistical Research Center 2002 Survey of Two-Year College Physics Programs

Number of Physics Sections Offered by Departments in Fall 2001 Term



AIP Statistical Research Center 2002 Survey of Two-Year College Physics Programs

Table 1. Types of Physics Courses Offered by Departments

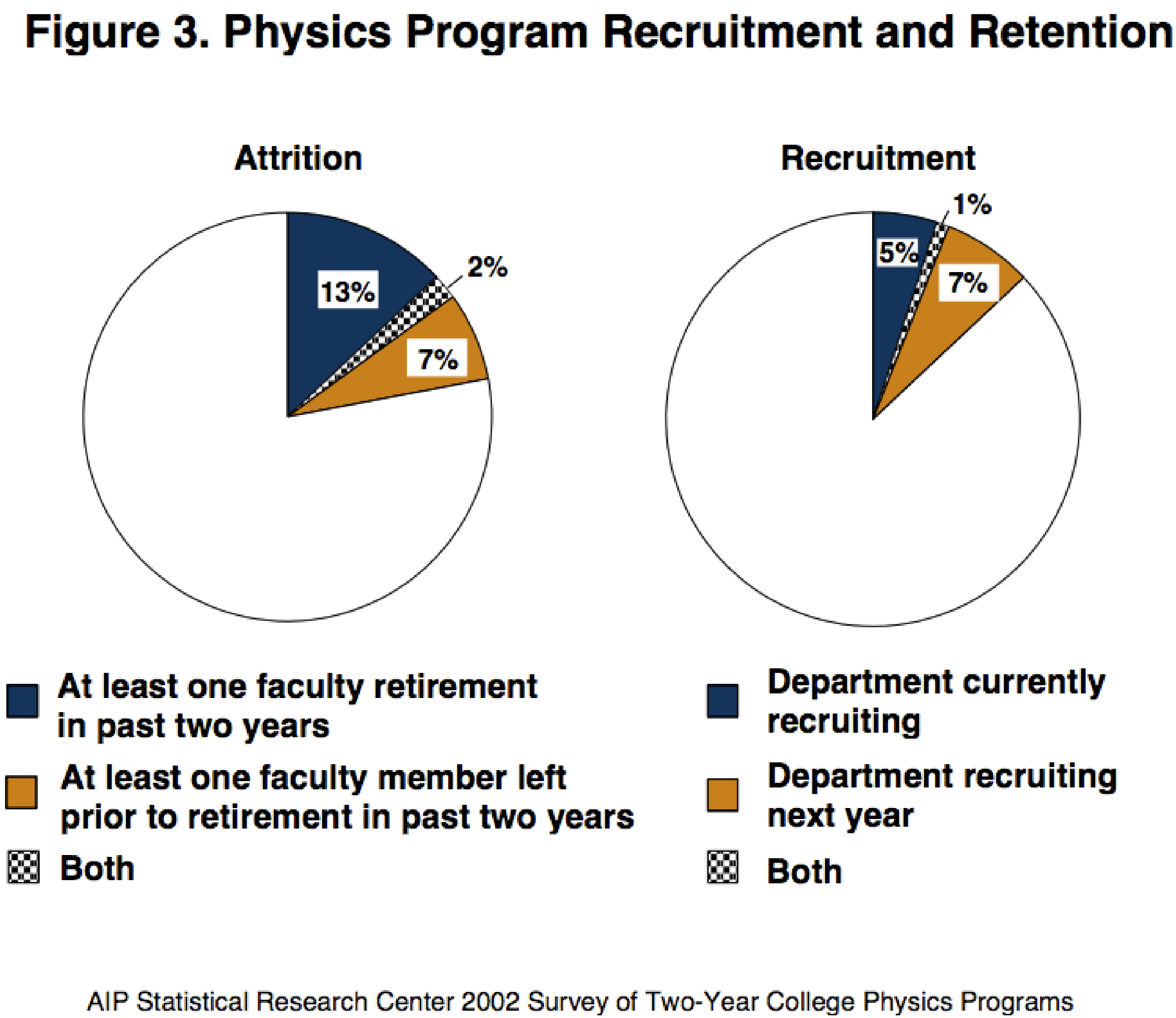
Course Name	Campuses Offering This Course	% of All Physics Sections Offered
Algebra/Trigonometry	84%	35
Calculus-Based Physics	72	30
Conceptual Physics	30	11
Applied Physics/Technical Physics	21	8
Other Physical Science (at least half physics)	15	7
Physics or Physical Science for Education Majors	13	5
Other Physics	10	3

AIP Statistical Research Center 2002 Survey of Two-Year College Physics Programs

Table 2. Types of Physics Courses Offered by Size of Physics Department

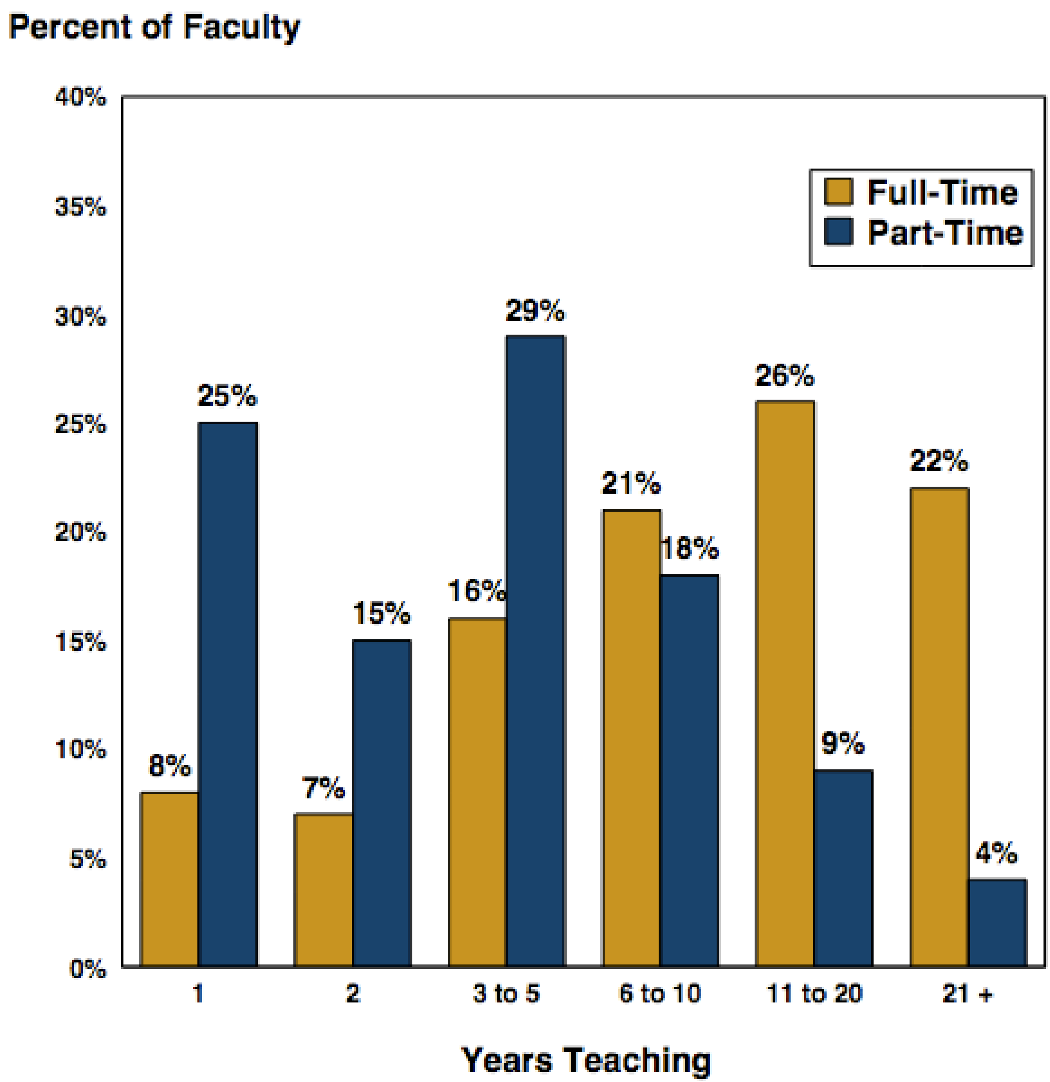
Course Name	Campuses Offering Fewer Than 6 Physics Sections (70%)	Campuses Offering 6 or More Physics Sections (30%)
Algebra/Trigonometry	79%	96%
Calculus-Based Physics	65	90
Conceptual Physics	23	48
Applied Physics/Technical Physics	17	31
Other Physical Science (at least half physics)	11	26
Physics or Physical Science for Education Majors	10	22
Other Physics	7	17

AIP Statistical Research Center 2002 Survey of Two-Year College Physics Programs



- This means there are ~ 50-100 new or replacement faculty positions every year

Figure 4. Number of Years Teaching at Current School



AIP Statistical Research Center 2002 Survey of Two-Year College Physics Programs

Table 3. Characteristics of Full-Time and Part-Time Physics Faculty

	Full-Time (64%)	Part-Time (36%)
Mean Number of Sections	2.4	1.3
Median Number of Sections	2	1
% with PhD or EdD	39	36
% Tenured/Permanent	79	4
% Tenure-Track	17	1
% Temporary	4	95
Median Years Working at Campus	10	3
Mean Years Working at Campus	12.7	5.9
% Women	15	13

AIP Statistical Research Center 2002 AIP Survey of Two-Year College Physics Programs

TYC Curricular Changes

Table 16. Types of Course Most Frequently Impacted in Curricular Changes

	Sample Schools	"Pool" Schools	Visited Campuses
Responding schools	178	65	9
% of schools indicating a change in at least one course	47%	75%	100%
Of schools that made a change, type of course changed:			
Conceptual	48%	59%	78%
Algebra/Trigonometry-based	75	92	89
Calculus-based	69	86	100
Technical	31	43	44
For K-12 teachers	19	37	89
Other	15	10	11

AIP Statistical Research Center 2003 Project SPIN-UP/TYC

What Kind of Curricular Changes?

Table 17. Most Frequently Indicated Aspect of Change to Curriculum

	Sample Schools	**"Pool" Schools**	**Visited Campuses**
Responding schools	178	65	9
% of schools indicating at least one curricular change	47%	75%	100%
Of schools that made a change, % that:			
Added a course	45%	39%	56%
Removed a course	18	10	0
Changed course content	33	55	56
Changed course pedagogy	51	74	100
Upgraded lab equipment	60	76	89
Revised lab equipment	55	71	78

AIP Statistical Research Center 2003 Project SPIN-UP/TYC

TYC Workshop Project
Microcomputer Based Laboratories

- One of the two “themes” for the TYC Workshop Project – implementing technology into the Physics Program
- Wanted to blend research-based curricular/laboratory ideas and the “new generation” of technology tools
- Wanted to use the developers of MBL curriculum, software and hardware
- Wanted to couple this with TYC implementers

MBL – Decisions Needed in 1990

- Choose a research-based curricular approach
  - Workshop Physics
  - Tools for Scientific Thinking
- This led to the developers that worked with us
  - Priscilla Laws, Dickinson College
  - Ron Thornton, Tufts University
  - David Sokoloff, University of Oregon (later)
- Choose technology
  - Apple computers – starting with Macintosh Classic, LCs, and SEs
  - Software
  - Interface, Sensors, and Equipment

Microcomputer Based Laboratories

- MBL Workshops – starting in 1991
  - Collaboration with Ron Thornton of Tufts University and Priscilla Laws of Dickinson College
  - And later David Sokoloff of the University of Oregon
- Conducted 21 MBL Workshops
  - 3-day "immersion" workshops
  - Hands-on with current equipment, software and curriculum
  - Equipment donation by Vernier Software, Pasco Scientific and as well as many others
- Curtis Hieggelke will elaborate on this more in the next talk

Implementing MBL at JJC and LC

- NSF Instrumentation and Laboratory Improvement (ILI) Grants for JJC and LC
  - JJC: 1991 – 1993 and 1997 – 2000
  - LC: 1992 - 1994
- NSF Leadership in Laboratory Development (LLD) Grant – 1993 -1996
- Internal Grants – LC – 1995, 1998, 2002, 2005, 2008

Development of MBL Tools

- Started refining existing activities in motion, force, and heat – student data (1992) Comparison.Both.1.docx
- New Column "feature" – 1993
  - Momentum and Impulse – student data (1993) Elastic.Graph.docx
  - Work & Energy – student data (1993) Work-Energy.Graph1.docx
  - Spring 1993 CaFD article "New Features in Mac MBL 4.0 Software" by Curtis Hieggelke
- Ron and David S.pict

Development of MBL Tools II

- Sound
- Magnetism
  - Development of Activities in 1994-1995
  - MBL Magnetism-Bar Magnet-May 18.docx
  - MBL_Magnetism_OneWire_May2495.docx
- Rotation
  - Development of Activities starting in 1994
  - Torque.docx
- Video
- Other

Implementation of MBL at Other TYCs

- By-product of MBL Workshops
  - Many MBL implemented at TYCs around the country
  - Many NSF proposals to aid in implementing MBL
  - Many presentations at local, state and national meetings

- Proposal writing training and resources for workshop participants

MBL Articles

- Summer 1992 CaFD
  - “A Friction Cart”, Tom O’Kuma, Lee College (TX)
- Spring 1993 CaFD
- “New World, Real World College Physics Education – The Diary of a Revolutionary”, Robert Spears, Firelands College (OH)
- “MBL in Physics and Learning Styles”, J.B. Sharma, Gainesville College (GA)
- Winter 1993/1994 CaFD
- “Real-World, Constructivist Carts for MBL”, Robert Spears, Firelands College (OH)
- “MBL: Ideas that Work”, Umesh Pandey, TVI Community College (NM)
- **“Confessions of an IBM (Mac)Motion User”, Chuck Hollenbeck, Chaffey Community College (CA)**
- **“MBL Update”, Curt Hieggelke, Joliet Junior College (IL)**
- **“Some Uses of MacMotion 4.0/Motion Software in the Mechanics Laboratory”, Tom O’Kuma, Lee College (TX)**

MBL Articles II

- Winter 1994/1995 CaFD
  - "Application of MBL to Undergraduate Research – Nonlinear Oscillation Study", Ting-fang Zheng, Manatee Community College (FL)
- Fall 1995 CaFD
  - "Airbags and Physics", Dwain Desbien, Highlands Community College (KS)
  - "News and Comments about MBL", Curt Hieggelke, Joliet Junior College (IL)
- Summer 2000 CaFD
  - **"VideoPoint Activities for the Conceptual Physics Student", Chuck Stone, Forsyth Technical Community College (NC)**
- Spring 2007
  - **"LabVIEW/LabPro Implementation", Jon Anderson, Centennial Senior High School (MN)**

Conceptual Survey of Electricity and Magnetism (CSEM)

- Primary Developers
- Curtis Hieggelke, Joliet Junior College
- David Maloney, Indiana University - Purdue University, Fort Wayne
- Thomas O’Kuma, Lee College
- Alan Van Heuvelen, Rutgers University (The Ohio State University)

Introduction

- Prior to 1995, assessments available were primarily in mechanics
- In the major topic area of electricity and magnetism, assessments were primarily in circuits
- Need for a survey that would assess students' concepts in electrostatics and magnetism

Development I
Working Conference on Introductory Physics - June 19-24, 1995 at Lee College

- Pre-Conference Preparation
  - Review of known electricity and magnetism assessments by participants and organizers
  - Individuals selected to present information to the Conference about these assessments
  - Review of PER on electricity and magnetism topics
- E & M Concept Inventory - developed by David Maloney
- Conference Purpose
  - To develop an electrostatics survey
  - To develop a magnetism survey

Development II
Working Conference on Introductory Physics - June 19-24, 1995 at Lee College

- Day 1- group and individual work sessions; followed by discussion of the E&M Concept Inventory
- Day 2 - Reviewing Maloney's EMCI, ranking E&M concepts; reviewing Dennis Albers's circuits RT assessment
- Day 3 - Discussion of alternative concepts; initial development of electrostatics and magnetism questions (2 rounds) and review of Chabay and Sherwood and CASTLE materials and assessment
- Day 4 - continued development of electrostatics and magnetism questions (2 rounds)
- Day 5 - Detail reporting and critiquing of Electrostatics and Magnetism Groups; revising questions (2 rounds)
- Day 6 - the final day of the Conference; 2 groups working on revising questions; Final Reports by Electrostatics and Magnetism Groups

Development III
Working Conference on Introductory Physics - June 19-24, 1995 at Lee College

- Initial Working Group on the Electricity Concept Inventory (later became the CSE)
  - Curt Hieggelke, Joliet Junior College
  - David Maloney, IPFW
  - Marv Nelson, Green River Community College
  - Marie Plumb, Jamestown Community College
  - Myra West, Kent State University - Stark Campus

Development IV
Electrostatics Topics Chosen

- Electrical charge and charge conservation
- Conductors/Insulators and transfer of charge
- Coulomb's Law and proportional reasoning
- Newton's Law of Motion, particularly the third law
- Electric fields
- Electric force and field superposition
- Force caused by electric field
- Electric potential
- Work, electric potential, field and force
- Induced charge and electric field
- Gauss' Law and shielding

Development V
Working Conference on Introductory Physics - June 19-24, 1995 at Lee College

- Initial Working Group on the Magnetism Concept Inventory (later became the CSM)
  - Mark Bunge, San Jose City College
  - Dwain Desbien, Highland Community College
  - Tom O'Kuma, Lee College
  - Alan Van Heuvelen, The Ohio State University

Development VI
Magnetism Topics Chosen

- Magnetic force due to moving charges in a magnetic field
- Magnetic force due to current-carrying wires
- Newton’s Law of Motion, particularly the Third Law
- Magnetic field caused by a current
- Magnetic field superposition
- Interaction of charges and permanent magnets
- Magnetic induction and Faraday’s Law
- Magnetic torque

Development VII
Working Conference on Introductory Physics - June 19-24, 1995 at Lee College

- Results of Conference
  - Developed Electricity Concept Inventory (became CSE Form A) - 37 questions on electrostatics; also, a taxonomy
  - Developed Magnetism Concept Inventory (became CSM Form A) - 19 questions on magnetism; also, a taxonomy
- A set of open-ended questions parallel to the ECI (29 questions) and MCI (19 questions) for testing with a variety of student groups

Testing and Development Year 1 - 1995-1996

- Initial Testing - Students
  - Some Summer 1995
  - Fall 1995 at JJC and OSU
  - Spring 196 at JJC, LC & IPFW
  - 178 ECI matched data plus 280+ others
  - 158 MCI matched data plus 20+ others
- Initial Testing - Faculty
  - 105 EMI, 86 MCI
- Continuing monitoring and evaluation by developers

Testing and Development
Year 2 - 1996-1997

- Re-writing of survey during summer of 1996, leading to
  - ECI - Form B (30 questions)
  - MCI - Form B (19 questions)
- IPC 1 at Joliet Junior College and Summer 1996 AAPT Meeting
- Presentation at International Conference on Undergraduate Physics Education, University of Maryland, August 1996
- Testing - Students at 9 Institutions
  - 141 ECI matched data plus 110+ others
  - 158 MCI matched data plus 30+ others
- Testing - Faculty
  - 83 ECI, 58 MCI
- Continuing monitoring and evaluation by developers

Testing and Development
Year 3 - Summer 1997

- Meeting at IPFW, July 25-26, 1997/Summer AAPT Meeting in Denver
  - Meeting of Curt, Dave, Tom and Alan
  - Change ECI to CSE, MCI to CSM
  - Created CSEM (20 questions from CSE and 12 questions from the CSM)
- Summer testing of CSE and CSM, Form C
- Continuing evaluation and re-writing to create Form D
  - CSE (33 questions)
  - CSM (19 questions)
  - CSEM (32 questions)

CSEM - Conceptual Area and Question Numbers

Charge distribution on conductors/insulators	1,2,13
Coulomb's force law	3,4,5
Electric force and field superposition	6,8,9
Force caused by an electric field	10,11,12,15,19,20
Work, electric potential, field and force	11,16,17,18,19,20
Induced charge and electric field	13,14
Magnetic Force	21,22,25,27,31
Magnetic field caused by a current	23,24,26,28
Magnetic field superposition	23,28
Faraday's law	29,30,31,32
Newton's third law	4,5,7,24

Other Individuals Who Made Contributions to the Development of the CSE, CSM, and CSEM

- Dennis Albers - Columbia College
- Ruth Chabay - Carnegie-Mellon University
- Randy Harrington - University of Maine
- Glenn Julian - Miami University of Ohio
- Tina Lenaert - University of Gent
- Bruce Sherwood - Carnegie-Mellon University
- Many other faculty members, student assistants, and students

Testing and Development
Year 3 - Fall 1997

- Testing - Students
  - 130 CSE matched data plus 100+ others
  - 147 CSM matched data plus 70+ others
  - 323 CSEM matched data plus 250+ others
- Testing - Faculty
  - 44 CSEM
- Continuing evaluation and some re-writing to create Form E for Spring 1998

Testing and Development Year 3 - Spring 1998

- Form E - early spring; Form F - late spring/summer
  - CSE (32 questions)
  - CSM (19 questions)
  - CSEM (32 questions)
- Testing - Students
  - 83 CSE matched data plus 20+ others
  - 74 CSM matched data plus 10+ others
  - 13 CSEM matched data
- Testing - Faculty
  - 51 CSEM

Testing and Refinement
Year 4 - 1998-1999

- Continuing evaluation and some re-writing to create Form G
- Testing - Students
  - 36 CSE matched data plus 20+ others
  - 43 CSM matched data plus 20+ others
  - 1971 CSEM matched data plus 500+ others
  - 18 institutions
- Testing - Faculty
  - 42 CSE, CSM and CSEM

Testing and Refinement
Year 5 - Summer 1999

- Refinement of Form G to Form H (mostly grammar and better diagrams)
- Introductory Physics Conference 4 - June 9 - 12, 1999 at Joliet Junior College
  - Additional refinement to selected questions
- Final forms of CSE, CSM, and CSEM

Testing
Years 5 - 7 - 1999 - 2001

- Extensive testing nationwide with some international testing
- Testing at high schools, two-year colleges, four-year colleges and universities
- Validity testing - Appropriate and Reasonable - Trig-Based and Cal-Based
- Reliability using KR20 of 0.75
- *Surveying students' conceptual knowledge of electricity and magnetism*, AJP, **69**, S12-S23 (2001).

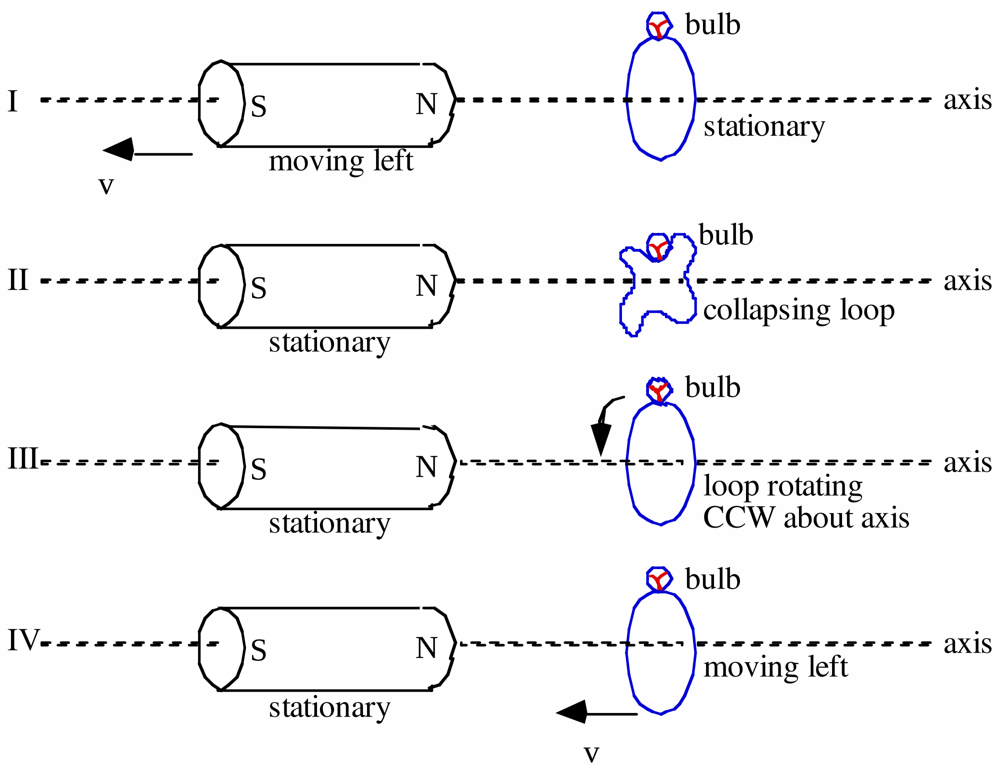
CSE/CSM/CSEM Results

Course	Pre	Post
Trigonometry-Based	24%	44%
$n \approx 800$, $g_h = 0.26$		
Calculus-Based	33%	49%
$n \approx 2{,}000$, $g_h = 0.24$		
Honors	40%	71%
$n \approx 100$, $g_h = 0.52$		

- **The findings were discouraging.**
- **Students have trouble with electrostatic ideas and even more trouble with magnetism ideas!**
- **What is the next step?**
- **(More data and more studies)**

Faraday's Law - Question I

The five separate figures below involve a cylindrical magnet and a tiny light bulb connected to the ends of a loop of copper wire. These figures are to be used in the following question. The plane of the wire loop is perpendicular to the reference axis. The states of motion of the magnet and of the loop of wire are indicated in the diagram. Speed will be represented by v and CCW represents counter clockwise.

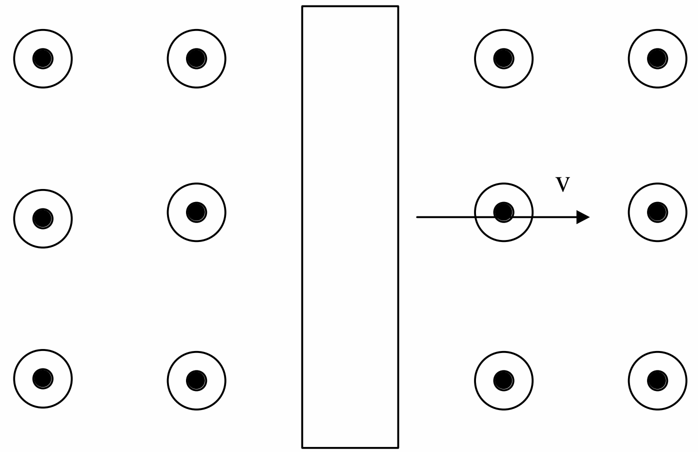


29. In which of the above figures will the light bulb be glowing?

(a) I, III, IV (b) I, IV (c) I, II, IV (d) IV (e) None of these

Faraday's Law - Question III

31. A neutral metal bar is moving at constant velocity v to the right through a region where there a uniform magnetic field pointing out of the page. The magnetic field is produced by some large coils which are not shown on the diagram.



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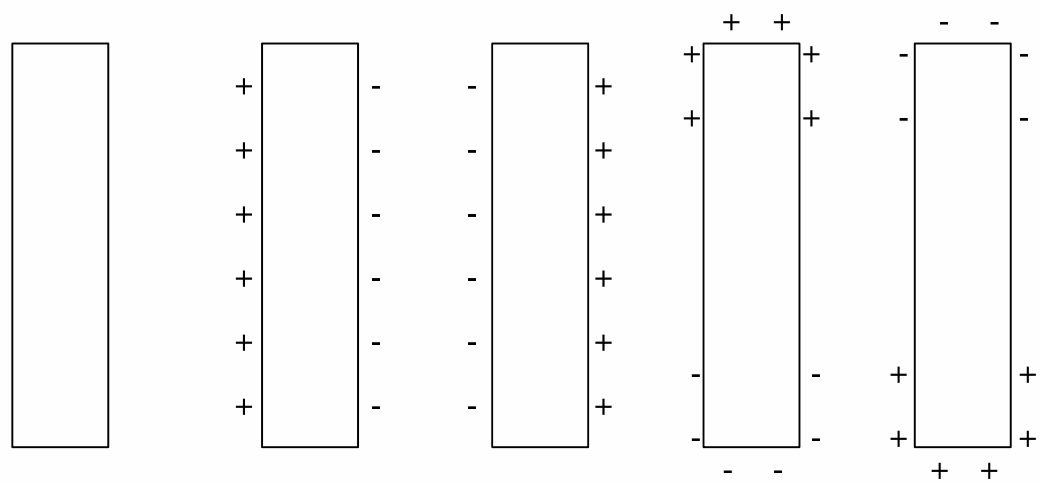
Which one of the following diagrams best describes the charge distribution on the surface of the bar?



(a) (b) (c) (d) (e)

Faraday's Law - Student Data I

QUESTION 29

N - Cal		A	B	**C**	D	E
2213	Pre	26%	22%	**14%**	25%	10%
1981	Post	18%	28%	**24%**	24%	5%
N - Trig						
431	Pre	28%	15%	**9%**	23%	8%
477	Post	26%	25%	**22%**	20%	5%

QUESTION 31

N - Cal		A	B	C	D	**E**
2114	Pre	14%	27%	33%	15%	**9%**
1884	Post	19%	20%	26%	15%	**18%**
N - Trig						
275	Pre	15%	26%	39%	12%	**3%**
278	Post	17%	18%	27%	15%	**23%**

CSE/CSM/CSEM Results
Post 2000

	Pre	Post
Trigonometry-Based	23%	47%
$n = 300$, $g_h = 0.31$		
Calculus-Based	31%	48%
$n = 5{,}000$, $g_h = 0.25$		

- It has been administered world wide, but most has not been reported
- Here are a few

CSEM Studies I

- Croatia – Planinic, Maja, "Assessment of difficulties of some conceptual areas from electricity and magnetism using the Conceptual Survey of Electricity and Magnetism"**, AJP, 74** (12), 12/06.
- The average difficulties in the six conceptual areas were compared to the average difficulties of the same conceptual areas of American students enrolled in algebra-based or calculus-based general physics courses. The difficulties of the conceptual areas show similar trends for the three groups of students. The most difficult area was found to be electromagnetic induction, followed by Newton's laws in the context of electricity and magnetism, together with the electric potential and energy. **The comparison of pretest and posttest results suggests that instruction in both algebra-based and calculus-based courses is not efficient in reducing the pretest difficulties of the conceptual areas; however, the impact of instruction differs among conceptual areas."**

CSEM Studies II

- Turkey – Demirci, Neset, “University Students’ Conceptual Difficulties About Electricity and Magnetism Concepts”
- “As a summary, in this study university students’ conceptual difficulties about electricity and magnetism concepts are investigated. In this purpose all students enrolled general physics-2 courses at Balıkesir University, the department of Science and Liberal Art and Necatibey Faculty of Education are chosen as a sample of this study. The CSEM test was applied as a pretest at the beginning of the spring semester of 2004, and as posttest at the end of same semester. Students’ mean percentage score of pretest was 27.104 and the mean percentage scores for posttest 53.394 were found. The male students have obtained higher mean score for both pre and post CSEM test than female students, and that result was statistically significant.”
- **“The CSEM test results obtained from this study, female students have gotten lower scores than male students from both pre and posttest and these results were statistically significant.**

CSEM Studies III

- Thailand – Narjaikaew, Pattawan, Emarat, Naromon, Soankwan, Chernchok, and Cowie, Bronwen, "Year-1 Thai University Students' Conceptions of Electricity and Magnetism"
- **"To sum up, the students' performance on the pre and post-test surveys implies that traditional instruction strategies are not improving students' understanding of physics concepts as much as any instructor would hope**. This raises the question of how well students can learn in their lecture classes through the use of formula to explain phenomena and by spending long periods of time sitting and copying notes from the board."

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