Summary of Identified Issues

Two physics sequences are of importance in articulation. We define these as follows.

1. University Physics (CAN Physics B or C) is the course taken by physical science and engineering majors. It uses calculus up to and including multivariable (vector) differential and integral calculus. This course has an associated laboratory for all but the modern physics term. It may or may not include a discussion section as well as a lecture.

2. College physics (CAN Physics A), sometimes referred to a "pre-med" physics, physics for biologists, or "algebra-trig" physics. This course is/can be taught with a small amount of calculus. College physics includes an associated laboratory.

Out of these designations arises a fundamental issue: the lack of articulation for the college physics course, as the vast majority of community colleges cannot offer both an algebra-trig course and physics course demanding "a little bit of calculus, in addition to the more demanding physics course for the intended major. The solution here will demand a collaboration of the physics faculty and faculty in other disciplines, particularly those in biological sciences, to reach an agreement that the "little bit of calculus" course can be articulated to the algebra-trig course. The solution of this issue would be a major step in easing this problem encountered by transferring students in these fields.

A related issue is the nature of the physics needed by those bioscience students intending to enter the health science fields. Presently, there is confusion as to what medical and similar professional schools require of their incoming students and what may be tested as part of their admissions process. We have agreed with the biological sciences faculty to investigate the desires of these post-graduate schools and seek to respond to the needs of those students.

A third issue emerges when students do not complete the physics sequence at a single institution, rather taking a semester here, another there, and hoping to complete some work after transfer. This piecemeal approach seldom is serviceable: students miss out on crucial units or topics offered in differing semesters at different institutions, and repeat segments they have had in a prior course. On the other side of the transfer process, the receiving institution is likely to require these students to repeat an entire course simply to acquire those essential modules not yet taken. To reduce costly and needless repetition, to reduce students' understandable frustration, to promote progress to degree, yet to ensure students' appropriate preparation, physics faculty must continue to resolve this issue. Several potential solutions are discussed in this report.

Identified Trends/Future Directions

Some universities (UC Davis) and several community colleges are currently offering mini-units to augment existing course work, permit review of topics, and allow transfer students who did not acquire education in some modules to make up that deficit.

At UC Davis, for example, one-unit modules are offered as a need is identified on a case-by-case basis as students transfer into the physics program. Similar self-paced modules are being explored on community college campuses in conjunction with labs or learning centers.

Comments from Statewide Meetings and the General Field

Physics faculty from all three segments met at the statewide meeting. Overall, there was easy agreement on the basic lower division major curriculum. The introductory physics curriculum has been fairly "standardized" as evidenced by the lack of variance in the textbooks.

During the 2001 statewide meeting, the assembled physics faculty focused on the university physics course, and in discussions with our bioscience colleagues on the college physics course.

Outstanding questions for the major preparation curriculum are these:

- How much modern physics and when? – CAN Physics Sequence B or C?
- Is introductory calculus based physics one year, four quarters, or three semesters?
- How much of what type mathematics should be pre or co-requisite to which sections of the course?
- How to deal with non-uniformity of sequencing within the course—a particular problem for students who do not complete the sequence before transfer, or who attempt to assemble the sequence by taking different terms at different community colleges.
- How much linear algebra and differential equations should be required in the lower division?

The first two questions are linked as the amount of modern physics included in the "introductory course" is a major portion (but not all) of the differences in the course length. The third question is complicated by the differences in mathematics sequences and the sequencing of the physics topics within the university physics course. We spent a good part of the statewide meeting working out a solution to the fourth question of sequence variation (see below). The fifth question was not significantly addressed and will need more discussion among physics faculty.

The statewide meeting focused on questions of topic sequence within the university physics course. We agree that some variation is to be expected and that we can ameliorate the negative effects of this on transfer by "decreasing the granularity" of the CAN system. We propose to agree on a set of physics topics or modules that could then be assigned module numbers. Thus the university physics sequence (as well as the college physics sequence) would be described not only by the current brief catalog description but also by the module numbers in each term. In this way instructors and articulation officers and college staff would get a much clearer picture of how much a student had covered in the sequence. This scheme would mean that an individual term-long course would be designated with a CAN number followed by a listing of the covered modules. Thus, those students required to have physics for a variety of majors, and particularly those who do not complete the sequence at a single institution, would readily understand in which term they would be offered urgent sequences. This method would also permit their counselors and their receiving institutions to readily identify which modules the student had completed, and identify strategies to enable students to complete needed "missing" modules without repeating coursework or delaying progress for transfer.

Our group discussion resulted in the following set of draft "course modules." For each module we have listed the major subtopics/concepts. We present the below for discussion in a wider group of physics faculty.

Module 1: MECHANICS

- Vectors and Scalars
- Newton's Laws
- Statistics
- Linear Kinematics and Dynamics
- Rotational Kinematics and Dynamics
- Conservation Laws
- Gravitation

Module 2: MECHANICAL WAVES & OSCILLATIONS

- Waves on a string
- Standing Waves
- Interference
- Resonance
- Superposition
- Sound
- Doppler Effect

Module 3: SIMPLE HARMONIC MOTION

Module 4: THERMAL PHYSICS

- Calorimetry
- Heat Transfer
- Kinetic Theory
- Thermodynamics

Module 5: FLUIDS

- Density
- Hydrostatics
- Archimedes Principle
- Pascal's Principle
- Hydrodynamics
- Bernoulli's Principle

Module 6: ELECTROSTATICS & DC CIRCUITS

- Charge
- Coulomb's Law
- Fields
- Potentials
- Gauss's Law
- Voltage, Current, Resistance
- Capacitance
- Kirchoff's Rules
- Flux
- EMF (?)

Module 7: MAGNETISM, AC CIRCUITS & MAXWELL'S EQUATIONS

- Faraday's Law
- Ampere's Law
- Biot-Savart Law
- Magnetic Fields
- RC,RL,RLC Circuits
- Phasors
- Inductance
- Lenz's Law
- Flux(?)

Module 8: E&M WAVES

- Speed of Light
- Color, Frequency
- Momentum and Energy of E&M Waves

Module 9: GEOMETRIC OPTICS

- Reflection
- Refraction
- Ray Tracing
- Lenses
- Mirrors
- Optical Instruments

Module 10: PHYSICAL OPTICS

- Interference
- Diffraction
- Polarization
- Dispersion
- Resolution
- Phase

Module 11: SPECIAL RELATIVITY

Module 12: QUANTUM MECHANICS

- Experimental Basis of Quantum Mechanics
- Particle-Wave Duality
- Wave Functions
- Atoms and Molecules
- Applications of Schrodinger's Equation
- Topics from Solid State, Nuclear & Particle Physics

It should be noted this is but a starting point for needed further discussion. The CAN Board and the segments would also have to adopt this modification/addition to the CAN scheme.

Our discussion with the biology faculty centered on the college physics sequence (CAN Physics Sequence A). This is the course required for biological science majors of all types and some of the other science majors, for example psychology, BA in geology, physical therapy, consumer science, *et cetera*. On all of the UC campuses and approximately one half of the CSU campuses, this course has a calculus prerequisite. While little calculus is used in the course, the reasons given for requiring it range from—"it raises the level of the course" to "because we can, since calculus is required for the bioscience major." Called for is continued discussion and collaboration of the physics faculty with the faculty in biological sciences to reach an agreement on this matter to resolve this barrier.

At the 2001 statewide meeting the issue of what the medical schools require was raised. It was found that much confusion exists as to exactly what is being taught on our campuses and what the health science professional schools desire/require. We will survey the CSU and UC physics departments and work to establish what the health science school requirements are.

Recommendations for the Discipline

- Survey the CSU and UC physics departments to determine how they respond to demands in the health sciences professional schools.
- Determine what is presently being required for MCAT preparation and for admission to health science professional schools.

Recommendations for Support Courses

- Continue to review the college physics courses as needed by majors in bioscience, seeking a resolution to this dilemma.

Topics for Further Discussion

- Seek to resolve how much linear algebra and differential equations should be required in the lower division.

Recommendations Forwarded/to be forwarded to

CAN: Advise the CAN Board of the discussions in the field concerning the modules proposal.

CIAC: Work with articulation officers and counselors to continue recommending to students that they complete sequences of courses at a single institution and that they complete their lower division preparation for the major prior to transfer.

Outreach presentations made by members of this group

Lead Faculty Coordinator Lawrence Coleman made an IMPAC presentation to a system-wide gathering of deans of undergraduate education.