I & II. Objective, course/learning experience

Below, we list six broad goals for graduates with a JMU physics major, connections to courses within the curriculum, and specific objectives related to these goals. Specific objectives are listed further below.

Goals

As a result of curriculum required for a major in physics at JMU, graduates will:

1. Appreciate the role of science in society and the historical development of physics in the ongoing quest to discover the structure of the universe.
2. Gain an understanding of the basic principles and the experimental basis of the various fields of physics and the logical relationships of the various fields.
3. Become capable problem solvers using techniques that require mathematical skills, conceptual and mathematical models, order-of-magnitude estimates and an understanding of limiting cases.
4. Develop competence in designing, constructing and using laboratory instruments and to draw valid conclusions from experimental data.
5. Develop competence in using computers for computation, data acquisition, numerical control, device development and information acquisition and processing.
6. Improve written and oral technical communication skills.

These goals were arrived at by the general consensus of the faculty during a departmental meeting and are reviewed every three years during the formulation of our strategic plan. Current goals 1–3 are broad, foundational goals related to the fundamental nature of physics, and all courses build on these themes. Goals 4–5 are typically reached through courses with an experimental or laboratory component in particular. Goal 6, which is often required in these laboratory courses, is also addressed in courses with a particular emphasis on presentation. Table 1 shows specific linkages to courses.

Objectives

Specific learning objectives related to each of these goals are listed here. These objectives were created by the Assessment Subcommittee and will be reviewed for approval by the faculty in the fall. The objections correspond to the broad goals described above.

As a result of curriculum required for a major in physics at JMU, graduates will be able to:

1.1 Describe the historical context and major conceptual shifts in ancient sciences, early mechanics, electromagnetism, quantum theory, modern physics, and current scientific research and technology.

Comment [A1]: Clear statement defining whom should be assessed: students graduating from the Physics major at JMU. This statement relates to Element I. B of the APT rubric.

Comment [A2]: The following objectives contain precise action verbs used to describe what graduating physics majors are expected to do.

Comment [A3]: In addition, each objective contains a rich and specific description of the content, skill, or domain being assessed. Using precise verbs with rich content helps to identify methods for assessing the objectives. These components relate to element I. A on the APT rubric.

1.2 Identify physics principles across disciplinary boundaries. Solve problems using physics concepts in applications within contexts outside of physics.

2.1. Explain basic principles, conceptual relationships, and major theoretical concepts at the intermediate/ advanced undergraduate level in the particular areas of:

a. Classical mechanics and relativity
b. Electricity and magnetism
c. Modern physics
d. Quantum mechanics and atomic physics
e. Thermodynamics
f. Optics and waves

3.1. Solve quantitative, conceptual, order of magnitude, and limiting case problems at the intermediate/ advanced undergraduate level in the particular areas of:

a. Classical mechanics and relativity
b. Electricity and magnetism
c. Modern physics
d. Quantum mechanics and atomic physics
e. Thermodynamics
f. Optics and waves

3.2 Solve problems using mathematical concepts, strategies and procedures to derive and manipulate formal mathematical relationships between physical quantities

3.3 Apply theoretical knowledge from coursework to interpret context-rich, real-world problems, including identifying appropriate limits allowing application of known formulas.

4.1. Independently conduct experiments in mechanics, electricity and magnetism, modern physics, and thermodynamics, including outlining experimental design and applying analysis of errors and uncertainties. Specifically, this includes:

a. Designing an appropriate laboratory investigation to address an answer to an unknown scientific question and drawing conclusions based on the data and analysis.

b. Making accurate physical measurements, and using experimental uncertainty to place limits and confidence intervals on final results.

5.1 Perform calculations and simulations using both calculator and computer-based strategies, such as iterating equations of motion to solve problems

6.1. Formulate hypotheses, explain measurements and analysis, and interpret experimental results in the context of prior theory as evidenced in written laboratory reports.

6.2. Effectively communicate theoretical concepts, solve problems, and respond to questions orally, including explaining assumptions and justifying approximations.

The linkage between our goals and objectives and their instructional delivery *via* the curriculum is given in Table 1. Links between objectives and assessment tools are presented in Table 2 below.

Course	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6
105	X	X	X			X
ASTR 120	X	X	X			
ASTR 121	X	X	X			
125	X	X	X			
126	X	X	X			
140	X	X	X			
150	X	X	X			
140L	X	X	X	X	X	
150L	X	X	X	X	X	
215	X	X	X			X
ASTR 220	X	X	X			
ASTR 221	X	X	X			
240	X	X	X			X
247	X	X	X	X	X	X
250	X	X	X			X
260	X	X	X			X
265	X	X	X		X	
270	X	X	X			X
275	X	X	X			
295	X	X	X	X		
297	X	X	X	X	X	X
ASTR 320	X	X	X	X	X	
335	X	X	X			
340	X	X	X			
342	X	X	X			
344	X	X	X	X	X	X
345	X	X	X	X	X	X
346	X	X	X	X	X	X
347	X	X	X	X	X	X
350	X	X	X			
360	X	X	X	X		
365	X	X	X		X	
366	X	X	X		X	
371	X	X	X	X		
372	X	X	X	X		

Comment [A4]: The following table maps the program's goals to the courses where these goals are covered. Mapping goals to courses is important; however, mapping the specific learning objectives would allow a program to more precisely identify where students are to gain knowledge/skills across the curriculum. This aspect of the APT addresses Element II.

373	X	X	X	X	X	
380	X	X	X			
381	X	X	X	X		
390	X	X	X		X	
391-392	X	X	X			X
397	X	X	X			X
398	X	X	X	X		
420	X	X	X			
455	X	X	X	X		
460	X	X	X			
480	X	X	X			
491-492	X	X	X			X
494	X	X	X	X	X	X
497	X	X	X	X	X	X
498R	X	X	X	X	X	X
499	X	X	X	X	X	X

Table 1*. The linkage of the instructional goals and the delivery methods. All courses are listed as PHYS (physics) unless otherwise indicated as ASTR (astronomy).*

III. Evaluation/Assessment Methods

Current assessment efforts include (i) assessment of all graduating senior physics majors through an ETS content exam, NW-9 General Education Assessment, and a departmental oral, problem-solving exam, (ii) assessing proficiency in laboratory and data analysis techniques in our advanced laboratory, (iii) discussion of student performance and feedback at the annual departmental retreat, and (iv) attendance by faculty at development workshops and conferences to learn current best practices used at other universities. The content assessment is performed with the use of the Educational Testing Service (ETS) Physics Major Field Test, which is a two hour multiple choice exam that covers both general physics as well we advanced topics. The General Education NW-9 Natural World assessment was offered for the first time this year and is not formally part of our assessment process for this graduating class. The senior conference exam (SCE) is an oral exam administered by three faculty members, one of whom is chosen by the student. The SCE measures technical communication skills, physics content as well as problem solving ability. These are addressed in detail below. In addition, though the Assessment Fellows program, we are exploring ways to assess the introductory courses in particular, to impact both physics majors and students from other majors who take physics as part of their core curriculum.

Comment [A5]: The following paragraph does an excellent job introducing the program's assessment methods. The initial descriptions of each method indicate that the ETS exam, the NW-9 and the oral problem solving exam are all direct measures of student learning (Element III B.).

Objective	ETS Intro/ Advanced Scores	ETS Aggregate Scores on Physics Subfields	Senior Conference Exam	Advanced Laboratory	NW-9 Natural World Assessment*
1.1			X		
1.2	X		X		X
2.1		X	X	X	
3.1	X	X	X		
3.2	X	X	X		X
3.3			X	X	
4.1				X	X
5.1				X	
6.1				X	
6.2			X	X	

Table 2*. The linkage between the assessments and learning objectives. ETS provides individual sub-scores for intro/advanced material and aggregate scores on specific subfields in physics. The senior conference exam provides an overall score for content, problem solving, and communication. The advanced laboratory requires all graduates to achieve specific competencies at the pass or high pass level. *The NW-9 assessment is not currently used as part of our formal assessment, but using the data from the first administration this year, we will determine how to formally incorporate the NW-9 as part of our assessment plan.*

Senior Assessment

The student program assessment for the Department of Physics and Astronomy consists of both a content assessment as well as a problem solving/communication assessment and is administered to all graduating seniors (approximately 15-20 physics graduates per year). It is arranged by the student's academic advisor at a time convenient for the student and committee and is scheduled for one hour during April of the senior year (or December in the case of a December graduate). The content assessment is performed with the use of the Educational Testing Service (ETS) Physics Major Field Test, which is a nationally normalized, two hour multiple-choice exam that covers both general physics as well we advanced topics. The ETS assessment is administered on Assessment Day, with the most recent administration occurring on Feb. 14, 2012. The senior conference exam (SCE) is a locally designed, oral exam administered by three faculty members, one of whom is chosen by the student. The SCE measures technical communication skills, physics content, and problem solving ability. These assessment instruments are used internally for program improvements.

Comment [A6]: This table does an excellent job detailing the relationship between assessment measures and the objectives. Linkage between the measures and objectives is supplemented with text below.

To improve clarity, the program could include abbreviated descriptions of each objective alongside the objective numbers (e.g., 1.1, Describe historical context and shift) .

Comment [A7]: The following paragraphs explicitly detail each of the program's assessment instruments including the content covered by the instrument, when the instrument is administered, and which students complete the instrument. These aspects greatly facilitate understanding of the program's assessment methodology and relate to Elements III. A, III. B, III. D, and III. E of the Rubric.

Comment [A8]: Clearly specifies the number of students assessed. Because all graduating students in the program are assessed by the instruments, the sample is inherently representative of the graduating students (Element III. D). Obtaining a census of students is not a requirement. However, care should be taken if using samples. Specifically, the sample should be representative of the population of interest.

ETS Major Field Test:

Students are required to participate as part of a 1-credit junior/senior seminar course (PHYS 491–2) in order to get full participation. This is necessary in order to get sufficient statistics as the number of majors graduating is typically fewer than 20. While participation is required, performance does not impact the student's grades or graduation status.

The reliability and validity of the ETS Major Field Test is provided by ETS based on its administration to over 2,000 students. The reliability coefficients are 0.88 (total), 0.80 (Sub-score 1, Introductory Physics), and 0.77 (Sub-score 2, Advanced Physics). The Standard Error of Measurements are 5.6, 7.1, and 7.5 respectively (total scores are on a scale of 120-200 and sub-scores on a scale 20-100).

Comment [A9]: Reliability evidence is provided for the ETS major field test. The high reliabilities (> .60) suggest that the scores obtained from the ETS field test are consistent. Reliability evidence helps address Element III. E. In general, providing information about test reliability and validity allows one to better understand the degree to which one can trust inferences made from assessment results.

As a competitive state university with about half our graduates planning for graduate work, we expect that student performance on the ETS test will average above the 50th percentile. A useful measure for program evaluation is the average performance on individual topics provided by ETS. This can show relative strengths and weaknesses in specific content areas, some of which correspond to particular courses in the curriculum.

Comment [A10]: Explicit specification of desired results for students (average score above the national 50th percentile). This statement relates to Element III. C.

General Education Natural World Assessment (NW-9):

Along with the ETS field test, graduating seniors also took part in the NW-9 Assessment through the Senior STEM Scholars competition through CARS. Since this was our first participation in this competition, we have not formally used the results as part of our senior assessment. However, the physics majors achieved the highest average score out of the four participating departments. We plan to examine the data more closely to decide how to formally incorporate the NW-9 in the assessment of our graduates' critical thinking skills before administering the assessment next spring. Since data generated is in a format recognized by SPSS, a program not typically used by members of the physics department, we will use the preliminary data to determine procedures in advance of the next administration of the test.

Comment [A11]: This statement shows thoughtful evaluation of the assessment process, helping address Element VI. B.

A preliminary sampling of information from the initial use of the NW-9 is listed below:

NW-9 Objectives	**Items Assessing Objectives**	**Scores**
1. Describe the methods of inquiry that lead to mathematical truth and scientific knowledge and be able to distinguish science from pseudo-science.	2, 5, 9, 14, 18, 28, 38-41, 55-57 13 items (19.7% of total test)	M = 10.23 (79% correct) SD = 0.93 α = N/A
2. Use theories and models as unifying principles that help us understand natural phenomena and make predictions.	17, 20, 22, 27, 64-66 7 items (10.6% of test)	M = 6.15 (88% correct) SD = 1.07 α = .45

3. Recognize the interdependence of applied research, basic research, and technology, and how they affect society.	1, 15, 16, 43-46 7 items (10.6% of total test)	M = 5.92 (85% correct) SD = 1.55 α = .71
4. Illustrate the interdependence between developments in science and social and ethical issues.	2, 19, 24-26, 29, 55-57 9 items (13.6% of total test)	M = 8.08 (90% correct) SD = 1.12 α = .45
5. Use graphical, symbolic, and numerical methods to analyze, organize, and interpret natural phenomenon.	4, 7, 8, 10-13, 21, 30-33, 51-53, 58-63 21 items (31.8% of total test)	M = 16.46 (82% correct) SD = 1.76 α = .26
6. Discriminate between association and causation, and identify the types of evidence used to establish causation	3, 34-37, 53, 60-63 10 items (15.2% of total test)	M = 7.38 (74% correct) SD = 1.45 α = .31
7. Formulate hypotheses, identify relevant variables, and design experiments to test hypotheses.	5, 6, 9-13, 18, 23, 28, 41, 42, 47-50, 54, 59, 60, 62, 63 21 items (31.8% of total test)	M = 17.69 (84% correct) SD = 2.25 α = .53
8. Evaluate the credibility, use, and misuse of scientific and mathematical information in scientific developments and public-policy issues.	2, 14, 24-26, 29, 38-40, 60-63 13 items (19.7% of test)	M = 9.92 (76% correct) SD = 1.55 α = .21

Table 3*. Preliminary results of General Education NW-9 Natural World Assessment.*

Senior Conference Exam:

The Senior Conference Exam (SCE) is a one-hour oral examination during which senior physics majors respond to a series of questions from three physics department faculty. They are arranged by the student's academic advisor at a time convenient for the student and committee and were each scheduled for one hour during April this year. Questions are intentionally chosen to require that the student demonstrate problem-solving ability and typically include questions that require a series of logical steps, estimation, and information that is not initially provided in the question. The examination provides a measurement of seniors' individual and collective communication skills, a measurement of their understanding of the principles and foundations of

Comment [A12]: Description of the Senior Conference Exam indicates that the instrument provides a direct measure of skills associated with the objectives listed in Table 2 (Element III. B).

physics, and a measure of their physics problem solving skills. Each faculty evaluator then rates the overall performance of the student. Average scores for each measured dimension are calculated for each student. Lastly, averages for each dimension are given for the group as a whole for comparison with previous years. The results are reported as percentages of the possible number of points for each dimension.

The SCE is evaluated by committees of three faculty members for each student evaluation. There is broad participation of the faculty. In 2012, 16 faculty members (out of approximately 20) served on at least one conference exam. While the assessment is necessarily subjective, a common rubric is used, and is included below. A simple inter-rater consistency measure is to look at all combinations of evaluators and determine the probability that they assigned the same score in a given SCE. By this measure, there is over 60% agreement on each of the four scales. Over 90% assigned scores within one point of the other raters. The Technical Communication rating is based on a four-level scale, while the other three categories are based on a five-level scale.

An additional, valuable part of the SCE is that we solicit feedback from the students on the positive and negative aspects of the physics major. While we often get a wide range of reactions, there are occasionally recurring themes which demonstrate a need to either support or change ongoing departmental practices.

As we are viewing our seniors in comparison to the population of undergraduate physics majors, we expect that they will perform as average or above in the categories evaluated. Overall performance is discussed at our annual retreat in order to inform possible curriculum changes.

Advanced Laboratory:

The Advanced Laboratory is required of all students for graduation and serves as an additional way to assure that graduates have become proficient in standard laboratory skills. It is organized as an independent laboratory in which students conduct experiments of their choosing in consultation with a faculty member in order to satisfy specific competencies expected of a graduate with a physics major. For each competency, students receive a pass or a high pass, where a high pass indicates excellent work, approximately in the top 20% of the class. The advanced lab is based on a mastery approach in which students are required to demonstrate at least proficiency in each area and do not receive credit for a competency until the item is completed to the satisfaction of the faculty evaluator. There are 13 competencies required of all graduates:

1) Write an abstract that is suitable for submission to an external conference or meeting.
2) Prepare and present a 15 minute or longer oral presentation on a scientific topic.
3) Assemble a piece of equipment or instrumentation.
4) (2 times) Perform a quantitative measurement that is of historical relevance such as Frank-Hertz, Hall Effect, etc.
5) Perform a measurement involving low level electrical signals.
6) Perform a measurement involving low temperatures or temperature dependent behavior.
7) Perform an optical measurement such as taking and analyzing an atomic spectrum.

Comment [A13]: Multiple faculty are used to rate student performance helping to mitigate any potential error/bias due to only having one rater (Element III. D). In addition, using multiple raters allows the program to assess inter-rater reliability, which could be used as validity evidence in Element III. E. PASS can aid with conducting and interpreting reliability analyses.

Comment [A14]: Employing a common rubric helps standardize the rating process and ensure that the scores reflect student performance on the specified learning objectives. This is a strong methodological practice when using performance assessments and relates to Element III. D.

Comment [A15]: Inter-rater reliability evidence is provided showing good consistency across raters (Element III. E). This reliability evidence increases the support for the Senior Conference Exam (SCE) scores as a useful assessment tool.

8) Develop a computer program on a standard language such as FORTRAN, VB, Java, or C++.
9) Interface a PC with a piece of instrumentation using LabView or equivalent.
10) (2 times) Prepare a referenced, complete report of an experiment you have performed.
11) Prepare a clearly written set of instructions for an experiment you have performed.
12) Fit experimental data to equations using a least squares method showing the actual detail of the method (not using Excel or some other curve fitting program).
13) Show evidence of the ability to keep a well-documented lab notebook for an experiment that extends over at least several weeks.

By completing these competencies in consultation with individual faculty members, students demonstrate their proficiency in the required element. All 2012 graduates have successfully completed the advanced lab, with the exception of one student currently making up an incomplete.

Although individual projects completed by students are supervised by many different faculty members, there is one faculty member each semester who oversees the advanced lab. The overall performance of the students is discussed in our annual retreat to determine if there are general trends which need to be addressed earlier in the curriculum. For instance, a sense that students were weak in writing formal laboratory reports resulted in a decision to increase the emphasis on writing ability in a freshmen/sophomore level lab (PHYS 246-7).

While the two exams (ETS and SCE) address different skills, we plot the average SCE Foundations and Principles score for each student versus their total ETS Major Field Test score below. Each axis spans the entire range of possible scores on the assessment instrument. The performance on the two scales are somewhat correlated, despite the fact that the SCE focuses on a much more limited range of material than the ETS test. The correlation ($R^2 = 0.243$) is low, as might be expected, given that the assessments focus on very different skills.

In Figure 2, we show the relationship of the ETS assessments with student GPA , which shows a weak correlation.

We note that of much greater importance is the fact that approximately half of the 2012 graduates actively prepared for the Physics GRE test in preparation for applying to graduate school, a challenging multiple choice test that is comparable to the ETS Major Field Test in content and format. Students who studied intensively for the Physics GRE last fall performed better than those students who did not prepare. In fact, the top 6 (out of 13) performers on the ETS Assessment were students who met weekly with each other and a faculty member (Brian Utter) during the fall semester to prepare for the Physics GRE.

Comment [A16]: Also relating to Element III. E, the correlation between ETS exam and SCE exam scores provides evidence for concurrent validity (the tests are measuring similar concepts). Although the correlation is only moderate, this is to be expected because the exams are different in scope as noted by the faculty. However, the moderate positive correlation does provide evidence that the tests measure similar skills.

Comment [A17]: Providing the correlation between the assessment measure and another measure of student performance (e.g., grades) is another example of validity evidence (Element III. E). The positive correlation between the two measures provides additional validity evidence for the ETS exam.

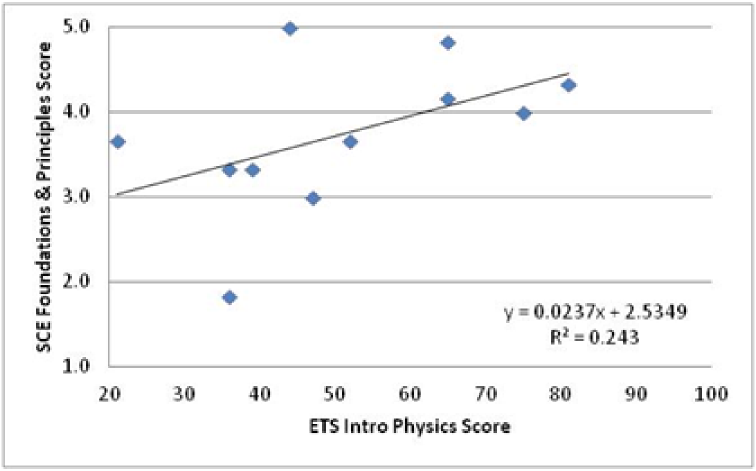

Figure 1. *Results on Senior Conference Exam Foundations and Principle score compared to total ETS Subject Field Test score for each student.*

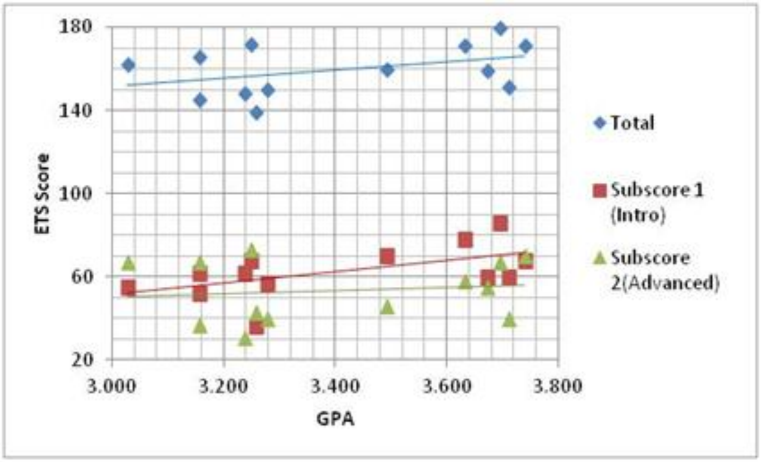

Figure 2. *Results on total ETS Subject Field Test score and each sub-score (Intro and Advanced material) compared to GPA for each student. There is a weak correlation with* $R^2 = 0.3$ *(Intro sub-score), 0.16 (Total score), and 0.01 (Advanced sub-score). The Advanced sub-score includes some elective material not required in the physics core.*

SCE Electromagnetism Theme:

Prior assessment results were used to select a focus area for the SCE. Out of the three faculty members, who each probe a line of questioning related to a particular question, one evaluator on each SCE focused on the area of electromagnetism. A series of possible questions that could be asked during the SCE was developed in consultation with the instructors of related courses. They are as follows:

- Set up a very general integral calculation of the electric field. Assume a localized charge distribution and find the E-field outside the charge distribution. (e.g. for a uniformly charged spherical shell of charge density rho, determine the electric field inside, within the shell, and outside the shell.)

- Determine a magnetic field near a current-carrying wire. Given a particular geometry of current-carrying wires, what is the B-field?

- Velocity selector: Given a B field, use two parallel and oppositely charged plates to construct an E-field to produce a velocity selector. e.g. what velocity is selected? what is the range of velocities selected?

- RLC Circuits: Using a combination of capacitors resistors and inductors (for instance, an R + C in series that is in parallel with a 2R + L in series). What is the current for high frequency and low frequency ac voltages.

- Capacitors: Determine the capacitance of a parallel plate capacitor. Determine the new capacitance if you insert a dielectric. Determine the capacitance if the dielectric is either thinner than the gap or covers only a fraction of the area.

- Capacitors: A circuit consists of two parallel plate capacitors of capacitance C in series across a potential V. If a slab of dielectric material of constant k is inserted into one of the capacitors, determine the total energy stored in the capacitors, the work done by the electrostatic force on the slab as it is inserted, and the energy supplied by the voltage source. What if you instead have a charged capacitor that is not connected to a voltage source?

- A charge q is placed above an infinite grounded conducting plate. Determine the potential above the plate. Determine the induced charge density on the plate and show that the total induced charge is -q.

The results of each of these instruments are discussed at the annual departmental retreat in order to provide a mechanism for programmatic change based on these results.

IV. Objective Accomplishments/Results

Physics Major Field Test

2011-2012Data:

The Educational Testing Service (ETS) Major Field Test for Physics is an instrument designed to measure physics content knowledge for senior physics majors. It was administered in February 2012. The total score is broken down into two sub-scores. The introductory physics covers topics normally covered in an introductory college physics course (classical mechanics/relativity, electromagnetism, and optics/waves). The advanced sub-score covers all other advanced topics (quantum mechanics and special topics). The total score is scaled to a range of 120-200, while the two sub-scores are scaled to 20-100. For each of the three categories: Total Score, Introductory Physics, and Advanced Physics, the mean results for JMU were not found to be statistically different from the National mean results for institutional means for 2004-2009 national results at 95% confidence interval.

Comment [A18]: Excellent use of statistical analysis to test whether JMU physics students scored differently than the National average. Use of statistical analysis is a component of achieving an exemplar rating on Element IV. A.

	JMU	National Average
Total	160 ± 12	149.6 ± 15.8
Sub-score 1	63 ± 12	48.7 ± 8.2
Sub-score 2	53 ± 15	49.6 ± 7.8

Comment [A19]: Clear table comparing graduating physics student performance to the national average. Recall that the program's desired results was that students score above the national average. Clarity of results is encompassed by Element IV. A.

Table 1. *JMU and national average scores for the ETS Major Field Test.*

As a student population compared to other universities with at least 5 test takers, our overall score is at the 89th percentile, sub-score 1 is at the 95th percentile, and sub-score 2 is at the 70th percentile. The 2012 graduating class includes a higher percentage of graduate school bound students, many of whom prepared for the Physics GRE test. As a result, the performance on the ETS assessment was quite strong.

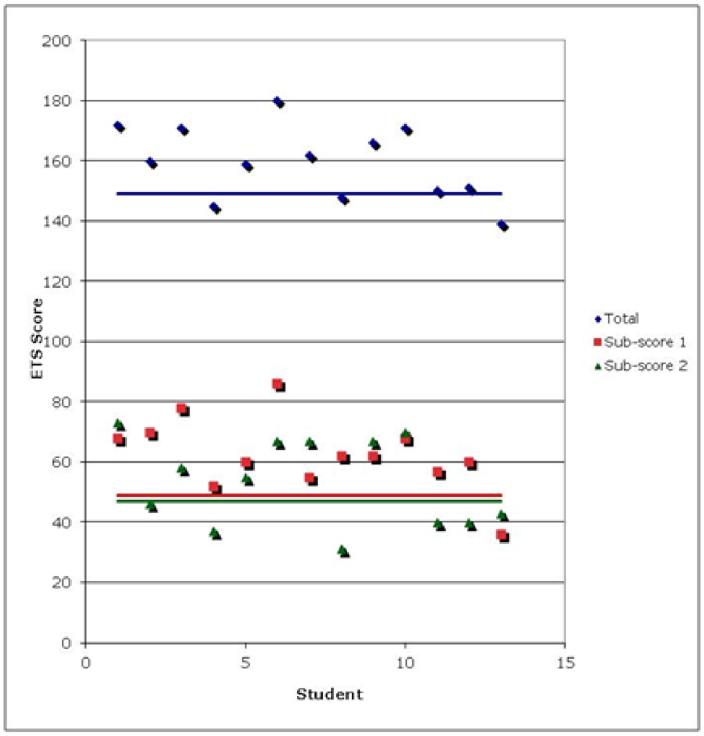

Figure 3. *Results of the ETS Major Field Test (Physics) for 2010-2011. Mean values for JMU students are indicated by the horizontal line.*

Additional assessment indicators, such as: mechanics & relativity, electromagnetism, optics/waves & thermodynamics, quantum mechanics & atomic physics, and special topics gave the following percentile results compared to national institutional results in 2004-2010. Mechanics & Relativity 94th percentile, electromagnetism 93rd percentile, optics/waves & thermodynamics 92nd percentile, quantum mechanics & atomic physics 71st percentile, and special topics 76th percentile. Compared to 2010-2011, the mechanics & relativity increased from the 65th to the 94th percentile, the electromagnetism score moved from the 30th to the 93rd percentile while the optics/waves & thermodynamics moved from 80th to 92nd percentile. Quantum mechanics & atomic physics moved from 50th to 71st percentile, and special topics moved from 10th to 76th percentile.

Comment [A20]: The following breakdown of subscores explicitly relates to the program's objectives. Clearly detailing how the results relates to the objectives is an important component of Element IV. A.

Comment [A21]: The program provides a history of results (Element IV. B), which facilitates trend analysis.

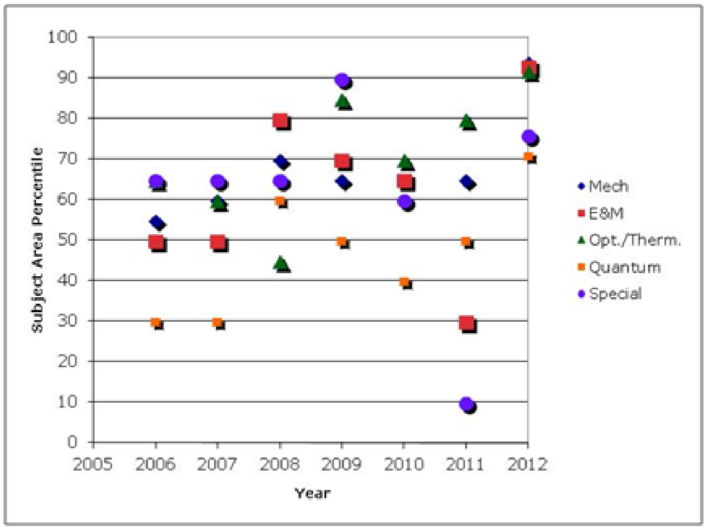

Figure 4. *Percentile for JMU students on each of the 5 sub-categories assessed by ETS: Mechanics, Electromagnetis, Optics/Waves/Themodynamics, Quantum Mechanics, and Special Topics. Performance was quite strong due to an above-average class of which half actively prepared for the physics GRE exam (a similar exam in content and style to the ETS assessment).*

Senior Conference Exam

In Figure 4, the SCE results for 2011-2012 are compared to historical data. For each of the measured dimensions, there were no statistical differences between the means (at an alpha = 0.05) compared to previous years. Data used to create this figure is presented in Table 2.

Comment [A22]: This program presents history of results for several in instruments. This is exemplary practice related to Element IV. B.

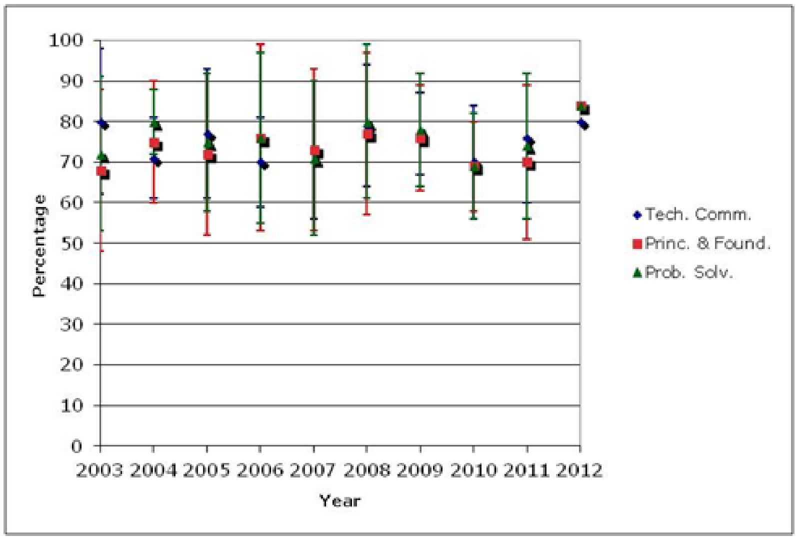

Figure 5. *The Senior Conference Exam (SCE) evaluates students in three major areas, Technical Communication, Principles and Foundations and Problem Solving skills. The results of this exam are summarized in this figure.*

	2010-2011		Five Year 2004-2009 Running Average	2009-2010		2008-2009		2007-2008		2006-2007		2005-2006	
Sample Size	**13**		**15.25**	**15**		**16**		**16**		**15**		**14**	
Measured Dimension	**Mn**	**sd**	**Mn**	**Mn**	**sd**	**Mn**	**sd**	**Mn**	**sd**	**Mn**	**sd**	**Mn**	**sd**
Technical Com.	80	15	73.8	76	16	70	14	77	10	79	15	73	17
Principles& Foundations	84	12	74.2	70	19	69	11	76	13	77	20	73	20
Problem Solving	84	12	74.8	74	18	69	13	78	14	80	19	71	19

Table 3. *Senior Conference Exam (SCE) Results and Comparisons 2005-2011*

Comment [A23]: This table juxtaposes current and past scores for easy analysis of trends (Element IV. B).

As of two years ago, a common scoring rubric is now used by the faculty when making their evaluations. The rubric is found in the appendix to this document. As expected, the range of performance is much larger than the drift in performance from year to year. However, the increase for the current class year correlates with the increase in performance on the ETS exam and the larger fraction of students preparing to enter graduate school in physics or a related field.

Results from SCE Electromagnetism Theme:

The assessment results in general were discussed among the faculty at the annual departmental retreat in May 2012. Reactions to the SCE theme suggest that students are performing roughly at the expected levels. That is, students with strong classroom performance tended to do quite well and academically weaker students struggled more.

Comment [A24]: This statement implies that multiple faculty discussed and interpreted results. Such practice shows ownership of the process across program faculty, an indicator of exemplary performance for IV. C.

Results from this discussion, including actions to be taken include:

• An advanced block course on "Electromagnetism 2" is being developed and will help address some of the deficiencies.

• We will continue with the focus on electromagnetism next year in order to gather more data on this subject.

Results from Student Feedback and Faculty Discussion

As described above, we also solicit feedback from students, asking them to describe aspects of the physics major they find particular good and aspects that they would prefer to see changed. These comments were presented and discussed at the departmental retreat in May 2012.

Positive feedback mentioned by more than one student include:

• Appreciation for the new Advanced Laboratory course structure (*change instigated by prior assessment*)

• Research experiences available are a strength of the program

• Student lounge and personal connections are valued

Negative feedback mentioned by more than one student include:

• A mathematical methods course is needed

• We should offer advanced courses in electromagnetism and quantum mechanics

• There should be increased use of math computer tools and computer programming

These and previous comments have led to the following actions:

1. The positive feedback for the reorganization of our Advanced Laboratory course from a single 3-credit course to a series of three 1-credit courses (244, 245, and 246) demonstrates the improvements we made last year in this course sequence. This change was made directly as a result from comments in prior Senior Conference Exams.

2. A mathematical methods course and advanced electives in electromagnetism and quantum mechanics are currently under development and these will directly address the first and third critiques above. This course has been discussed by the faculty during the past year in response to feedback in last year's assessment. A faculty group (chaired by Kevin Giovanetti) has proposed a rough course outline, which was approved by the faculty. They are now working towards a specific outline/syllabus in order to offer the course.

3. The topic of computers in the curriculum (point 4) is an ongoing issue that we will continue to discuss as a faculty next year.

Advanced Laboratory

Students completed the advanced laboratory successfully as a cohort according the the course coordinator in discussions at our departmental retreat. It was determined that no further action is currently needed as students settle into the current course format.

Connection to Learning Objectives

The assessment results can be mapped back onto the learning objectives described above:

Objectives	Brief Summary	Proposed Actions
1.1	Adequate performance based on Senior Conference Exams	None
1.2, 2.1, 3.1, 3.2	Strong performance based on ETS Assessment in part due to preparation for Physics GRE exam by a large fraction of graduate school bound students	While motivated for the Physics GRE, this preparation (in the previous semester) clearly solidified core knowledge. We will continue to support students interested in preparing for the GRE by facilitating weekly GRE preparation meetings in the fall.
3.3	Good performance based on Senior Conference Exams	None
4.1, 6.1	Students demonstrate proficiency based on performance in Advanced Laboratory	Continue the ongoing process of encouraging students to accomplish competencies throughout the semester.
5.1	Adequate performance, but requests in Senior Conference Exams for additional computer modeling experience	Current discussions include offering a freshman-level computational course and offering an upper-level elective which has only been taught once in the previous 8 years. Each would offer additional opportunities to pursue computational physics.
6.2	Strong performance based on many opportunities to present and satisfy Advanced Lab requirements (departmental research symposium, summer research symposium, region and national conferences)	We will continue to encourage students to present research data through posters and talks beyond the proficiency requirements in Advanced Lab. Students also have more opportunities to tutor and serve as learning assistants, which are additional avenues for informal discussion of physics.

Comment [A25]: The following table summarizes the results and directly relates them to each of the program's objectives. Explicitly mapping the results in relation to the objectives should facilitate identification of strengths and weaknesses. A clear and direct mapping relates to Element IV A on the APT rubric.

V. Dissemination

The assessment results are now discussed among all full-time faculty as a routine part of our annual departmental retreat in May. This is a natural time to discuss larger issues such as programmatic assessment, student performance, and potential changes within the curriculum and department. In addition, while the Assessment Coordinator leads the conversation with input from the Advanced Lab instructor, the entire faculty is able to comment in order to produce a coherent picture of our graduates that includes as complete a picture as possible. As described in Section IV, a number of improvements to the program have been made or are currently being pursued based on the results of the assessment process. Historically, the department is successful in continuing these discussions in the fall and pursuing issues which need to be addressed.

Comment [A26]: The following paragraph documents how the program disseminates results. All faculty are included in the process. Dissemination relates to Element V.

Beginning this year, we provided students with the results of the ETS test for their own self-evaluation. In addition, we provide informal feedback on their performance in the Senior Conference Exam by identifying their strengths and thanking them for taking part in the assessment process.

This assessment report will also be distributed to the entire physics faculty and will be available for distribution to the administration and external reviewers of the program.

VI. Uses of evaluation/Assessment Results and Actions Taken

Many of the improvements made based on assessment results were described in section IV. These include:

Comment [A27]: Improvements to the Physics BA BS curriculum documented in this section directly relate to the results of the assessments. Element VI. A.

1. Reorganization of our Advanced Laboratory course from a single 3-credit course to a series of three 1-credit courses (244, 245, and 246) last year, which is now receiving positive feedback from students. This change was made directly as a result from comments in prior Senior Conference Exams.

2. A mathematical methods course and advanced electives in electromagnetism and quantum mechanics are currently under development. These courses have been discussed by the faculty during the past year in response to feedback in last year's assessment. A faculty group (chaired by Kevin Giovanetti) has proposed a rough course outline, which was approved by the faculty. They are now working towards a specific outline/syllabus in order to offer the course.

3. Increased attention to teaching as a possible career. Many opportunities to teach, both formally through a new Learning Assistant program and the Science and Math Learning Center and informally through outreach, are increasing both the career options and ability to communicate science effectively.

In April 2010, Dr. Brian Utter (Associate Professor, Department of Physics & Astronomy) assumed the role of the department's Assessment Coordinator. In May, he served as an Assessment Fellow at JMU's CARS (Center for Assessment and Research Studies), which has involved a broad evaluation of our departmental assessment practices. A number of changes to this year's assessment plan have directly resulted from this experience and the feedback from last year's APT. This includes (i) making learning goals/objectives more student-centered, (ii) adding assessable and specific learning objectives along with the broad goals (section I), (iii) making explicit the link between assessment instruments and learning objectives (section III), (iv) making explicit the results of assessments in regard to specific learning objectives (section IV), (v) inclusions of the Advanced Laboratory as an explicit tool for assessing laboratory skills, and (vi) including more information on correlation coefficients and connection between the ETS data and student GPAs. In addition, a large number of smaller changes were made, such as using more precise language stating that results get distributed to all faculty or that all graduating seniors are included in the assessment pool.

Comment [A28]: The program demonstrates critical evaluation of the previous assessment process by listing past considerations and changes. This is an important component of Element VI. B.

While it appears that we are on track with regard to our overall efforts, there are a number of efforts continuing in the upcoming years to improve the assessment process. These include (i) refining the specific objectives created this year in Section I, (ii) evaluating whether additional data could be gathered using our current Senior Conference Exam, and (iii) assessing the introductory sequence of courses in particular, as these courses impact a large number of majors, including Chemistry, Engineering, Biology, and others.

Comment [A29]: The Physics program presents specific intended improvements for the assessment process addressing Element VI. B.