Physics

Bachelor of Science in Physics (62/63)

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UNIVERSITY OF ARKANSAS AT LITTLE ROCK Plan No. 62/63
Assessment Progress Report Form (Calendar Year 2005)

I. Our Traditional Approach

Our core strategy to assess our physics degree programs is to determine how well our majors understand key concepts in physics and mathematics, the concepts that all physics graduates should have mastered, given competent, motivated students and an ideal learning environment. These Learning Objectives (LOs) represent key principles and concepts. This list has evolved over the years but is the same as the one submitted in last year's report (Attachment C).

Force Concept Inventory

We use the Force Concept Inventory (FCI), a nationally recognized instrument for evaluating student conceptual understanding of force, motion, and mechanical energy at both the introductory course and the graduating senior level. The purpose of the former is to assess the effectiveness of the teaching methods being applied at the introductory level; the purpose of the latter is to find out if our upper level courses do alter student misconceptions and build a correct conceptual understanding.

Online Homework Service

In previous years we have used an online homework service (UT Homework Service) in our introductory sequence (PHYS 2321/2322) that allowed us to compare our student performance on selected problems (problems that illustrated specific topics in our LOs) with the rest of the students around the country who also were using that same homework service. We have now switched to another online homework service that unfortunately does not tabulate data in such a way that we can evaluate our students on a national norm.

Senior Seminar Experience

We use our senior seminar course as our capstone evaluation to assess students' general knowledge of physics; all the faculty complete an evaluation survey of each of our graduating seniors twice during their final semester, a survey with specific reference to general knowledge.

Major Field Test (MFT)

We have begun administering the Major Field Test in Physics to our graduating seniors and now have initial results. The purpose of the Major Field Test for us is to learn how well our students perform in the various topical areas of our discipline; with this knowledge a thoughtful plan for curricular improvement can be developed and implemented.

Faculty and Stakeholder Involvement

We use our Physics Advisory Council (a group of industry, medical, national and state agency, and education professionals with a background in or a working knowledge of physics in the workplace) that includes several of our alumni to guide us in decisions about curriculum. We are taking part in a college-wide telephone survey of our graduates in order to learn what aspects of our program has served them well and which components need an upgrade.

II. Data Gathered in 2005 and How We Will Use It

Force Concept Inventory

We surveyed two classes of Physics for Scientists and Engineers I during the calendar year 2005 using the FCI instrument. The results of this 30-question survey are given below:

	Number of Students	Average Correct (Maximum of 30)
Class 1	23	18.39
Class 2	12	18.58

These results are consistent with low-to-mid range of the national results from classes using the active engagement pedagogical techniques (instead of the traditional lecture approach for which results hover in the 12-14 range). We use this result to rationalize our continued use of the active engagement technique and continue to work to improve its effectiveness at raising student performance on the FCI.

In previous years we have noted one specific area of student weakness on the FCI: Newton's 3rd Law (the action-reaction principle). Students were typically scoring at the 25% level with these questions. Based on that earlier finding the faculty teaching the introductory courses began including specific in-class activities and assigning additional homework exercises addressing this principle. The result of that curricular modification is that now (in 2005) students perform at the 60% level on these questions. Plans are in place to continue emphasis on exercises and assignments relating to Newton's 3rd Law.

The results of the FCI in 2005 do reveal a predominant misunderstanding on one key aspect of Newton's Laws of Motion: a uniform motion in one direction does not require a net force in that direction. There are two questions on the FCI which speak to this principle and the scores this year were at the 25% level on these two questions. The two instructors currently teaching the introductory calculus-based physics have decided to increase the emphasis on this aspect of force and motion in order to address this student weakness. The increased emphasis will take the form of an additional in-class exercise and an additional homework and exam question that deals with this aspect of Newton's Laws of Motion.

We had four students graduate with a BS degree in physics in CY 2005. We only asked two of them, the ones graduating in December 2005, to take the FCI survey. The result is that the two students scored 27 and 29, again out of a total possible score of 30. There was no common question missed by both students. There was no one topical area that was common to the missed questions. Our interpretation is that these two students represent our stronger, more well-prepared graduates and that their upper level courses strengthened their conceptual understanding of the basic ideas of force and motion that was introduced in the introductory course. We plan to continue asking our graduating seniors to take the FCI as part of the senior seminar course and using the results to assess the effectiveness of the upper level courses.

Online Homework Service

We have adopted WebAssign as our online homework service for our introductory courses. Students work a series of homework sets, one from each chapter, that are chosen by the instructor, problems which are identical in nature to the written problems and chapter illustrations in the text, but with different numerical values. Students have a limited number of chances to enter an acceptable numerical answer or analytical expression. We are not using the results of WebAssign as part of our assessment strategy now, but we will do so in two ways in 2006. It is rather straightforward for the two instructors in the class to agree to assign the same problem to both classes in order to determine how well students are picking up on the concept of the problem. That same problem will then be given to our graduating seniors during their senior seminar course in order to see if the upper level courses improved student proficiency with that concept. The problems chosen for this assessment component will relate directly to the departmental LOs. As a second method for using WebAssign for program assessment we will pick 10 of the LOs, find the relevant problems that were assigned the students in the four sections, and tabulate how well they performed on those questions. We will then report that data next year.

Senior Seminar Experience

Of the four students who graduated in CY 2005 we have data on the senior seminar presentations for two of them. The one evaluation criterion that is important here is the one that addresses knowledge of physics. Faculty chose between poor, average, and superior (actually not done or poorly done, adequate, or well done). On the question of whether the level of physics was appropriate, the two students scored at the adequate (average) level or slightly above. These results will be used to modify the plan for assigning topics for senior seminars. During 2005 (and certainly in previous years as well) students were allowed to pick their own topics for seminar and in many cases faculty did not provide adequate guidance for focusing the seminar topic in such a way that the fundamental physical concepts could be illustrated. In 2006 students will be required to choose from a pre-determined list of topics and there will be a faculty member responsible for each of those topics and will mentor the student in such a way that the presentation does bring out the fundamental physics of the topic, i.e. the physics covered in the required courses for our majors. In addition, the evaluation sheet that is completed by all the faculty in attendance will be modified to better reflect the physics content requirement for the presentation. In this way we will begin to address prior weaknesses in our assessment plan, i.e. failure to link the senior seminar to our Learning Objectives.

Major Field Test (MFT)

Of the four graduates in 2005, we have results for 3 on the Major Field Test in Physics. The main purpose of the MFT will be gathering data on our curricular effectiveness for the various subdisciplines of physics, e.g. mechanics, electricity and magnetism, waves and optics, heat and thermodynamics, quantum mechanics, atomic physics, nuclear physics, and relativity. In this way we can link the MFT directly to our Learning Objectives. A cohort of at least 5 students is required for the ETS to provide the subject area breakdown that we require for this application. We will reach and exceed that number once the Spring 2006 graduates join that initial cohort of 3. Until then, we report without comment the scores for the three who took the exam in December 2005.

Student	Scaled Score (120-200)	% at or below
1	147	55
2	156	70
3	157	75

Once the results for the additional students come in and we have the subject area breakdown we will review that data and then as a faculty develop a curricular plan to address any critical weaknesses and to boost overall student performance on the MFT.

III. Faculty and Stakeholder Involvement

We have no news data to report for faculty and stakeholder involvement. Our Physics Advisory Council (PAC) remains active although there were no formal meetings during 2005. Two social events were held in 2005 and several PAC members were in attendance on both of those occasions. We were in informal conversations with several of the PAC members on a question of curriculum, specifically the advisability of requiring our majors to take a separate course in computer programming. We have not resolved this question but we do find the input from the PAC to be very helpful as we grapple with this question. But we have not yet clearly defined how the PAC will contribute directly to our program assessment.

We do not have any further survey results from our alumni. Our questionnaire mail-out from several years ago did not yield many replies and we are now joining with the other departments in CSAM and participating in the telephone surveys being conducted by a separate department here on campus. Once those results are in the faculty will review them and consider if the comments of the alumni call for changes in direction or emphasis within our program. Also, once the results of the MFT are in we will share those results and our interpretations with our alumni via a newsletter.

IV. What Else We Did, Did Not Do, Are Proposing To Do

The Physics and Astronomy Department used assessment funds awarded in 2005 to support the travel for Al Adams to attend the annual meeting of the American Association of Physics Teachers in Anchorage Alaska. He discussed program assessment with several members of the organization and was made aware of a 2005 publication by the American Association of Physics Teachers entitled *Guidelines for Self-Study and External Evaluation of Undergraduate Physics Programs.* The guidelines are arranged around five questions:

1. What are the characteristics and goals of students in our program?
2. Does the department's physics curriculum help students fulfill their goals?
3. Do we have adequate resources to support the objectives of our undergraduate physics program?
4. What support outside of the classroom and laboratory does our program provide to help students achieve their goals?
5. Does the climate in our department effectively support and energize our students?

Al Adams will share this booklet with the Physics and Astronomy faculty and propose that the faculty answer those five questions for our program.

We have not initiated an exit survey or interview with our graduating seniors as a method for increasing stakeholder involvement. This possibility was suggested by the reviewers of last year's report. Al Adams will propose this option to the faculty.

We are not devoting a complete faculty meeting as of now to the issue of program assessment. In discussing program assessment with AAPT members from around the country Al Adams learned that many departments do just that and he will propose to the faculty that Physics and Astronomy devote at least one faculty meeting each year to reviewing the assessment data (e.g. the MFT results) to determine if a specific plan of action is necessary to address a program weakness.

Attachment C **Learning Objectives and Codes**

Major Fields	Code	Learning Objectives	Major Fields	Code	Learning Objectives
Atomic Physics	**A1**	Bohr model	**Nuclear Physics**	**N1**	Radioactive decay
	A2	Hydrogen atom - energy levels		**N2**	Types of decay
	A3	Life-time broadening		**N3**	Binding energy
	A4	Zeeman effect		**N4**	Basic nuclear decay equations
	A5	Spectroscopic notation	**Optics**	**O1**	Refractive index
Circuits	**C1**	Ohm's law		**O2**	Lens formula (simple telescope)
	C2	Simple DC circuits		**O3**	Diffraction limit, gratings
	C3	P = I2 R		**O4**	Michelson interferometer
	C4	RC, LR time constants		**O5**	Non-reflective coatings
Electromagnetism	**EM01**	Maxwell's equations	**Practical**	**P1**	Oscilloscope
	EM02	Coulomb's law		**P2**	Amplifier gain fall-off
	EM03	Lorentz force, F = q v x B, F = I l x B		**P3**	Error analysis
	EM04	Capacitance: vacuum, dielectric		**P4**	Ideal Diode behavior
	EM05	Electrostatic potential difference		**P5**	Nuclear radiation - penetration dept
	EM06	Superposition principle		**P6**	OR gate
	EM07	Accelerating charge through a potential	**Quantum Physics**	**Q1**	deBroglie wavelength
	EM08	Ampere's law		**Q2**	Uncertainty principle
	EM09	Faraday's law of induction		**Q3**	E(photon) = hc/lambda
	EM10	Lenz's law		**Q4**	Compton scattering
	EM11	Gauss's law		**Q5**	Spherical harmonics
	EM12	Dir. of M field from current carrying wire		**Q6**	Pauli Exclusion Principle
	EM13	Current loop as a magnetic dipole (far away)		**Q7**	Photoelectric effect
	EM14	Radiation from accelerating charge		**Q8**	Finite square well
	EM15	Electrostatic field from charge distributions		**Q9**	Infinite square well
General	**G1**	Vectors, resolving components		**Q10**	Free particle
	G2	Complex exponentials		**Q11**	Simple harmonic oscillator
	G3	Units		**Q12**	Spin and statistics
	G4	Angular frequency		**Q13**	Expectation values
	G5	Basic geometry		**Q14**	Franck-Hertz experiment
	G6	Exponentials & natural logs-time constants		**Q15**	Adding angular momenta
	G7	Field lines		**Q16**	Hamiltonian from classical Hamiltor
	G8	Matrices		**Q17**	Two-particle psi, fermions vs boson
	G9	Fourier series - simple cases	**Solid State Physics**	**SS1**	Bragg Reflection
	G10	Meaning of divergence		**SS2**	Hall effect
	G11	Small angle approximation		**SS3**	Why E of conduction electrons > kT
	G12	Separation of variables			
Mechanics	**M01**	Uniform circular motion	**Special Relativity**	**SR1**	Length contraction
	M02	Conservation of energy		**SR2**	Time dilation
	M03	Conservation of angular momentum		**SR3**	E2 = (pc)2 + (mc2)2
	M04	Conservation of momentum		**SR4**	Speed of light = constant
	M05	Newton's Law of Gravitation			Simultaneity
	M06	Simple harmonic oscillator			Lorentz transformation
	M07	Rotational motion	**Thermal Physics**	**T1**	Blackbody radiation
	M08	Simple pendulum - omega =sqrt(g/l)		**T2**	Entropy
	M09	Kinematics		**T3**	Carnot cycle

	M10	Work-energy theorem		**T4**	Specific heats of monatomic, diatomic gas
	M11	Collisions, elastic and inelastic		**T5**	Equal a priori probabilities
	M12	Getting F from V		**T6**	p-V work
	M13	Density		**T7**	Average energies in thermal equilibrium
	M14	Moment of inertia		**T8**	pV processes
	M15	Normal Modes		**T9**	First Law
	M16	Work		**T10**	Second Law
	M17	Newton's Second Law, incl. F = dpdt		**T11**	Fermions and bosons
	M18	Falling body with air resistance	**Waves**	**W1**	Interference
	M19	Friction		**W2**	Doppler effect
	M20	Impulse		**W3**	Diffraction
	M21	Orbital motion		**W4**	Group velocity and phase velocity
	M22	Center of Mass, Reduced mass		**W5**	Travelling Waves
	M23	Small oscillations		**W6**	Refraction and reflection
	M24	Lagrangian		**W7**	Standing Waves
	M25	Hamiltonian		**W8**	Wave Properties