Tuning USA Interim Report – Utah

November 18, 2009

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2. **Tuning Process in Utah** (See Sections 3 & 4 for items specific to History and Physics.)

   a. **Why did your state choose to participate in the Tuning project? What problems or issues did you hope to address?**
   Utah saw the Tuning project as a natural continuation of the work we had done for the previous 11 years to coordinate and define general education among the nine state institutions of higher education and with our "majors' meetings" coordinating courses and requirements in more than 30 disciplines.

   The kinds of issues we hoped to address fall into the categories of accountability / assessment, transparency, and equivalency. More specifically, we have been working for several years on accountability and assessment, and we saw the Tuning process as a possible way to define expectations in the disciplines so they are equivalent from institution to institution and are demonstrable, hence assessable. Only with demonstrated outcomes can institutions be accountable. But the adoption of demonstrable outcomes must come from faculty working together if these outcomes are to have a real impact. We already had faculty groups working through our annual majors' meetings, and we welcomed the extensions of that work made possible by Tuning. Many in our teams also saw Tuning as an opportunity to show students, parents, employers, other institutions of higher education, and government policy makers what our students are prepared to do, what they know, and what skills they have when they graduate with a degree in physics or history. This is the transparency advantage of Tuning. The idea that we would survey employers and bring some congruency between our work in higher education and the needs of employers was also attractive, especially since this interaction has been seriously neglected in the past.

   b. **What, if anything, happened in your state as a result of engaging in the Tuning process that might not otherwise have happened? (For example, were there unexpected outcomes of the collaboration among institutions, including work on transfer and articulation, conference/academic presentations, or other efforts or discussions that emerged as a result of Tuning?)**
   Tuning became a focus of our annual "What Is an Educated Person?" Conference in 2009 (a conference with about 150 participants from throughout the state). The 2008 conference focused on Essential Learning Outcomes, which connected in a natural way to the Tuning discussions of outcomes. We have had the opportunity to present information on Tuning to the State Board of Regents, the Higher Education Presidents' Council, the Higher Education Chief Academic Officers, and several deans from Utah institutions, as well as the "What Is an Educated Person?" Conferences. We have made presentations at the Association for Institutional Research (William Evenson, Atlanta, June 2009 – with Cliff Adelman) and State Higher Education Executive Officers Policy Conference (Teddi Safman, Denver, August 2009). We have been invited to present at the Western Academic Leadership Forum in April 2010.

The Tuning process has involved in depth discussion of outcomes and levels of expectation among representatives of history and physics departments across the state. There has also been discussion in the Tuning teams of correct strategies to involve their respective departments in local discussion of the outcomes and their curricular and assessment implications.

The two-year institutions were able to focus on the implications for their programs of preparing students to transfer to four-year programs. So far, this has been a very healthy discussion; we hope it goes further and affects curriculum and assessment.

Several members of the team began as serious skeptics. In particular, they did not believe that this would be a faculty-driven process, but assumed from all of the necessary learning about the process they were being fed up-front that this would be very centralized in practice, with the expectation that institutions would shift to a common curriculum when it was over. After a few months, these fears abated due to the way the project was conducted – i.e. with serious faculty discussion and give-and-take on outcomes, but explicit avoidance of prescribing curriculum or programs to achieve the outcomes. Due in part to the faculty initiative in the process, we have adapted Tuning to our own needs – some are slightly uncomfortable saying that what we have done is Tuning as defined in Europe. Nevertheless, the motivations and goals are consistent with the previous work in Europe, and we have worked through a process that has been rewarding and productive.

c. <u>How did Tuning complement work that already was going on in your state?</u>

Utah has conducted faculty discipline majors' meetings for 11 years now, with representatives from each of the nine Utah System of Higher Education institutions for each of 32 disciplines. These groups meet annually. They review syllabi and texts to coordinate courses among the institutions. They identify competencies for successful transfer within the System. They discuss and determine content, pedagogy, and assessment practices. These majors' meetings have reinforced faculty ownership of the curriculum in their disciplines and have initiated discussions at the discipline level that include faculty from community colleges to those from research universities. These meetings have thus developed a level of trust and respect among faculty from diverse institutions, something that was essential for the Tuning process. Furthermore, the groundwork that was laid in the majors' meetings on curriculum has made it possible to explore discipline outcomes much more efficiently than would have been possible otherwise. Tuning has fit into the evolving agenda of the majors' meetings as a natural next step.

Utah established a Regents' Task Force on General Education in 1997. This group, with representatives from each of the nine public institutions in Utah, oversees issues of transfer, articulation, and assessment in the state and has helped develop state policy on general education. They established the "What Is an Educated Person?" Conference series, now in its 12th year, that involves academics from around the state and some years has included government leaders and representatives of business and industry. They are now planning another major conference aimed specifically at business and industry and government leaders in

April 2010. They have instituted research in Utah on student success factors, and two years ago they brought Cliff Adelman to the "What Is an Educated Person?" Conference to tell Utahns about the Bologna Process and Tuning. This led to ideas for an "Educational Resumé," analogous to the Bologna Diploma Supplement and to emphasis on learning outcomes, beginning with the high level outcomes identified in the AAC&U LEAP Program. The Task Force has served as an informal advisory body for the Utah Tuning project, and their work dovetails nicely with the goals of the project.

The Regents' Task Force on General Education has been pursuing for about three years the implementation of student e-portfolios to serve as "Educational Resumés." These are envisioned to include assessable evidence of the achievement of the learning outcomes applicable to the student's course of study. They can be used to demonstrate achievement to prospective employers, transfer institutions, parents, and other interested parties, in addition to being a record for the student herself. Several pilot projects with e-portfolios are currently underway in the Utah System. Tuning is helping us to specify demonstrable outcomes and levels of expectation that will be documented in these Educational Resumés.

d. <u>How did the array of institutional diversity affect the project? Also, were the right people involved?</u>

We worked with faculty and student representatives from community colleges, four-year colleges, comprehensive universities, and research universities. This range of perspectives proved valuable, especially for the diversity of experience with students in the first two years. Different perspectives brought diverse questions to the table and helped us craft outcomes and process in a way that worked for all of these levels of institution. We did have the right people involved: our teams were selected from the majors' meeting participants who had been appointed by department chairs. In the process of forming the teams, we consulted chairs and deans and informed chief academic officers. These campus leaders helped us make substitutions from the majors' meetings groups where necessary. The advantage of forming our teams from the previously constituted majors' meetings groups was that these faculty members were already acquainted, had developed a level of respect, and trusted one another. Our student members were selected in consultation with department chairs.

e. <u>If your state picked an academic discipline or disciplines that had previously been "tuned," to what extent did you rely upon existing Tuning materials from Europe or elsewhere? How helpful was the advice from European experts?</u>

Both physics and history were previously "tuned" in Europe. They read the European reports. These reports guided us in the kinds of questions to ask and the form of the various elements of the process that we reached. The content of our results was not so influenced by the European reports, even though the reports gave us a starting point. Rather, we arrived at our results through discussion and analysis of the reality of teaching physics or history in our diverse set of institutions, a reality that is quite different from that in European higher education. So the European report and experts provided an important framework within which we carried out the

project. Without the report and the experts, we would not likely have achieved as much in these few months.

f. <u>If your state picked an academic discipline or disciplines that had not previously been "tuned," how did this affect the project?</u>

Not applicable.

g. <u>What barriers or obstacles did each group encounter? (For example, how did state budget cuts affect the project?) How were these challenges addressed?</u>

It was indeed fortunate that the Lumina Foundation for Education provided full funding for this project. Without that funding we could not have carried it out. With it, we were able to engage the process rather fully. Lumina paid the part-time salary of the project director; again a necessity in this difficult economy. Without being able to bring in this additional part-time person, we could not have managed the project in our System, where we have unfortunately lost personnel over the period of the project.

The other major challenge was simply the workloads of many of our team members. For some of the two-year institutions, the faculty member on our team is the only physics or history faculty member at the institution. The demands on these faculty members are heavy, and adding another project is very difficult. For this reason, we held many of our team meetings by IP-video, so we could at least eliminate the travel time to those meetings. Of course, we also adjusted assignments as needed.

As will be discussed in Section 10 on the surveys, it was initially somewhat complicated to get IRB approvals for our student surveys. This was done differently on every campus, but we were able to work out a standard procedure that was accepted by all the IRB Chairs in the System.

h. <u>What were viewed as the strengths/weaknesses of the process?</u>

One weakness of the process was the front-loading of a huge amount of information about a process that most of our teams were completely unfamiliar with at the beginning. Even the language of Tuning developed in Europe was entirely unfamiliar. That information had to be digested just to get started, and the process of learning about the process fed on fears that this was really a top-down project. We got over those fears, as discussed above, but we had to spend a lot of our limited time on the project learning about the process and putting it in proper perspective.

A second weakness was the initial focus on surveys. The faculty needed to discuss the expectations of their discipline, and the surveys diverted them to a somewhat mechanical aspect of the project. We moved on from that, as discussed elsewhere, but with the effect of delaying the survey part of the project beyond the 8-month (April-November) project timeline.

The Tuning process as outlined for us needs more attention to the role of employability in defining qualifications. Employability is important, but it must be kept in perspective so that degrees are not driven to become too narrow.

The most important strength of the process for us has been the opportunity for faculty rethinking and definition of the discipline. The teams took the project and made it their own, thereby reinforcing both faculty ownership of and faculty responsibility for the disciplines. This took some time, and there were skeptics on the team for the first 3-4 months. The fact that they were won over testifies that this process can work in the US context.

Another strength is that the in-depth faculty discussions established foundations for discussions within the departments in individual institutions. The team has reached this point eager to help their colleagues in their home departments begin to profit from the definition of measureable outcomes produced in this project.

The flip-side of the previous comment is that this project has also furthered the System-wide conversation that we have endeavored to foster through the Regents' Task Force on General Education, the "What Is an Educated Person?" Conferences, and the Majors' Meetings.

A final strength of the process is that it has brought us into participation with an international discussion, providing greater confidence in our results as well as access to a much wider pool of thought on educational processes.

i. <u>How does the process differ from other learning outcomes efforts?</u>

The Tuning process focuses explicitly on employer and alumni feedback for guidance, as well as student and faculty input. This focus is different from other learning outcomes efforts in the disciplines. While we have not finished gathering the survey information from employers and alumni, we are in process and intend to complete that work and factor it in to our efforts to implement the results of this process in the individual institutions.

Second, while some disciplines have established explicit learning outcomes for their majors, physics has not done so on a national basis. Furthermore, very few of the learning outcomes efforts have been carried out at the discipline level; more often, they have started at the institution level. Tuning complements overarching sets of learning outcomes at the institution level, like the Essential Learning Outcomes (ELOs) proposed by AAC&U's LEAP Project by drilling down to demonstrable outcomes appropriate to each discipline in addition to generic outcomes that are the wider responsibility of the institution, or the joint responsibility of several disciplines.

Finally, we seek to define measureable outcomes that allow us to provide a guarantee to transfer institutions, to employers, and to state policy makers of what our graduates represent. This goes well beyond other learning outcomes efforts.

j. **<u>If one or more of your work groups deviated from the process outlined during the Chicago convening, please explain these changes and why they were made so that we have a better understanding of how Tuning applies in the Tuning process?</u>**

As will be discussed in Section 10 on the surveys, we surveyed students early, to get ahead of the early semester ending in our institutions. The semesters ended in April, so we had a very narrow window to reach these students before fall. However, it quickly became clear that the surveys were taking too much attention away from the work of thinking through learning in the discipline. The Team needed to focus on learning outcomes and benchmarks for levels of expectation, so we put the other surveys on hold, to be handled as much as possible by the project director with whatever help he could find. So the surveys were de-emphasized, and some are still in process. But this allowed us to work through outcomes, benchmarks, and degree profiles in a more thorough and useful way.

k. **<u>What lessons have you drawn from this project? What differences, if any, were there in how the process was perceived by the SHEEO office? Participating faculty members? Non-participating faculty members in the disciplines with participating faculty members?</u>**

This project has reinforced our views of the need for faculty to grapple with their disciplines jointly, especially across a diversity of institutions. Faculty need the insights that come from alumni, employers, and students in their development of expectations in the disciplines. The system-wide discussion provides a foundation and develops leadership for departmental discussions at individual institutions.

3. History Tuning Process in Utah

a. How did Tuning complement work that already was going on in your state?

The historians welcomed the chance to bring further focus to concerns expressed in the state-wide majors meetings about the role of history programs in higher education.

b. How did the array of institutional diversity affect the project? Also, were the right people involved?

Because of the several years of meeting as colleagues across the state, the historians were able to build on a level of trust that united us across institutions.

c. How did each group go about formulating the outcomes that define the academic discipline? Please describe the approach used and submit meeting agendas, if possible.

The historians referred to the report of the history Tuning project from Europe, but turned to the learning outcomes recommended by our professional organization– the American Historical Association—since many of us had been aware of that work of many years (see Section 6). The historians did meet face to face, but also did much of our collaboration electronically.

d. Were disciplinary or professional organizations consulted?

See above. Also consulted was the work at Georgia State University and the QUE project through American Association of Colleges and Universities. We also consulted the AACU project Liberal Education and America's Promise (LEAP).

e. In what ways were students involved in your Tuning work? What input or feedback did students provide, and how was it provided? What weight was student participation and input given?

The student member of the History Tuning Team was an undergraduate student attending the University of Utah. He was present at all meetings and involved in the electronic discussions. Some historians have agreed to hold student focus groups early in Spring 2010 in order to add some depth to the student surveys.

4. Physics Tuning Process in Utah

a. How did Tuning complement work that already was going on in your state?

See above, Section 2.c. Specifically related to Physics Tuning, we discovered several efforts underway or in the thinking stages to review physics curricula. This project was welcomed as furthering those goals.

b. How did the array of institutional diversity affect the project? Also, were the right people involved?

See above, Section 2.d. All of the comments in Section 2.d apply strongly to the Physics Team – it was valuable to include community colleges to research universities, and the right people were involved, in every case leaders in their departments and people with influence on both curriculum and assessment.

c. How did each group go about formulating the outcomes that define the academic discipline? Please describe the approach used and submit meeting agendas, if possible.

The Physics Team met frequently (meeting agendas attached as an appendix) and considered categories of outcomes that are essential. They referred both to the report of physics Tuning from Europe and, mainly as individuals, to information from the professional organizations: American Institute of Physics, American Physical Society, and American Association of Physics Teachers. The team discussed proposed outcomes at length and achieved consensus on the main "themes" of physics learning outcomes and on the list of specific outcomes under each "theme." They arrived at seven "themes," each with multiple bullet points of specific outcomes attached. (See Section 7, below.)

d. Were disciplinary or professional organizations consulted?

The three relevant national physics organizations are American Institute of Physics (AIP), American Physical Society (APS), and American Association of Physics Teachers (AAPT). AIP, in particular, has collected considerable data on physics employment. None of these organizations prescribes curricula or learning outcomes, but APS and AAPT have committees dealing with physics education at various levels. We did not consult the organizations directly, but we used materials from their web sites. This was not done formally, but by individuals bringing this information into the team discussion. Given more time for the project, we would get more directly involved with the disciplinary organizations.

e. In what ways were students involved in your Tuning work? What input or feedback did students provide, and how was it provided? What weight was student participation and input given?

We had a student member on the Physics Tuning Team who participated fully. He gave thoughtful opinions in our discussions of outcomes and benchmarks, and he organized a meeting with other students to discuss the issues raised in the Tuning process. His report of that meeting is attached in the Appendix. The physics student was a mature re-entry student who

finished a BS in physics at Utah Valley University in Spring 2009, after the project began. He began graduate work in physics in the fall at University of Utah. Because he is now familiar with two rather different institutions in the Utah System, he has been able to offer especially useful insights. Given his age and perceptiveness, he was accepted as a colleague in the Tuning discussions.

5. **Suggestions of next steps for advancing these discussions.**

a. **Do your academic discipline work groups intend to continue this work? Why, or why not?**
Yes, with less frequent meetings. They will coordinate each year in the Majors' Meetings, and they will meet as they can in between. They will address the implications on what has been done so far of the surveys that are still underway. They will also share experiences and ideas about sharing the results of the Tuning process with their individual departments.

b. **What do your state's work groups view as the next logical steps for expanding and deepening the Tuning work?**
An important next step would be the development of an Educational Resumé e-portfolio template for students. Students would be required to give evidence in their Educational Resumé of accomplishing the learning outcomes at the levels specified in the benchmarks for their disciplines.

A second suggestion is to extend the Tuning work in physics to the PhD level.

Third, we would consider developing inventories in the disciplines of what we are doing well and what is not working in the current approaches relative to the Tuning outcomes and benchmarks.

Fourth, our groups believe it is important to give some attention to student workload issues related to our learning outcomes and how these relate to the current credit system in US higher education. The relationship between workload and credit hours varies between disciplines, due in part to historical developments, so this work could profitably begin in individual disciplines.

Faculty workload is another essential concern if we are to make real progress with the big issues raised by Tuning.

Finally, we believe it would be appropriate to expand the Tuning project to additional disciplines in our state and to selected disciplines in other states.

c. **If you could do further work in this area, what would it be?**
Educational Resumés, as discussed above. We would like to bring aspects of our work with the two disciplines, history and physics, to closure and then expand to other disciplines in Utah.

d. **Who needs to hear about this work, and why?**
Accrediting organizations and Higher education leadership groups so they can learn about the accountability and assessment possibilities in Tuning.
Discipline professional associations so they can work on a national disciplinary basis to develop learning outcomes and benchmarks.

State and federal policy makers, employer groups, Chambers of Commerce education committees so they can learn about the potential for transparency and accountability inherent in Tuning.

6. Clear expression of learning outcomes by academic discipline and level: History in Utah

The historians adopted the following learning outcomes as defined by the American Historical Association. http://www.historians.org/teaching/ACE/Taskforcereport.cfm
(See also: Katz and Grossman, "The History Major and Undergraduate Liberal Education, Report of the National History center Working Group to the Teagle Foundation," Sept. 29, 2008.
http://www.historians.org/perspectives/issues/2008/0812/0812nhc1.cfm

- *Historical Knowledge* --(a command of a substantial body of historical knowledge)
- *Historical Thinking* –
  - recognizes the "pastness" of the past (awareness of continuity and change over extended time spans) .
  - - recognizes the complex nature of past experience (a command of comparative perspectives, which may include the ability to compare the histories of different countries, societies, or cultures)
  - - recognizes the complex and problematic nature of the historical record (appreciation of the complexity of reconstructing the past, the problematic and varied nature of historical evidence)
- *Historical Skills* –
  - skills in critical thinking and reading (ability to read, analyze and reflect critically and contextually upon contemporary texts and other primary sources; an ability to read, analyze, and reflect critically and contextually upon secondary evidence, including historical writings and interpretations of historians)
  - - research skills (ability to gather and deploy evidence and data to find, retrieve, sort and exchange new information)
  - - construct reasonable historical arguments (ability to design, research, and present a sustained and independently-conceived piece of historical writing; ability to address historical problems in depth, involving the use of contemporary sources and advanced secondary literature)

The American Historical Association has also issued in 2008 "Internationalizing Student Learning Outcomes in History: A Report to the American Council on Education," which includes language which guided the History Tuning Group.
http://www.historians.org/teaching/ACE/Taskforcereport.cfm#skills

Discipline-specific outcomes – students taking history courses will come to:

- Recognize connections between the past and the present; i.e., locate both self and others in time and spaces
- Acquire familiarity with the uses—and the limitations—of historical comparison as an analytic tool
- Grasp temporal relationships and integrate multiple chronologies within the same analytical frame of reference

- Demonstrate the capacity to deal with differences in interpretation
- Critically analyze narrative structures and construct narratives
- Demonstrate an ability to recognize and interpret multiple forms of evidence (visual, oral, statistical, artifacts from material culture)
- Recognize the distinction between primary and secondary sources, understand how each are used to make historical claims

Transferable skills/general competencies

- the ability to recognize and analyze change over time and space,
- to handle diverse forms of evidence, and
- to master forms of written, oral, and visual expression that facilitate communication with peoples of other regions and cultures. The goal should be to provide all students with ways of approaching the world and thinking about themselves in the dimensions of time and space.

Benchmarks

As the History Tuning Group continues its discussions about specific outcomes and specific student experiences, we will be considering this model recently sent to Norm Jones, USU, from Margaret McGlynn, Associate Professor, Department of History, University of Western Ontario, http://www.ssc.uwo.ca/history/faculty/mcglynn/

Recommended expectations and outcomes for first year classes:

- Content delivery
    - Introduction to fundamental structures and transformations leading to the modern world.
- Familiarity with the library and electronic resources
- Full understanding of plagiarism and its problems
- Basic primary source skills
    - What are primary sources?
    - Authorship and audience
    - *Veritas et Utilitas*: Truth and Usefulness
- Basic secondary source skills
    - What are secondary sources?
    - Secondary sources as interpretation
    - Dealing with different interpretations
    - Synthesis of extensive reading
- Basic paper-writing skills
    - Organization
    - Footnoting
- Participation and communication skills
    - Small group discussion

[These aims might be best achieved with short, focused frequent assignments.]

Recommended expectations and outcomes for second year classes:

- Content delivery
    - The examination of nations, regions and historical themes
- Content diversification: the opportunity to experience
    - new fields
    - new approaches
- Intermediate primary source skills
    - Close reading
    - What do they tell us beyond the obvious?
- Intermediate secondary source skills
    - Identifying thesis and argument
    - Identifying sources
    - Critiquing [article-length texts]
- Basic research skills
    - Integration of primary and secondary sources
    - Framing research questions
- Intermediate writing skills
    - The thesis statement
    - Developing an argument
- Participation and communication skills
    - Effective argument and exchange

[These aims might be achieved by a combination of short assignments and a final "research paper" of c. 8-10 pages.]

Recommended expectations and outcomes for third year classes:

- Content delivery
    - intensified detailed and conceptual knowledge of more specialized subjects
- Primary source skills
    - analysing rhetoric
    - understanding the structure and presentation of a document
    - situating the source in relationship to other primary sources
- Secondary source skills
    - understanding and questioning author's evidence, thesis and argument
    - situating, analyzing and assessing historical works in their historiographical contexts and traditions
    - exposure to a variety of theoretical approaches to historical analysis
- Research skills
    - generating own research questions for written assignments
    - developing skills of detection and inquiry
    - combining a variety of sources (eg primary sources, secondary sources, oral history, works from different disciplines) in written and oral assignments
- Writing skills
    - writing effectively in longer assignments
    - integrating a wide variety of primary and secondary source materials into written work

- Participation and communication skills
    - student-led presentations and class discussions
    - self-directed learning
- Overall
    - reinforcing and refining skills developed in first and second year courses
    - devising individual explanations and interpretations
    - thinking laterally across disciplines, subjects, time, themes, regions and nations

Recommended expectations and outcomes for fourth year classes:

- Content delivery
    - The expectation is that students will add to their own knowledge base through active directed reading in highly focused courses.
- Primary source skills
    - Extensive and sophisticated engagement with primary sources is expected, possibly at an archival level.
- Secondary source skills
    - Students are expected to be familiar with the historiography of the field and to engage it directly in their own research and writing.
- Research skills
    - Students are expected to develop their own research questions in consultation with faculty and pursue them through all available and appropriate primary and secondary sources.
- Writing skills
    - The development of a complex and sustained historical argument, properly supported with evidence from primary and secondary sources.
    - The presentation of that argument in clear, correct and compelling prose.
    - The proper documentation of the research process through footnotes and bibliography.
- Participation and communication skills
    - Engagement with peers in discussion of both source material and the process of writing history.
    - The clear and effective presentation of the student's own research
    - Positive and effective discussion of other students' research.
- Overall
    - Drawing on the skills and insights of years one through three to produce historical work which is original to the student.

7. Clear expression of learning outcomes by academic discipline and level: Physics in Utah

a. discipline-specific outcomes for physics

For each of the competencies listed below, the student will demonstrate

1. Understanding of the Nature of Science and Nature of Physics

- Understanding of the role of evidence
- Understanding of the role of experiment in physics
- Understanding of the role of research in physics and the variety of approaches to research
- Understanding of cause and effect
- Understanding of scientific ethics
- Understanding of science as a community effort
- Understanding of major historical threads in the development of physics

2. Mathematical Skills, Modeling Skills, and Problem Solving Skills

- Algebra, calculus, and manipulation skills
- Understanding of the meaning of mathematics in physical context:
  - Ability to connect physical quantities and algebraic symbols
  - Understanding of the physical meaning of vector algebra
  - Understanding of the contexts for equations
- Estimation skills
- Graphical skills and interpretation
- Ability to build physical models by abstracting the most important concepts
  - Understanding of what one can learn from simple models
- Ability to build and work with mathematical models
  - Ability to cast story problems into mathematical models
  - Ability to explain the physics in a mathematical model
  - Ability to explain the differences between problem solving and modeling
- Ability to map problems to new problems with similar mathematics but different physics
- Ability to organize problems by identifying physical principles, identifying relevant vs. irrelevant quantities, and making appropriate diagrams
- Ability to organize quantitative information by clearly stepping through the mathematics of the problem solution

3. Understanding of Physics Concepts

- Basic understanding of the major threads of physics concepts: conservation laws, forces (gravity, e&m), fields, Newton's laws, work and energy, optics, thermodynamics, relativity, quantum mechanics
- Understanding of contexts of physics applications by identifying key elements in the functioning of an arbitrary physical system and relating them to model construction

4. Laboratory Skills

- Skills necessary for safe practice
- Understanding of and commitment to laboratory safety
- Ability to carry out error analysis, understanding what errors mean

- Understanding the primacy of data in physics
- Understanding how to evaluate data quality and the importance of such evaluation
- Understanding how things get measured
- Understanding the connections between what one measures and how one infers the physical interpretation of the measurements
- Understanding how to collect, organize, and present data and connect it to physical principles

5. Scientific Communication Ability (written, oral, and visual communication)

- Writing ability: complete, punctuated sentences, organization, good logic
- Scientific writing ability: be able to explain in words rather than equations
- Presentation skills: informal presentations to peers, formal presentations
- Teaching ability at BS/BA and MS/MA levels; ability to impart knowledge to others

6. Computational and Information Skills

- Ability to use scientific packages intelligently
- Knowledge of the rudiments of scientific programming
- Ability to use Excel or similar; Maple, MatLab or similar computer algebra
- Understanding of numerical analysis
- Information literacy at appropriate levels

7. Research

- Ability to apply physics competencies semi-independently
- Ability to synthesize physics principles and applications
- Ability to present research motivations, findings, and significance

Categories of Physics Competencies

Knowledge – Themes 1, 3, 6, and 7
Skills – Themes 2, 4, and 6
Social Responsibility – Themes 1 and 5
Communication – Themes 5 and 7

Levels of Sophistication Developed as Students Study Physics

At each of the levels of sophistication described below, students will be able to demonstrate the following:

1) Ability to identify physical laws by name and to provide definitions of important terms related to the physical laws
2) Understanding of the meaning of physical laws and knowledge of their general formulas
3) Ability to apply the general formulas or concepts to specific limited situations
4) Ability to design or describe experiments that could test a specific formula

5) Understanding of the limits of validity of general formulas and the domains of validity of physical theories
6) Understanding how empirical science functions, i.e. the supremacy of experiment and observation in establishing physical theory
7) Ability to apply physical laws across different subdisciplines of physics and appreciation of common threads
8) Ability to construct specific formulas for specific situations from established general formulas
9) Understanding of general physical principles outside the context of their mathematical expression
10) Ability to construct mathematical models from general principles without reference to other specific, limited-use formulas
11) Ability to teach effectively and see where common pitfalls in understanding occur

It should be possible to make metrics from these levels (or a revision of them). For instance, for the 2-year level, we design metrics that expect sophistication up to level 3, for the BS/BA level we design metrics to test for sophistication levels up to level 7 or 8, and for the MS/MA level we make metrics looking for sophistication up to level 11.

Benchmarks: Examples illustrating the levels of expectation for 2-year, BS/BA, and MS/MA programs for each of the above seven physics competency "themes"

The following examples of levels of expectation are not intended to be prescriptive of curriculum or of particular ways to demonstrate achievement of the outcomes. They are illustrative and should be adaptable to other example problems. Their concreteness is intended to clarify, in a way that should be accessible to all physics faculty, what level of expectation is appropriate for students at the 2-year level, the BS/BA level, and the MS/MA level.

1. Nature of Science, Nature of Physics

The 2-year student should demonstrate the ability to

- Understand that physics is possible because nature is predictable *and* understandable; physics is interesting because nature is not *too* simple. Physical theories are based on patterns in nature, discernible by patient and objective observation and experiment.
- Understand that physics is not a collection of facts or tables of numbers, or even a set of immutable laws, but rather a process to gain knowledge about the physical world.
- Understand that scientific theories must be testable because physics theories are only an approximation of the true, underlying behavior. The testing of a theory allows it to be modified and refined towards a more accurate representation of nature.
- Identify causes and effects in various situations.

- Understand that the acceptance of scientific theories is based on evidence rather than authority or popularity.
- Understand the difference between, and mutual dependence of, science and technology.
- Understand that physics is the most fundamental and foundational of the sciences.
- Understand that physics is a human enterprise that requires as much creativity and passion as other human endeavors.
- Identify the typical portrayal of scientists in the popular media as incomplete stereotype.
- Understand that science can be applied ethically or unethically.
- Recognize pseudo-scientific claims by their reliance on authority, lack of objective evidence or obfuscation of sources.
- Understand that mathematics is both a tool and a language with which the ideas of physics are expressed and investigated.

The BS/BA student should demonstrate the ability to

- Do everything on the 2-year student list in addition to the following:
- Understand the interplay between theoretical and experimental progress in physics.
- Understand that science is, and how it is, more self-correcting than other disciplines or realms of human activity.
- Put major advances in physics in historical context and know about the people involved.
- Understand the difference between dependent and independent variables and controlling (for) variables in experiments.
- Develop the knowledge and determination to behave ethically in the scientific arena.
- Explain the difference between observational and experimental science.
- Understand the role of science in society and the importance of universal scientific literacy.
- Give a coherent summary of the major laws of physics in mathematical form, and show by example several areas of physics united by similar mathematical forms.

The MS/MA student should demonstrate the ability to

- Do everything on the BS/BA list in addition to the following:
- Understand, detect, and avoid various ways of committing scientific fraud.
- Explain the importance of historical context in physics and relate some of the stories behind the physics.
- Explain science as a community effort, how scientists collaborate, and how scientific knowledge is shared.
- Advocate for ways to increase scientific literacy in the general population.
- Explain some philosophical conceptions of scientific knowledge, e.g., falsification vs. verification, correspondence theory of truth, various interpretations of QM, etc.
- Explain the nature of science and physics to school and community groups.

2. Mathematical Skills, Modeling, and Problem Solving (3 Examples)

(1)

The 2-year student should demonstrate the ability to

- Categorize a problem and explain it conceptually; for example, recognize that energy is conserved as a mass oscillates on a spring and explain at what point in the motion the energy is potential, kinetic, or both.
- Recognize the known and unknown quantities of the problem and assign the appropriate algebraic symbols to these quantities.
- Select the equations involving the known and unknown quantities that are appropriate to solving the categorized problem. For example, they should select the equations that describe the kinetic energy and potential energy of the mass/spring system.
- Set up the complete equation that mathematically describes their problem; in this example, the conservation of energy of the mass/spring system.
- Solve a basic conservation of energy problem assuming a massless spring and ignoring friction and drag. A student should be able to algebraically manipulate the basic equations to solve for the desired variable, showing each step from beginning to solution.
- Recognize if their numerical answer is reasonable for the given problem.

The BS/BA student should demonstrate the ability to

- Do everything on the 2-year student list in addition to the following:
- Distinguish between relevant and irrelevant quantities given in a problem. They should understand what approximations can be made (the massless spring, ignoring air resistance, etc.) and justify their decisions.
- Determine and numerically solve the differential equations of motion for multiple springs and masses, the mass/spring system swinging as a pendulum, and/or include any rotational motion, friction, and air resistance appropriate to the problem.
- Design an experiment testing the validity of the conservation of energy in a mass/spring system. They should be able to analyze data and explain sources of experimental error.
- Present solutions to a problem; graphically and numerically explain the problem and solution to others.
- Recognize if a problem needs to be solved numerically instead of analytically.
- Employ the scientific method in problem solving.

The MS/MA student should demonstrate the ability to

- Do everything on the BS/BA list in addition to the following:
- Apply the conservation of energy principles to more complex systems. A student should have a greater understanding of the differential equations and their applicability to a variety of problems.
- Understandably teach problem solving methods to 2-year and BS/BA students.
- Recognize deficiencies in their skill set necessary to solve the problem and know how to overcome them. For example, they should recognize they need to obtain a particular math concept, and know how to self educate such a concept from the available resources.
- Solve problems at every stage of the scientific process (i.e. hypothesize, etc.)

(2) Example of levels of expectation for organizing a physical problem. Reference numbers refer to Levels of Sophistication (above).

The 2-year student should demonstrate the ability to

- Identify the physical principles that underlie a problem from the 2-year physics curriculum
  - Identify the relevant physical laws and know their names, e.g. Coulomb's law or Gauss's law (1)
  - Know the definitions of important terms or symbols in the relevant physical laws (1)
  - Be able to identify what formulas are relevant (2)
  - Be able to identify when a specific problem solving approach is the most expedient way of solving a given problem, e.g., when to use conservation of energy vs. forces/kinematics (3)
- Express the meaning of the relevant physical laws or principles in words (2, 9)
- Express the elements of the problem in terms of the symbols in the relevant formulas(3)
  - Correctly formulate the problem in mathematical terms (3)
- Draw appropriate schematic diagrams showing relationships among the elements of the problem, e.g. free-body diagrams (3)
- Estimate the order of magnitude of the expected result from general physical principles, independent of calculating from a formula (3)

The BS-level student should demonstrate the ability to

- Do everything on the 2-year student list, but for the <u>more sophisticated problems</u> in the B.S. curriculum. In addition, the B.S.-level student should be able to:
- Suggest experimental tests of the validity of the model embodied in the problem as the student has set it up (4, 5)
- Recognize the same mathematical problem or model in different physical contexts, e.g. gravitational fields and electrostatic fields (7)
- Specialize general formulas for specific problems (8)
- Determine mathematically the conditions under which simplifying assumptions can be made, e.g., when the Coriolis effect can be neglected for projectile motion (5)
- Set up problems in more complicated geometries, e.g. two- and three-dimensional problems or curvilinear coordinates
- Estimate the order of magnitude of expected results for problems involving multiple physical concepts

The MS-level student should demonstrate the ability to

- Do everything on the BS-level student list, but for the <u>still more sophisticated problems</u> in the MS curriculum. In addition, the MS-level student should be able to:
- Set up problems combining several subfields of physics, e.g. mechanics and electricity & magnetism (7)
- Use curvilinear coordinates extensively and with facility in physics problems
- Teach problem organization and solving effectively to 2-year and BS-level students (11)
- Incorporate advanced mathematics (e.g., complex analysis, group theory) into problem solving (8,10)

(3) [Note: This is drawn significantly from Knight's *Instructor Guide for Physics for Scientists and Engineers* where he quotes from the physics education research.] **Problem Solving Skills**

1. Given a variety of problems, can the student sort them into meaningful categories? Can the student identify the underlying physical principles, and determine whether the problem would be best solved by using Newton's laws, one or more of the conservation laws, etc.? Benchmarks could be set for the 2-year, BS/BA, and MS/MA levels by the complexity of the problems.
2. Re-describe the problem. Describe the physical systems – particles, interactions, charges, fields, and whatever else is relevant.
3. Use quality arguments to plan solutions
   - Recognize patterns in the information.
   - Identify simplifying assumptions, such as whether to use a particle or a continuum model, whether or not to include air resistance, etc.
   - Determine what is relevant versus what is irrelevant.
   - Begin building physical models by abstracting the most important concepts.
   - Make decisions by first exploring their consequences.
4. Elaborate qualitative arguments in greater mathematical detail.
   - Draw some sort of sketch, make appropriate diagrams
   - Clarify geometrical relationships, usually with the aid of a coordinate system
   - Add details as needed such as free-body diagrams
   - Graphical skills and interpretation
   - Be able to cast story problems into mathematical models
   - Understand the meaning of the mathematics in the physical context:
     - Identification of physical quantities with algebraic symbols
     - Understanding the contexts for equations
   - Recognize the physics in a mathematical model
5. Organize quantitative information: clearly step through the mathematics of the problem solution. Determine whether the symbolic or numeric answer is reasonable.

Benchmarks could be made for each of the different steps of the problem solving skills, varying levels of difficulty for the 2-year, BS/BA, and MS/MA students.

3. <u>Physics Concepts (3 Examples)</u>

(1) Physics Concept: Conservation of Energy

The 2-year student should demonstrate the ability to

- Understand the definitions of kinetic energy, potential energy, and work. (1)
- Understand energy as the capacity to do work (definition of energy). (2)
- Understand the notion that energy can change form but cannot be created or destroyed in a closed system (definition of conservation law). (1,2)
- Make a clear distinction between the *principle* of energy conservation and the *identification* of various sources of potential energy (gravitational, mechanical, electrical, etc.). (1,8)
- Understand conversion of energy into dissipative forms (friction) and the resulting energy deficit; understand that this energy is not destroyed but is converted to microscopic random motion. (3,5)
- Understand the notion of conversion efficiency; be able to discuss this in contexts such as power generation. (3)
- Relate energy conservation to the notion that you can't get something for nothing (no perpetual motion or efficiency greater than unity). (2,9)

The BS/BA student should demonstrate the ability to

- Do everything on the 2-year student list in addition to the following:
- Understand the relationship between Newton's laws and energy conservation and the intrinsic advantage of scalar vs. vector formulations of a problem. (2)
- Understand the meaning of graphically presented potential curves and landscapes, turning points, forbidden regions. (9)
- Understand the role of energy conservation in the "crises" that led to the advent of quantum mechanics, e.g., the ultraviolet catastrophe. (6)
- Understand energy conservation in the context of quantum mechanics; specifically: (2,10)
    - The meaning of the wave function in forbidden regions and its connection to the Uncertainty Principle.
    - The Hamiltonian formulation and the connection between commutation relations, simultaneous eigenvalues, and integrals of motion.
- Understand energy conservation as applied to thermodynamics and statistical mechanics; specifically: (1,5,7)
    - The definition and role of temperature and entropy in the formulation of thermodynamic potentials.
    - The role of energy conservation in defining statistical ensembles (microcanonical, canonical, grand canonical, etc.).
- Understand the generalization of energy conservation to include energy incorporated in mass (special relativity). (5,8)
- Identify the role of energy conservation n in other advanced topics in physics, e.g., radiative transitions, photoelectric effect, radioactive decay. (7,8)

The MS/MA student should demonstrate the ability to

- Do everything on the BS/BA list in addition to the following:
- Relate energy conservation to general principals of symmetry and reversibility; understand the relationship between energy conservation and time-invariance of physical laws. (2,9)

- Understand the connection between conservation laws and the action principle (Hamilton's principle). (2,10)
- *Begin* to understand the ways in which symmetries and associated conservation laws place constraints on general theories, including those that are competing theories and/or not yet generally accepted. (5,7,10)
- Demonstrate the capacity to explain the concept of energy conservation to 2-year and BS/BA students (11).

(2) Gas laws and simple thermodynamics competencies

The 2-year student should demonstrate the ability to

- Discuss the impact of the principles of conservation of energy and the 2nd Law of Thermodynamics in modern society, relating them to things such as, but not limited to, the production of commercial electricity, transportation, and environmental issues. Appreciate the power of these laws to uncover pseudo-scientific snake oil!
- Calculate the changes in length and volume of solids, liquids and gases as functions of temperature, and use these ideas to explain, for instance, the workings of a thermometer, or the common manifestation of such things as cracked roads, and creaky houses.
- Explain the concepts of heat capacity and latent heats, and to use these to describe and sketch the temperature of a substance as a function of added heat (or as a function of time) as it evolves from a solid, through a liquid and into the gas phase.
- Use and explain the conservation of energy, or 1st Law of Thermodynamics, written as $dU = dQ - PdV$, or $dU = TdS - PdV$, identifying each term in sample gas law or calorimetry problems.
- Articulate and discuss the difference between the internal energy of a system and temperature. Explain thermal equilibrium in terms of these concepts. Understand that for an ideal gas, the internal energy is simply related to average kinetic energy of a molecule in the gas.
- Use the ideal gas law, $PV = NRT$, or $P=nk_BT$ to discuss the behavior of a finite amount of gas undergoing changes in Pressure, Temperature or Volume.
- Understand and perform simple heat diffusion calculations using $dQ/dt = kAdT/dx$, and connect this equation to the use of R-values in modern construction.
- Explain both an adiabatic process, $dQ = 0$ and an isothermal process, $dT =0$. Follow the calculus derivation of a gas expanding from one pressure and volume to the next, either adiabatically or isothermally, and explain that the work done by or on the gas can be represented by the area under the P(V) curve.
- Explain Entropy as an ordering principle, and recognize that it is related to the quality of energy in a system – the higher the entropy, the lower the quality of the energy in the system.

The BS/BA student should demonstrate the ability to, in addition to the traits and competencies above,

- Solve the heat diffusion equation, for simple geometries and discuss the notion of heat flux – solve the particle diffusion equation and explain diffusive properties in terms of microscopic models of

particle concentrations and their energies , i.e., answer questions like, “why does heat flow from hot to cold”, based on the motions of microscopic particles.

- Explain quantitatively and illustrate modes of energy transfer through radiation, conduction and convection, and explain for instance, the order in which these processes may occur, i.e., why the onset of convection when conduction and radiation are insufficient modes of heat transfer.
- Use statistical mechanics to define the entropy from the density of states and connect this form to the 2nd Law when expressed as $dS = dQ/dT >= 0$.
- Explain the Carnot cycle as a limiting case of a reversible process with $dQ = 0$ and $dS = 0$. Demonstrated knowledge should include quantitatively reproducing the Carnot cycle on a PV-diagram, and using the ideas of the Carnot efficiency and refrigeration COP in examples such as in the PV-cycle of real heat engines, refrigerators, appliances and power stations.
- Obtain quantitatively the partition function for simple systems, and use it to derive the average energy and Helmoltz free energy of those systems.
- Show facility with partial derivatives, being able, for instance to define heat capacity as partials of either the entropy, energy or enthalpy, with respect to temperature, holding the appropriate quantity fixed, and being able to define by transformation, the Gibbs Free Energy and chemical potential.
- Discuss the meaning of and use of partition functions and distributions, particularly the Maxwell-Boltzmann distribution, and the Fermi and Bose-Einstein distributions.
- Explain examples of the applications of statistical mechanics such as the workings of a laser, the magnetization of materials or the gas-liquid phase transition of simple fluids.
- Discuss the difference between Bose and Fermi particles and cite examples of how distributions of either type of particle are manifest in various physical systems, such as in semiconductors for Fermi particles, and in the formation of Cooper pairs in superconductivity.

The MS/MA student should demonstrate the ability to, in addition to the traits and competencies above,

- Explain the role that statistical mechanics plays in the foundations of quantum mechanics, through the use, for instance of the formalism of Hamilton-Jacobi, Poisson brackets, ensemble averaging, etc.
- Show proficiency in statistical mechanics, particularly as it is used in modeling magnetic and fluid systems.
- Use statistical mechanics for calculating the rates of reaction for interacting systems, based upon the principles of minimizing the energy and entropy production rate.
- Assemble a model necessary to perform a calculation for a particular research need, in condensed matter physics or other solid state application.

(3) Benchmarks for Rotation and Angular Momentum

The 2-year student should demonstrate the ability to

- Define and calculate the angular momentum for moving point masses or rotating symmetrical objects.
- Define and calculate the moment of inertia for symmetrical objects.
- Apply the law of conservation of angular momentum to simple situations (where the direction of the angular momentum vector does not change).
- Calculate the torque applied to an object given the force vectors acting on it.
- Calculate the change in angular momentum for a constant torque.

The BS/BA student should demonstrate the ability to, in addition to the traits and competencies above,

- Calculate the principal axes and the moment of inertia tensor for an object.
- Calculate the free rotation of a rigid body.
- Apply the law of conservation of angular momentum to more complex situations.
- Use Eulerian angles to describe rotation.
- Calculate the precession and nutation of a gyroscope.
- Use the kinematic equations for rotations and know when they apply (constant angular acceleration).
- Describe how rotational kinetic energy fits into overall energy conservation.

The MS/MA student should demonstrate the ability to, in addition to the traits and competencies above,

- All of the above at a deeper level.
- Students at this level should be able to explain and teach the above concepts to two-year and BS/BA students.

4. <u>Laboratory Skills:</u> the simple pendulum as a test example

All students at the 2-year level and beyond should be able to follow instructions and complete a cookbook style lab. But a 2-year student and beyond should be able to do much more in an open-ended lab.

The 2-year student should demonstrate the ability to

- Reduce uncertainties in taking data
  - Timing the pendulum for several swings rather than one swing
  - Starting timing after the pendulum has been released
  - Use a visual cue to start timing rather than a verbal cue from a partner
  - Start and stop at the top of the swing rather than the bottom of the swing
- Take consistent measurements
  - Always measuring to the center of mass of the bob, rather than the length of the string, as the masses may be different sizes
- Design experiments, understanding that they should only change one variable at a time(whenever possible)
  - Measure the periods for different lengths, leaving the mass and angle of swing alone
- Graph the results using Excel or a similar program
- Determine the functional dependence on the variables (fit a trendline)
  - Mass doesn't matter; angle of swing doesn't matter; but length does:
    T proportional to $(\text{length})^{-1/2}$
- Make a prediction based on their experimental data
  - What is the period of a 4 m long bowling ball pendulum?
- Take measurements using the appropriate apparatus necessary for the experiment
- Decide what apparatus is appropriate.
  - A stop watch will do; a photogate is more precise but is not necessary for this experiment
- Come up with an appropriate technique to do the experiment. The technique includes most of the above ideas.
- Compare their results to the theoretical predictions
  - Did we get a length to the -½ power; is the constant = $(2\pi\sqrt{9.8})$?
- Evaluate the level of uncertainty of the data
  - For example, they get a power = -0.48 instead of -0.50. Is this good, bad or within uncertainties? If they used the photogate with the microsecond resolution timer, then the result is bad. If they used the precision stopwatch, then it's a good result within uncertainties, and if they used the unreliable $2 stopwatch, the results are definitely within uncertainties. (I have a set of stopwatches from WalMart that, when the students use them, the times are all over the place, ±0.7s. The same students with precision watches agree within ±0.2 s, which is approximately human reaction time.)
- Explain in a written report what was done in the lab, what was used, what could be improved.

The BS/BA student should demonstrate the ability to, in addition to the traits and competencies above,

- Carry out full uncertainty analysis on their data and calculations
- Evaluate from their data whether the small differences are systematic or real
    - Is the slight upward trend in the period vs starting angle real or just uncertainty? It turns out to be a real effect.
- Correct their data for systematic uncertainties
    - Measured the lengths of the string rather than to the center of mass
- Model the experiment in software, and see if theory agrees with experiment
    - In fact, if I have time, I have my students do an Excel spreadsheet carrying out numerical integration for their various starting angles, find the period from the spreadsheet, and compare that to their actual data. Amazingly, the spreadsheet data falls right on top of the actual data.
- Develop equipment to make measurements (a capstone-type project)

The MS/MA student should demonstrate all of the traits and competencies above, plus develop a full experiment and demonstrate the ability to

- Find in the literature what comparable experiments have been carried out previously
- Gather the necessary equipment
- Build/design any equipment that is not otherwise available
- Develop the procedure to do the experiment and analysis

5. Scientific Communication (written, oral, and visual communication)

"Scientific Communication" in this context refers to any way students communicate their physics knowledge to fellow students, professors, and the public, in either an oral or written manner.

In the examples below, "undergraduates" refer to students who are taking coursework towards the 2-year or BS/BA level of competency. Students at the MS/MA level are assumed to be graduate students.

The 2-year student should demonstrate the ability to

- **Homework:** Write out, with appropriate diagrams as necessary, a complete solution to an assigned homework problem (appropriate for this level), explaining in complete sentences the steps used. Explain orally, to a fellow student or their professor, this solution.
- **Lab Report:** Write out a clear and grammatically correct laboratory report concerning an experiment they have performed in lab, including: Introduction, Experimental Setup, Data, Results and Conclusions. Student is expected to do this for a pre-arranged experiment. A reader should be able to comprehend the purpose and results of the experiment without reference to any other materials (such as the lab manual the experiment is derived from).

The BS/BA student should demonstrate the ability to

- **Homework:** Write out, with appropriate diagrams as necessary, a complete solution to an assigned homework problem (appropriate for this level), explaining in complete sentences the steps used. Student should be able to cogently argue for any approximations made in the course of the problem, backing them up with calculations. Students should recognize situations were more information is needed to solve a particular problem.
- **Lab Report:** Write out a clear and grammatically correct laboratory report concerning an experiment they have performed in lab, including: Introduction, Experimental Setup, Data, Results and Conclusions. Student is expected to do this not only for pre-arranged experiments, but also those of their own devising.
- **Presentation:** Orally communicate the contents of a written lab report, class project, or original research in the form of a short, informal talk. A reader/listener should be able to comprehend the purpose and results of the experiment without reference to any other materials (such as the lab manual the experiment is derived from). The oral presentation should include visual aids, such as electronic slides, that are visually attractive and effective in clearly communicating the scientific ideas involved.
- **Literature:** Summarize, either in written or oral form, the contents of a scientific paper they have read or a talk they have attended. Students should know the required elements of a proper citation of scientific sources.
- **Thesis:** Should the student be involved in a research project, student should be able to write an extended report discussing their research ("Senior Thesis"). This should be formatted like a scientific paper, including: Abstract, Introduction, (Body), Conclusions, and References.
- **Teaching (Tutor/Teaching Assistant):** Should the student be so inclined and have the opportunity, student should assist students at the 2-year level in all competencies of physics

through the form of tutoring, either as a private tutor or acting as a teaching assistant in a discussion/recitation section.

The MS/MA student should demonstrate the ability to

- **Homework:** Write out, with appropriate diagrams as necessary, a complete solution to an assigned homework problem (appropriate for this level), explaining in complete sentences the steps used. Student should be able to cogently argue for any approximations made in the course of the problem, backing them up with calculations, and to explain any new formulas or models used in solving the problem.
- **Lab Report:** Write out a clear and grammatically correct laboratory report concerning an experiment they have performed in lab, including: Introduction, Experimental Setup, Data, Results and Conclusions. Student is expected to do this not only for pre-arranged experiments, but also those of their own devising.
- **Presentation:** Orally communicate the contents of a written lab report, class project, or original research in the form of a short, informal talk. A reader/listener should be able to comprehend the purpose and results of the experiment without reference to any other materials (such as the lab manual the experiment is derived from). The oral presentation should include visual aids, such as electronic slides, that are visually attractive and effective in clearly communicating the scientific ideas involved.
- **Literature:** Summarize, either in written or oral form, the contents of a scientific paper they have read or a talk they have attended. Students should know the proper way to cite scientific sources.
- **Thesis:** Should the student be so required, student should be able to write an extended report discussing their research ("Master's Thesis"). This should be formatted like a scientific paper, including: Abstract, Introduction, (Body), Conclusions, and References, and be of high enough quality to be published in a peer-reviewed journal.
- **Teaching (Tutor/Teaching Assistant):** Assist undergraduates in all competencies of physics through the form of tutoring, either as a private tutor or acting as a teaching assistant in a discussion/recitation section.
- **Teaching (Lab Assistant):** Organize and supervise a laboratory session for undergraduates using a pre-arranged experiment. Student should be able to instruct undergraduates on the proper methods of Scientific Communication at the levels listed above.

6. Computational and Information Skills

The 2-year student should demonstrate the ability to

- Read and collect data via an interactive laboratory experiment using Labpro or other similar program
- Read, graph and explain spreadsheet data
- Read and calculate mean, median, mode and standard deviation from spreadsheet data
- Fit data to simple functions such as a line or a Gaussian distribution
- Estimate and recognize functions that are candidates for fitting a function
- Read and employ finite difference algorithms in a spreadsheet to generate data

NOTE: The above competencies are intended to implement existing utilities in a program such as Excel, not to require students to write their own programs.

In addition to the above, and assuming the above become refined during the BS/BA years of study, the BS/BA student should further demonstrate the ability to

- Understand the difference between a symbolic manipulator and a procedural language
- Read, understand, and implement an algorithm written in pseudo-code
- Write and build code from a standard language such as C++
- Execute a wide range of mathematical operations in a symbolic environment
  - E.g. algebra, integration, differentiation, simplification of expressions
  - Solve simple differential equations
  - Write and build code in some symbolic environment
- Employ both a symbolic manipulator and procedural language to solve a system of linear equations and matrices
  - Example: Solve the resistor cube problem for variable resistors and currents
- Find the eigenvalues and eigenvectors for a large system of equations
  - Example: Use finite difference rotations to diagonalize a matrix in order to find the eigenvalues
- Employ both a symbolic manipulator and procedural language to solve finite difference problems
  - Example: Calculate the maximum height and range of a baseball hit at differing altitudes, when considering drag, gravity, mass, and size of the ball
- Implement the Fast Fourier Transform on data
- Fit functions
- Solve problems employing Newton's method programmatically
- Implement mathematical functions symbolically on the computer, such as finding divergence, curl and/or gradient of a differentiable function in spherical coordinates

In addition to the above, the MS/MA student should demonstrate the ability to

- Generate and evaluate digital signal data
- Understand and explain the concept of accuracy in computing
- Carry out local interpolation and cubic splines
- Evaluate definite integrals by the trapezoidal rule, Romberg integration and Gaussian quadrature

- Solve linear and nonlinear ordinary differential equations
- Solve initial value problems using Runge-Kutta and adaptive methods
- Solve boundary value problems by shooting and finite-difference methods
- Solve partial differential equations: parabolic (diffusion), elliptic (Poisson), and hyperbolic (wave/advection)
- Implement finite-difference and finite-element spatial discretization
- Implement explicit, semi-implicit and implicit time-stepping schemes
- Carry out stability analysis

7. Research

Example research project using spectroscopy to analyze the color of tea, with goals to understand the factors affecting the color of tea and to propose a commercially viable scheme for characterizing tea color

The 2-year student should demonstrate the ability to

- Understand the nature of the sub-discipline in which they are carrying out research – how it fits into physics as a whole
  - Example: Understanding the basic theory of light, color and spectroscopy as an application of introductory physics concepts.
- Understand the qualitative nature of one or more open problems in this sub-discipline
  - What is the array of possible tea colors? How is tea color currently characterized in the industry? Why might one want a more scientific characterization? How could one use spectroscopy to illuminate this problem?
- Read the literature aimed at "the scientifically literate" (e.g. Scientific American, popular books) as well as more scientific documents (more advanced textbooks, American Journal of Physics) and make connections to ideas learned in introductory courses.
- Learn what are the "tools of the trade" and how to use them
  - What is the Standard Reference Method (SRM) for determining color? What is a spectrometer?
- Begin to understand the nature of physics work outside of the artificial classroom environment, where everything is cut and dried, where every question has an answer at the back of the book

In addition to the above, the BS/BA student should further demonstrate the ability to

- Read the scientific literature: journals – to some limited extent – as well as advanced textbooks which go beyond undergraduate curriculum. Begin to learn how to teach oneself needed material.
  - American Journal of Physics, spectroscopy journals, texts on theory of color and light
- State precisely the nature of the research problem
  - How to adapt the SRM method to characterization of the color of tea
- Carry out standard laboratory, mathematical, or computational tasks necessary to the kind of research project being undertaken
  - E.g. in order to build equipment, the student may need to learn machine shop, plumbing, or vacuum technology skills. For a theoretical project, the student may need to learn advanced mathematical or computation skills.
- Take direction to attack some small portion of the problem – build equipment, take data, analyze data, run (maybe code) canned programs
  - Assist in the design, building, calibration of the spectroscopy system. Learn/use/program canned data acquisition programs. Assist in the taking of data with the spectrometer. Process the spectrometer data and present the results, e.g., in graphical form. Interpret how different teas manifest different colors based upon these results.
- Present the research problem, explain the work performed and state how it fits into the context of the problem. Clearly state results, if any. Written and oral presentation. Audiences: experts, professional physicists, students.
- Learn how to synthesize elements of several sub-disciplines and to investigate a problem and create new knowledge
  - Light, color, optics, spectroscopy,...

In addition to all of the above, the MS/MA student should demonstrate the ability to

- Understand scientific literature pertaining to research project and understand current status of this problem/issue
- Self-teach new concepts, subjects, techniques as needed by the research project
  - Theory of light, color, spectroscopy. Existing approaches to characterizing color. Design and/or improve apparatus for doing the spectroscopy
- Take ownership of the research problem: be able to identify open problems and make proposals for future work
  - Note that the spectral results depend upon the age of the sample. Try to figure out what is causing this. Propose/make new measurements which might explain this.
- Add value to knowledge pertaining to the chosen research problem, either by extending existing results, solving open problems, or adding additional clarity to known results
- Contribute to research-level publication in scientific journal; explain project and results to professionals and students

b. <u>transferable skills/general competencies</u>

These are mainly included above. E.g. demonstrated ability to communicate effectively can be seen in the competency theme on scientific communication. The most important general competencies are identified in Section 10 of this report, Survey Results.

8. **Map of history degrees to employment fields or professions, with explanations of how potential jobs for graduates were identified**

The American Historical Association publishes *Careers for Students in History.* http://www.historians.org/pubs/Free/careers/Index.htm. Most of the Utah history departments use it to guide their advisement of majors. It lists the following:

- **Historians as Educators**
  - Elementary Schools
  - Secondary Schools
  - Postsecondary Education
  - Historic Sites and Museums
- **Historians as Researchers**
  - Museums and Historical Organizations
  - Cultural Resources Management and Historic Preservation
  - Think Tanks
- **Historians As Communicators**
  - Writers and Editors
  - Journalists
  - Documentary Editors
  - Producers of Multimedia Material
- **Historians As Information Managers**
  - Archivists
  - Records Managers
  - Librarians
  - Information Managers
- **Historians As Advocates**
  - Lawyers and Paralegals
  - Litigation Support
  - Legislative Staff Work
  - Foundations
- **Historians in Businesses and Associations**
  - Historians in Corporations
  - Contract Historians
  - Historians and Nonprofit Associations

The historians expect further guidance for their discussions about history degree employment will be available upon completion of the employer and alumni surveys.

9. **<u>Map of physics degrees to employment fields or professions, with explanations of how potential jobs for graduates were identified</u>**

We have unsystematic data from our various institutions on where our alumni have gone. However, we also have excellent reports from the American Institute of Physics (AIP) that have been compiled from careful surveys. We have relied primarily on these reports for the employment information at the BS/BA and MS/MA levels.

<u>Two-Year Students:</u>
There are no formal degrees in physics at the two-year level. Of the nine institutions in Utah, five (Southern Utah University, Snow College, Dixie State College, College of Eastern Utah, and Salt Lake Community College) do not offer bachelor degrees in physics. All five provide two-year preparation for students who wish to transfer to a bachelor-granting institution to study physics. In these two-year physics programs, "employment" is universally to **continue education at a BS/BA institution**.

<u>BS/BA Degrees:</u>
The other four Utah institutions (University of Utah, Utah State University, Weber State University, and Utah Valley University) all offer BS/BA degrees in physics.

1. **Summary of the findings of the "Initial Employment Survey of physics bachelor's, classes of 2005 and 2006,"** from the AIP Statistical Research Center.

- After receiving their degrees, new physics bachelors follow two main career paths: continuing their education at the graduate level or entering the workforce. In recent years, a little less than half of the degree recipients chose to immediately enter the workforce. A significant number of these individuals will enroll in a graduate program after working for a year or two.

- The paths that physics bachelor's pursue differ by the highest physics degree offered by the department from which they received their degree. Physics bachelor's receiving their degrees from departments that also grant graduate-level physics degrees are more likely to pursue graduate study in physics than are bachelors who receive their degrees from departments where a bachelor's is the highest degree offered. It is unclear the extent to which this difference is the result of the undergraduate experiences they had in the physics department or career goals that they had prior to starting college.

- In the classes of 2005 and 2006, the majority of the new physics bachelor's chose to immediately continue their education at the graduate level. Of them, nearly two-thirds chose to continue their studies in physics or astronomy. The balance of the students enrolled in a variety of graduate programs with engineering being the most frequently chosen field.

- Physics bachelor's who continue their education in physics and astronomy tend to be better supported by their graduate departments than the students who pursue other fields. Also, physics bachelor's who enroll in a PhD program, regardless of field, tend to be better supported than students enrolling in a master's program.

- The private sector continues to be the single largest employer of physics bachelor's hiring 57% of the bachelor's who secured full-time employment directly after receiving their degree. A significant proportion (13%) of new physics bachelor's took positions as high school teachers. Seventy percent of these new teachers indicated they were teaching at least one physics class.

- Science, Technology, Engineering and Math (STEM) continue to be the most common fields in which new physics bachelor's work. In the private sector, nearly two-thirds of physics bachelor's work in STEM fields. A significant proportion (~1/3) of the new physics bachelor's accepted positions in the private sector that are non-STEM related. These non-STEM jobs cover a wide variety of positions including retail sales and finance.

2. Employers in Utah that recently hired new physics bachelor recipients

- Air Force Civil Service
- Black Diamond Equipment, Ltd
- BlueHost, Inc.
- DHI Computing Services
- General Electric
- K-tec
- L-3 Communications
- Simco Electronics
- Sohl Source Consulting
- Solitude Mountain Resort
- Sylarus Technologies
- U.S. Army Dugway Proving Ground
- University of Utah Hospital and Clinics
- Wasatch Front Regional MLS
- Wasatch Photonics
- Watson Pharmaceuticals

Note: This is only a portion of the employers who hired recent physics bachelors into technical positions.

Source: AIP Statistical Research Center, Initial Employment Surveys, classes 2006 thru 2008.

3. Type of Employment of Physics Bachelors, 5 to 8 Years After Graduation
Source: AIP Statistical Research Center, 1998-99 Bachelors Plus Five Study
Based on physics bachelors with no additional degrees who are not primarily students

- Software 24%
- Engineering 19%
- Science & Lab Technician 9%
- Management, Owner & Finance 20%
- Education 12%

- Active Military 6%
- Service and Other Non-Technical 10%

4. Employment Map for Physics BS/BA Degrees in Utah

BS Physics Pre-Professional:	Graduate school in science or engineering Industrial research National laboratory research Other technical employment Business
BS Physics:	Lab technician Engineering aide Business, marketing, sales Patent law Consulting
BA Physics:	Science writing Law school Patent law Medical school, dental school, veterinary school, etc. Business, marketing, sales
BS Physics/Mathematics:	Actuarial science Applied mathematics Graduate school in science or mathematics
BS Physics Pre-Medical:	Medical school, dental school, veterinary school, etc. Biomedical industry Patent law Business, marketing, sales
BS Physics Applied:	Industrial research Patent law Business, marketing, sales Graduate school in science or engineering
BS/BA Physics Teaching:	Secondary education
BS Physical Sci Composite Teaching:	Secondary education

<u>MS/MA Degrees:</u>

University of Utah and Utah State University offer MS/MA degrees in physics.

1. **Summary of the findings of the "Initial Employment Survey of Physics Master's, classes of 2005 and 2006,"** from the AIP Statistical Research Center.

- Overall, about 60% of the master's entered the workforce, with only a small percent not having secured some type of employment in the winter following the year they received their degree. A much larger proportion of the US citizens immediately entered the workforce than non-US citizens (76% vs 24%).

- The remaining master's immediately continued their graduate education at another department. Two-thirds of these choose to remain in the field of physics. As noted above, initial outcomes of physics master's vary greatly by citizenship with foreign citizens being 3 times more likely to continue with graduate study than their US counterparts.

- The private sector continues to employ about half of new physics master's that enter the workforce. The vast majority (93%) of physics master's employed in the private sector indicated working in the fields of natural science, technology, engineering, or mathematics (STEM).

- Physics master's recipients accept positions in a variety of employment sectors. The master's employed at colleges and universities, which includes 2-year colleges and University Affiliated Research Institutes, are often laboratory coordinators, programmers, and instructors. Two-thirds of the master's employed as high school teachers are primarily teaching physics with the balance primarily teaching mathematics or another science. The master's employed in the active military came from both military academies and non-military schools.

2. **Employment Map for Physics MS/MA Degrees in Utah**

MS/MA Physics:	Industrial research and development Doctoral program in physics or related field
MS Computational Physics:	Industrial research and development Biomedical industry
MS Instrumentation Physics:	Industrial research and development
MS Upper Atmospheric Physics:	National or military laboratory research Industrial research
MS Industrial Physics:	Industrial research and development

10. Survey results from students, recent graduates, employers and faculty members and how these were used in deliberations

As explained in the previous sections, we delayed most of the surveys while we thought through the learning outcomes and related disciplinary issues. We did carry out the student surveys early as discussed below. The status of the other surveys is also discussed below.

a. How did you go about surveying students?

Each team member arranged to survey several classes near the end of Winter Semester 2009. These surveys were done in class on bubble sheets. We talked with several IRB Chairs or institutional officers about the approval process for these surveys. By emphasizing that we collected no identifying information, we were able to simplify IRB approvals considerably. In most cases, campus testing centers or institutional research offices set up computer programs to read the bubble sheets and provided computer files of the results. We discuss the results below.

We surveyed general education (first two years of study) and discipline majors groups separately.

b. How did you identify recent graduates to survey?

This was done primarily in collaboration with Alumni Offices. In some departments, the departments themselves have kept good records of their graduates, from which lists have been compiled. These surveys are currently in process and should have results to report in January, 2010.

c. How did you identify employers to survey? Who responded to your employer surveys? HR? Hiring managers? How might this have affected outcomes?

First, we worked with Utah Technology Council (UTC), a trade organization, who agreed to survey their membership for us. This survey is currently out to technology organizations and to venture funding organizations, including banks and other financial institutions. It is anticipated that we will have responses from a mix of CEOs and HR or hiring managers. We expect, given the nature of UTC's relationships with the companies, that about half of the respondents will be CEOs, which should give an interesting picture of the views of company leaders. We should have results available for discussion by mid-December. The financial companies, at least, should give us information useful to the History Team as well as the Physics Team.

We have also compiled a list of other major employers in Utah, including education and government sectors. UTC has agreed to cross-reference this list with their membership to avoid duplication with the survey UTC is conducting for us. We are waiting for the response to finalize this list of additional employers. We expect to survey the additional group in January, 2010.

d. **Did you use the European survey or design your own? Why, or why not? If you used the European survey, did you add optional questions? Why or why not? Were problems encountered, if any? How could these have been avoided?**
We used the European survey items for general competencies, primarily for uniformity and comparability. We prepared our own versions of the explanatory paragraphs in order to avoid terminology problems and make the surveys as friendly as possible to our audiences. We did not add optional questions because of the short time frame for this project.

We did not (so far) use the European survey staff to set up and analyze our surveys. This was due, first of all, to the short time window we had for student surveys, requiring us to handle them locally and on paper. Then we found that in working with Alumni Offices, these offices, with us paying the costs, were set up to identify the relevant alumni and handle the surveys. Finally, the employer surveys also worked out locally when we made our connections with UTC, described above. Faculty surveys have so far been small and handled directly by the team members.

e. **Are there other approaches Tuning participants should explore in the future for gathering this information?**
Our approaches have worked well, even though most of the results are expected in the next 2-3 months. We would recommend taking the time to review the general competencies listing to adapt it for the US higher education context and perhaps even for local (i.e. state) needs.

f. **How were the survey results used to come up with the set of transferable skills graduates at various levels should have?**
The only survey results available to us early in the process were the student surveys of general competencies. These were used primarily by individual team members bringing the summary information from their students into the discussions of learning outcomes. The priorities for general learning outcomes as seen in the student surveys influenced the related discipline-specific learning outcomes developed by the teams.

A particularly important aspect of the survey results was the identification of important competencies that are not well developed and low priority competencies that are perhaps better developed than they are worth. These vary greatly from institution to institution, and the overall analysis of this view of the results is continuing. These issues were seen by the teams as indicators of particular needed curricular reforms.

Survey Results

These will be provided to Lumina Foundation early in 2010 when the additional surveys are completed and the results can be put in a common format. (Every institution used a different format!) The common format will allow preparation of a statewide summary of results. (Individual institution results of student surveys are now available, and these are what have been used in the activities described above.)

11. **Profiles of degree programs by institution. (It may be helpful to view these as half- or full-page pitches for your programs that are grounded in learning outcomes, including outcomes the program emphasizes beyond those agreed upon as part of Tuning. These also should include descriptions of where graduates are finding employment related to their degrees.)**

[Note: Many of these degree profiles are expressed in terms of credit hours and courses, the US higher education currency. As we continue the Tuning work, the Utah Teams intend to work toward expressing their degree and program profiles in terms of the learning outcomes in Sections 6 & 7.]

Utah System of Higher Education
History Degree Profiles

Utah State University (USU) Department of History Degree Profile

UNIVERSITY OVERVIEW

Utah State University fulfills a unique role in the Utah System of Higher Education as the state's land-grant and space-grant university. The land-grant designation makes Utah State responsible for programs in agriculture, business, education, engineering, natural resources, sciences, and the traditional core of liberal learning—humanities, arts, and social sciences. The university gives particular emphasis to programs involving the interaction of land, people, and the environment. USU is a "Doctoral Research University / high research activity" institution as designated by the Carnegie Foundation, providing doctoral and master's level education and supporting significant research efforts by its faculty.

The institution has 850 faculty who provide education for more than 23,000 undergraduate and graduate students, including 10,000 in its continuing education sites located throughout the state of Utah. The University has seven colleges, more than 200 majors, and 130 research-related classes. USU also has 3 branch campuses and Extension offices in all of Utah's 29 counties. Utah State is accredited by the Northwest Commission on Colleges and Universities.

HISTORY DEPARTMENT

At Utah State University, the Department of History's primary mission is to train undergraduates to research, analyze, synthesize, and communicate accurate conclusions about change over time by using the historical method. At the same time we aim to inculcate cultural literacy and provide the knowledge necessary for informed decision making by citizens of Utah, the United States, and the world.

On the undergraduate level, the History Department serves the campus through general education, general interest courses, the History major, the History Teaching major, minors in History and Classics, and interdisciplinary programs, all of which give our students crucial work skills as well as enriching their lives. History offers BA/BS degrees, with a general history emphasis and a History Teaching emphasis. It offers minors in the same programs, along with minors in Classical Civilization, Latin, and Greek.

Our total enrollment of majors and minors, including Religious Studies and Classics, is 426. Of these, 353 are History majors and 25 are History minors; Religious Studies has 13 majors and 3 minors; Classics enrolls about 35 students. The number of History majors has grown rapidly. In 2005 there were 249 majors; by Fall 2009, the number increased 47% to 366 majors in History/Religious Studies. Nearly 80% of the students we teach are not "declared" in the department. Gen Ed accounts for many of these, but our upper division courses are taken by people from all colleges. A significant portion is for other majors that require our courses, such as International Relations and American Studies.

On the graduate level, the History Department prepares MA and MS students to research, teach, edit, and administrate by further enhancing their ability to ask hard questions, research them, and communicate their conclusions clearly. In addition we emphasize the acquisition of the skills of open inquiry and debate as well as team work and collaboration. Each year, we admit 10-12 new graduate students into our program. Most work with the department as graduate assistants as they pursue their coursework and research.

History participates in American Studies major and minor, and in the Folklore minor, as well as the British and Commonwealth Studies minor and the Latin American Studies Program. The Religious Studies Program (administratively connected to the department) offers the BA/BS in Religious Studies, with a minor; the program began enrolling students in the fall of 2006. Both of the endowed chairs connected with the Religious Studies Program will hold tenure in History.

History has 20 tenure-track faculty on its Logan and RCDE campuses along with one senior lecturer. All have PhD's and offer a wide range of courses. With a standard load of 2/2 on the Logan campus (one large survey, one small seminar, and two upper division courses), faculty members teach a mix of courses that are defined geographically, chronologically or thematically. The Department has its greatest depth and strength in the modern American West, the classical world, and early modern Europe.

BACHELORS DEGREE (BA, BS)

The History Department models its work with undergraduates on seven critical learning outcomes. As students move from survey courses, through upper-division classes (with a more focused chronological, regional, or thematic structure), to their senior capstone class, they develop competencies . . .

in terms of ***Historical knowledge***:

(1) pursuing coursework that examines a broad range of historical experience

in terms of ***Historical thinking***:

(2) recognizing the past-ness of the past and appreciating the unfamiliar structures, cultures, and belief systems of historical actors
(3) understanding the complexity and diversity of historical situations, events, and past mentalities
(4) recognizing the complex, problematic, and constructed nature of the historical record itself

and in terms of ***Historical skills***:

(5) developing skills in critical thinking and reading
(6) developing research skills
(7) developing the ability to construct reasonable historical presentations that are carefully structured, clearly expressed, and persuasively argued

Students in the History major complete their work in a capstone class that focuses on the creation of a senior thesis based on primary source evidence and readings in major secondary sources. Students with a History Teaching Emphasis complete their capstone experience in a class that focuses on pedagogical theory and practice; in addition, they take the Praxis exam to demonstrate their mastery of a wide range of historical subjects.

EMPLOYMENT: While pursuing undergraduate studies, our majors may apply for various types of employment in the department as: undergraduate teaching fellows, rhetoric associates, supplementary instructors, and academic tutors. Students who complete the bachelors degree with a History major report that they are most likely to seek employment after graduation (71%) while 42% will pursue further education in graduate or professional school. Three-quarters of graduates report employment in areas related closely or somewhat closely to their degree. Roughly 60% state they will be working in business, 25% in education, and 8% in government. Most plan to work in Utah.

MASTERS DEGREE (MA, MS)

In line with the recommendations of our discipline's key professional organization (the American Historical Association), our masters program focuses on five essential learning outcomes: http://www.historians.org/projects/cmd/2005/Report/index.cfm

Historical knowledge

(1) A base of historical knowledge, combining both a breadth and depth of knowledge, a familiarity with more than one historiographic tradition, and the ability to synthesize different types of historical knowledge (such as might be required to construct a survey course). Master's programs should incorporate a comparative, if not a global, perspective on history. Program graduates should be "educated history generalists."

Historical thinking

(2) Learning to think like a historian, which includes "historical habits of mind" and "historiographic sensibilities" (i.e., a critical and self-conscious approach to the constructed nature of historical knowledge).

(3) The foundations for a professional identity as a historian, including a familiarity with the historical development of the discipline, an introduction to ethical standards and practices, and an awareness of the multiple contexts of professional practice.

Historical skills

(4) Research and presentation skills, evidenced by the completion of a substantial research project demonstrating content mastery, a familiarity with primary research, and competent historical analysis.

(5) A solid introduction to historical pedagogy, in the broadest sense of the term: the cognitive processes involved in teaching and learning history; appreciating how learners of different ages attain their understanding(s) of history; and understanding how historians present the past to different audiences. Most students work as "graduate assistants," receiving practical training in the "presentation of history to non-specialists."

The Department identifies three particular areas of strength in its graduate studies: U.S. Western history environmental studies, and religious studies.

Masters students pursue either the M.A. or the M.S. degree. The former requires competency in a foreign language (equivalent to having completed two years of a foreign language at the undergraduate level); M.S. students may be required to incorporate computer science, statistics, or environmental or other applied science in their research.

EMPLOYMENT: USU graduates relocate all over the world in a variety of undertakings. Some acquire jobs in historical societies, museums, and publishing. One graduate manages the architectural archives of the LDS church; another works as the associate director of the Cayman Islands National Museum; a third works for Research and Educational Programs in the U.S. Bureau of Land Management. Some pursue careers in high school teaching. One of these has become the Director of Religious Education for the Diocese of Utah. Others teach at the junior-college level. One recent student went from his master's at USU to New Zealand as a Fulbright Scholar. A number of master's graduates choose to go on for their Ph.D.'s. Some have pursued Ph.D.'s at Northwestern University, Georgetown University, Arizona State University, Washington State University, Michigan State University, UCLA, UC-Davis, and the Universities of Wisconsin, Minnesota, Colorado, Oklahoma, and Arizona. Among our master's graduates who later completed doctorates are faculty members at the University of Arizona, Kent State University, Brigham Young University, Southern Oregon University, Middlebury College, BYU-Idaho, Case-Western Reserve, and Cal Poly-Pomona. A few of our master's graduates go on to law school.

The History Department at Weber State University offers the following American Institutions course:

- American Civilization

The History Department awards three Bachelor's Degrees

- History
- History Teaching
- Social Science Composite Teaching Major

and offers minors in:

- History
- History Teaching
- Public History
- Asian Studies

The History Department graduates about 30 majors per year with half going into teaching, a few going to graduate school, and the rest finding employment in fields which recognize their skills in reading, writing, research and analyzing information.

The History faculty at the University of Utah strives to make outstanding scholarly contributions to the discipline and to instill historical knowledge, perspective on human experience, critical thinking skills, and effective writing in all our graduate and undergraduate students. We are also a community of citizens engaged in service and devoted to the enrichment of intellectual and public life at the University, throughout Utah, and beyond. We offer the B.A., M.A., and Ph.D. degrees. History students can explore periods and regions ranging from ancient

Mesopotamia, Greece, and Rome to the modern Middle East, Asia, Europe, and the Americas. Our faculty specializes in topics that include politics, diplomacy, warfare, and intellectual life as well as gender and women's history, medicine and science, colonialism and intercultural contact, religious expression and practices, and environmental history. Our curriculum reflects long-standing disciplinary tradition in its organization by region, nation-state, and time period, but it also embodies a newer orientation toward transnational, comparative, and thematic courses. Faculty involvement in Middle Eastern Studies, Gender Studies, Asian Studies, Ethnic Studies, International Studies, Latin American Studies, and Environmental Studies reflects the department's long-standing commitment to interdisciplinary programs. History courses emphasize written and oral skills, analysis and critical thinking, and the ability to assess conflicting interpretations. These skills prepare students for the responsibilities of citizenship and cultivate an awareness of the complexities of life. History provides valuable preparation for careers in university and college teaching and research, primary and secondary education, law, government, public service, journalism, libraries and museums, international business, and medicine.

History provides valuable preparation for careers in university and college teaching and research, primary and secondary education, law, government, public service, journalism, libraries and museums, international business, and medicine. Students of history explore periods and regions ranging from ancient Mesopotamia, Greece, and Rome to the modern Middle East, Asia, Europe, and the Americas. Areas of emphasis include politics, diplomacy, warfare, and intellectual life, as well as gender and women's history, medicine and science, colonialism and intercultural contact, religious expression and practices, and environmental history. Our curriculum reflects long-standing disciplinary tradition in its organization by region, nation-state, and time period, but it also embodies a newer orientation toward transnational, comparative, and thematic courses.

The History Department offers the following general education courses:

Diversity

- History 4700-1 African American History Since 1890
- History 4670-1 Native American History

Humanities Exploration

- History 1100 History of Western Civilization to 1300
- History 1110 History of Western Civilization Since 1300
- History 1220 Asian Civilizations: Modern History and Societies
- History 1310 Latin American Civilization Since the 1820s
- History 1460 Middle Eastern Civilization: Modern Period
- History 1500 World History to 1500
- History 1510 World History Since 1500
- History 3210 Age of Total War

International Requirement

- History 4271 European Exploration, Imperialism, and Decolonization 1750 to Present
- History 4780 The Korean War

The Department offers three advanced degrees (click on them to see their requirements in the Graduate Handbook): the M.S., M.A., and Ph.D. Students pursuing these degrees specialize in Asian History, Colonialism and Imperialism, Comparative Gender, European History, Latin American History, Middle East History, Religious History, US History, and World History.

The M.S. degree is designed for all those who "love history" including: students looking for a Masters level degree but not bound for the Ph.D., secondary educators, military service members, and those pursuing employment in government, archives, libraries and other sectors. The M.S. has *no thesis* and *no language requirement.* The M.S. is, in most cases, a terminal degree that is non-research focused and best suited for individuals not intent on pursuing a Ph.D.

The M.A. degree is primarily for those intent on pursuing Ph.D. work. The M.A. degree has both a language and thesis requirement and is considered training for individuals seriously considering the Ph.D. and a career in research, publication, and collegiate teaching.

The Ph.D. is the highest degree conferred and best suited for those planning on careers in the academy.

At Southern Utah University it is the Department of History and Sociology. The department offers **Bachelor Degrees in:**

- History
- Sociology
- Social Science Composite

- Professional Education Requirements for Secondary Licensure

The department also offers Minors in:

- History
- Sociology
- and is developing one in Anthropology

At Utah Valley University it is the Department of History and Political Science. In keeping with the University's mission, the History and Political Science department is dedicated to providing students with a broad range of opportunities and experiences in general-education and discipline-specific courses in economics, geography, history, and political science. Classes are taught in ways that foster critical thinking and analysis of complex issues and materials through lecture, reading, class discussion, and the development of written- and oral-presentation skills. The History and Political Science department strives to provide a reflective, multicultural, and international perspective.

The department offers Associate Degrees in:

- AA/AS in History and Political Science

The department offers Bachelor's degrees in:

- BA in History
- BS in History Education
- BA in Political Science
- BS in Political Science
- BA/BS in Integrated Studies Emphasis in History
- BA/BS in Integrated Studies Emphasis in Social Sciences

The department offers Minors in:

- History
- Political Science

At Dixie State College there is no history department and there are no degrees in History offered.

At Salt Lake Community College it is the department of History and Anthropology. The history program is designed to expose students to a variety of history fields and to the methods used by historians. Students who complete the program will be well prepared to undertake upper division history courses or complete a four year degree.

Our faculty specializes in varied topics such as American West, intellectual history, politics, international relations, gender and women's history, immigration, religious history, urban and environmental history. History students can therefore explore and select history courses based on their interests, time periods, and regions.

The department lays stress on written, oral and analytical skills thereby preparing students for several careers in teaching, research, government and administration.

Program Description: The History Department provides a wide variety of courses that range from general surveys to specialized topics. The program goes far beyond an emphasis on coverage and content; each course deals directly and indirectly with the historian's craft, i.e., the practice of interpretation and narration based on the systematic analysis of evidence. Additionally, all regular offerings carry the General Education designation. This means that this program is also a vehicle for students to broaden their perspectives and deepen their understandings of the world around them.

Academic Student Learning Outcomes	Program Objectives/Student Learning Outcomes	Program Assessments.
1	Students will: a) acquire substantive knowledge of the major social, political, and economic themes in a variety of history fields; b) understand the ways in which the study of the past informs the present; c) understand the methodologies historians utilize; d) be able to identify major schools of thought.	To gauge the program's effectiveness in increasing students' substantive knowledge in History, the History Department may employ any or all of the following: *A survey of majors who have completed the program. * A survey of graduates who have completed upper-level courses elsewhere. * Embedded writing assignment(s) across selected sections of American Civilization (History 1700) which will be scored using a departmentally agreed-upon rubric. *Embedded writing assignment(s) in selected sections of the 4 majors courses: 1100, 1110, 2700, and 2710 which will be scored using a departmentally agreed-upon rubric. * Other measures as designed by the History Department faculty.
2	Students will speak and write analytically, comparatively, and persuasively about historical themes, interpretations, arguments and ideas in a skilled and respectful manner.	To gauge the program's effectiveness in increasing students' oral and written communication skills, the History Department may employ any or all of the following: *A History conference or workshop where majors or graduates present their own research or portfolios of work. * Embedded writing assignment(s) across selected sections of American Civilization (1700), a sample of which will be scored using a departmentally approved rubric. * Embedded writing assignment(s) in selected sections of the 4 majors courses: 1100, 1110, 2700, 2710 which will be scored using a departmentally approved rubric. * Other measures designed by the History faculty.

4	Students will be able to: a) gather, identify, differentiate and analyze data from both primary and secondary historical sources; b) interrogate and contextualize sources; c) evaluate contested interpretations; d) use evidence to create narrative; e) revise narrative in the light of new findings.	To gauge the program's effectiveness in teaching students to think critically, the History Department may employ any or all of the following: * A survey of our majors/graduates that will probe the students' sense of their own metacognitive growth and affective development in this area while in our program. * A History conference or workshop where majors/graduates present their own research or portfolios. * Embedded writing assignment(s) across selected sections of American Civilization (1700), a sample of which will be scored using a departmentally approved rubric. * Embedded writing assignment(s) in selected sections of the 4 majors courses: 1100, 1110, 2700, 2710 which will be scored using a departmentally approved rubric. * Other measures designed by the History faculty.

Utah System of Higher Education
Physics Degree Profiles

University of Utah Department of Physics & Astronomy Degree Profile

The Department of Physics & Astronomy was known before July 1, 2009 as the Department of Physics. New degree programs in Astronomy are forthcoming but will take some time to develop. This degree profile describes degree programs in physics only.

Undergraduate Degrees (4 year cycle)

- BS in Physics with pre-professional emphasis
- BS in Physics with pre-medical emphasis
- BS in Physics with applied emphasis
- BS in Physics Teaching
- BS in Astronomy (currently under development)

All of the above degrees are optionally offered as BA degrees. This distinction has no bearing on Physics course requirements. A BA requires 4 semesters (16 credits) of a foreign language. The BA in Physics is rarely if ever elected.

The University of Utah requires 122 semester credit hours for a bachelor's degree. For physics majors, 33-35 of these credit hours are devoted to mandatory general education that cannot otherwise be satisfied by the requirements for a BS in Physics.

Core requirements: All of the above degrees, except for the BS in Physics Teaching, require a common core of courses that consists of mathematics through ordinary differential equations and linear algebra; two semesters of general chemistry (and associated laboratories); two semesters of introductory physics (and associated laboratories) through mechanics, electromagnetism, and light & optics; and a semester each of introductory quantum mechanics & relativity, thermal physics, and intermediate physics laboratory. (These last three are 3000-level courses.) At least 30 credits of upper division physics courses (3000-level and above) and some additional math courses are required for the non-teaching majors according to the particular emphasis (see below).

Pre-professional emphasis: This degree provides the highest level of rigor in the discipline of physics. Designed for students intending to go on to a doctoral program in physics or a closely related discipline (*e.g.*, astronomy, materials science, engineering). However, students who terminate their studies with this degree will have strong backgrounds in the fundamentals of physics used in research in industrial or national-laboratory research settings. Their problem-solving skills make them attractive as employees in a wide variety of technical and business endeavors. Additional courses include one semester of mathematics covering partial differential equations and complex variables; a semester of computational physics; a semester each of advanced theoretical mechanics, electricity & magnetism, quantum mechanics, and statistical mechanics; and additional elective courses selected in consultation with an advisor.

Applied emphasis: This degree provides a solid but streamlined foundation in theoretical physics and provides additional training in applied fields within physics and (guided by close consultation with an advisor) at the interface between physics and other disciplines. Designed for students intending to pursue technical careers in industrial research, it should also serve students interested in patent law, business, or marketing & sales. This degree could also lead to more advanced study in related fields (*e.g.*, biophysics, medical physics, or materials science). Additional courses include one semester of mathematics covering partial differential equations and complex variables; a two-semester sequence covering theoretical mechanics, electricity & magnetism, quantum mechanics, and statistical mechanics; at least one semester each of computational physics, applied optics, and electronics; and additional elective courses selected in consultation with an advisor.

Pre-medical emphasis: This degree provides a solid but streamlined foundation in theoretical physics with additional courses geared toward biomedical applications. It is designed for students who wish to major in physics and then apply to medical school, and it provides time and room in scheduling for the student to take all of the additional chemistry and biology courses required.

These students should be highly attractive to medical schools for their rigorous training in physics, an understanding of which is in ever greater demand in the clinical realm. The program should also be a solid preparation for dental school, veterinary school, or a career in a related medical field. It should

provide students with an excellent background for pursuit of the MD/PhD combination degree. The broad training across all science disciplines should also be attractive to employers of technically skilled workers in biomedical and clinical settings. It should also serve students interested in patent law, business, or marketing & sales. Additional courses include one semester of an applied mathematical methods course for biology and medicine; a two-semester sequence covering theoretical mechanics, electricity & magnetism, quantum mechanics, and statistical mechanics; a two-semester sequence in "Physics of the Human Body"; and additional elective courses selected in consultation with an advisor.

BS in Physics Teaching: This degree is designed for those intending to become secondary school teachers with a primary assignment of teaching physics. It also provides additional courses in math and chemistry that should help in enabling students to teach within these disciplines, as well. Core requirements are the same as for non-teaching majors, except for the semester of thermal physics. Three additional upper division physics courses and a teaching methods course complete the major. Two additional courses in geology and atmospheric science allow the student to qualify for physical sciences teaching endorsement.

Graduate Degrees (6 year cycle)

- MS in Physics
- MA in Physics
- MS in Computational Physics
- MS in Instrumentation Physics

All degrees require a minimum of 30 credit hours in courses numbered 5000-level and above. A minimum of 20 credits must be non-thesis coursework. In the case of those degrees involving a thesis or final project, 6-10 credits are in research. Master's degree programs are generally intended for students wishing to enter the job market with a higher degree of qualification (and higher salary) than a bachelor's degree. In the case of a MS degree with thesis or final project, the student should be better equipped to function in an industrial research and development setting.

Supervisory Committees: The supervisory committee, consisting of three faculty members, is primarily responsible for approving the student's academic program, preparing and judging the qualifying examination, approving the thesis subject, reading and approving the thesis, and administering and judging the final oral examination. A satisfactory score on the Common Exam, a written exam given to all entering graduate students (including and especially PhD candidates) may count for the qualifying examination. The chair of the supervisory committee directs the student's research and writing of the thesis or dissertation. Decisions concerning program requirements, examinations, and the thesis or dissertation are made by majority vote of the supervisory committee.

MS in Physics (thesis option): A supervisory committee is appointed to guide the study and thesis research of acceptable candidates. The final oral examination is a defense of the thesis.

MS in Physics (non-thesis option): A supervisory committee is appointed to guide the study of acceptable candidates. A non-thesis Master's student must pass a specialized exam (written, oral, or both) administered by the supervisory committee.

MA in Physics: Either a thesis or non-thesis MA degree is indistinguishable from the MS degree, except that Candidates for the MA degree must be certified by the Department of Languages and Literature as having demonstrated "standard proficiency" in at least one foreign language.

MS in Instrumentation Physics: This program qualifies those with training in science and engineering fields to work with and develop modern instrumentation and control. Study includes numerical analysis by computer, electronics, microprocessor and minicomputer data acquisition and control techniques, and the physical principles of the operation of various measurement transducers. The student takes part in developing an instrumentation project selected from a variety of research and industrial test areas. In many cases, the project occurs in disciplines other than physics. Courses include advanced computational physics, electronics, and instrumentation optics. The courses are scheduled to accommodate students with daytime employment. Students finishing this course of study are generally equipped to take on more demanding, technically intensive roles in industrial research and development. The typical student already has a job at an engineering or industrial firm and is looking to expand his/her qualifications and ability to be promoted.

MS in Computational Physics: This Physics Masters of Science program provides interdisciplinary training in the use of computers to solve problems in Physics, Computer Science, and Mathematics. With advice and assistance from a supervisory committee the student selects a computational project connected with ongoing campus research or with his or her employment. The project report and documentation constitutes the Master's thesis. Courses include computer interfacing, scientific visualization, and numerical methods. Students with this degree should be attractive to companies requiring expertise in computer modeling, non-analytical problem solving, and simulation. Applications range from industrial production to medical imaging and visualization, to the entertainment industry.

Utah State University Department of Physics Degree Profile

USU Physics Department Objectives

Degree programs in Physics are aligned with the Physics Department's overall goals and objectives, which are

- to communicate the beauty and utility of the fundamental principles of the physical universe and the power of describing nature in quantitative terms,
- to create new knowledge,
- to foster critical and creative thinking,
- to enhance the ability of citizens to participate in a technological democracy,
- to assist in the preparation of elementary and secondary school teachers,

- to provide opportunities for students to sharpen their communication and interpersonal skills, and
- to develop new tools and texts to improve physics pedagogy.

The degree programs of the department are constructed to be rigorous, yet flexible, and are intended to help students prepare for careers in academia, government and industrial laboratories, medicine, law, teaching, and business. Required course and laboratory work in these programs carefully balances theory and experiment. Because the department believes one must participate in discovery to understand science, undergraduates are encouraged to engage in departmental research early in their studies, and a formal research experience is integral to most departmental programs.

Undergraduate Degrees (4 year cycle)

Degrees offered:

The Physics Department offers the following undergraduate degree options: BS in Physics, BA in Physics, BS in Physics with Professional Emphasis, BS in Physics with Applied Emphasis, Double BS in Physics and Mathematics, BS in Physics Teaching, and BS in Composite Teaching—Physical Science.

Except for the two teaching degrees, all of the above minimally require a common core that consists of mathematics through differential equations and linear algebra, two semesters of introductory physics through electromagnetism and optics, a semester each of modern physics, classical mechanics, electromagnetism, and intermediate laboratory, and two credits each of computer methods in physics and research.

In addition to the above, the BS in Physics requires optics and thermal physics and eight additional elective credits in physics (55-57 total credits). The BA in Physics requires six additional elective credits in physics beyond the common core of courses, plus the philosophy of science, the history of scientific thought, and two years of a foreign language (72- 74 credits). The BS in Physics with Professional Emphasis requires one semester each of optics, thermal physics, wave phenomena, advanced classical mechanics, and advanced electromagnetism, two semesters of quantum mechanics, and two additional terms of laboratory (70-72 credits). The BS in Physics with Applied Emphasis requires a semester each of optics and thermal physics, an additional term of laboratory, and 12 credits in other technical departments, at the junior level or higher, with a coherent theme; the latter requires Department of Physics approval (64-66 credits). Finally, the Double BS with Mathematics is the BS in Physics plus 24 specified math credits (75-77 credits).

The two teaching degrees are quite different. The BS in Physics Teaching requires math through differential equations and linear algebra, a course in statistics, introductory astronomy, two semesters of introductory physics, one semester each of modern physics, classical mechanics, intermediate laboratory, and computer methods in physics, five additional elective credits in physics (that may include research), a two term sequence in another science (taken by the respective majors), and a capstone course, Science in Society. The BS in Composite Teaching requires two semesters of calculus, a course in statistics, two terms of astronomy, two terms of introductory physics, two terms of introductory chemistry, a semester of organic chemistry, one semester each of introductory biology, geology, and meteorology, Science and Society, and 5 additional credits in physics. Each teaching degree requires 35 credits in education. Both require a lot of credits (90-92 for Physics Teaching, 91 for Composite Teaching)—disproportionately, according to our bias, weighted to education.

Employment Profile

The BS in Physics is intended for students who are more than casually interested in physics but who have no intention of pursuing its study at a graduate level. This degree equips the recipient with potentially sufficient technical background to work as a lab technician or engineer aide. Supplemented with a few courses in business, perhaps, such a degree could be used to find employment in technical sales or management. With a stronger complement of business and economics courses, this degree might well provide entrée into a career in finance or marketing. Students interested in medicine and dentistry might find taking this degree (along with the usual courses in biology and chemistry) would distinguish them from other applicants competing for admission to professional schools. Such a degree would also be attractive for those wishing to practice patent law.

The BA in Physics is intended for students with a strong interest in the philosophical implications of physics, in its methodology and corpus of knowledge, but with no intention of pursuing the study of physics or a related discipline at the advanced level. With this degree, students might pursue advanced work in the philosophy, history, or sociology of science. They might embark on careers as writers of science for newspapers or popular magazines, as publicists or grant writers for technical firms, or as writers of educational texts. They might pursue careers in patent and corporate law. Some (with appropriate supplementary courses) might enter medicine, dentistry, or veterinary science. Others might use their knowledge in management positions or in other aspects of business.

The BS in Physics with Professional Emphasis is primarily designed to prepare students for continued study in physics, astronomy, materials science, and other related areas of physical science and engineering. Students terminating study with this degree, however, will have strong backgrounds in the fundamentals of physics used in industry or in research at national laboratories. Their strong problem solving skills should make them attractive as employees in a wide variety of technical and business endeavors.

The BS in Physics with Applied Emphasis provides a firm foundation in the macroscopic physics essential to industrial research and development, incorporates significant experience in one other area of engineering or science, and is sufficiently streamlined that students can actually complete the requirements in four years. By suitable choice of collateral courses (done in close consultation with Departmental advisors), students with this degree can create attractive credentials for employment in many areas of technological industry, business, sales, and marketing. Such students may also go on to advanced study in some fields of engineering, materials science, biophysics, medical physics, chemical physics, and geophysics.

The Double BS with Math combines the minimal BS degree requirements in Physics and Mathematics. The intent of the program is to allow students with unusually strong quantitative skills and interests to explore the close relationship of mathematics and theoretical physics. Though holders of this double degree will be well suited for careers in actuarial science and applied mathematics, many will probably wish to continue the study of one or other discipline at the advanced level. Such students are advised to supplement the minimal requirements listed above with appropriate courses to facilitate their admission to graduate work.

The BS in Physics Teaching is designed for secondary school teachers who will seek positions in which teaching physics is their primary assignment. The program provides enough background for the recipient of this degree to teach some other science and mathematics courses as well. The BS in Composite

Teaching is designed for secondary school teachers who will teach physics as one component of their assignments, along with chemistry and perhaps mathematics.

Graduate Degrees (6 year cycle)

Students seeking the Master of Science degree can pursue a regular MS (Physics), an MS-Upper Atmospheric Physics option, or our Industrial Physics (IMS) option. The regular MS can take on Plan A, Plan B, or Plan C forms. In Plan A (30 credits), the student takes 6 to 15 credits of research, writes and defends a research thesis, and presents a departmental colloquium. In Plan B (30 credits), the student takes two or three credits of research, writes and defends a research paper (typically a literature review), and presents a departmental colloquium. In Plan C (33 credits), the student can take no research credits, but must present in writing and orally to his/her supervisory committee a paper on some aspect of graduate physics education. The Upper Atmospheric degree is a Plan A masters only, and the IMS is Plan B only.

The Upper Atmospheric Option takes advantage of the Department's very strong research program in upper atmospheric physics. Originally designed specifically for students from the Air Force Institute of Technology (AFIT), the program is generally available to all students interested in this particular branch of applied physics.

The evolution of the IMS program has occurred with the assistance of industry and government representatives. One of the key features of the program is a requirement for the student to spend either the summer or one full semester in an internship. This program will be coupled with our BS with Applied Emphasis to create a BS-to-MS option.

All Master degrees are intended for students who wish to enter the workforce with higher qualifications than a BS or as additional preparation for further graduate studies.

Weber State University Department of Physics Degree Profile

COLLEGE OVERVIEW

Founded in 1889, Weber State University is an accredited, open-enrollment, multi-campus university serving the diverse needs of Ogden and Northern Utah. Weber State is a coeducational, publicly supported university offering professional, liberal arts and technical certificates, as well as associate, bachelor's and master's degrees in a broad variety of liberal arts, sciences, technical and professional fields. WSU offers more than 200 undergraduate degree programs—the largest and most comprehensive undergraduate offering in the state. In addition, the university offers eight graduate degree programs. The Ogden campus covers more than 500 acres and houses 37 academic buildings, as well as the Ott Planetarium, the Val A. Browning Center for the Performing Arts and the Kimball Visual Arts Center. More than 23,000 students study full and part time, and residence halls can accommodate 668 students. The university prides itself in its excellent teaching, extraordinary commitment to meeting the needs of students at every stage of life and ongoing service to the community. Online courses, distance learning, independent study and evening classes are offered at times and places to meet the complex needs of students balancing family and work responsibilities. To accomplish its mission, the university, in partnership with the broader community, engages in research, artistic expression, public

service, economic development, and community-based learning experiences in an environment that encourages freedom of expression while valuing diversity.

PHYSICS DEPARTMENT

The Physics Department at WSU offers courses in physics and astronomy. The mission of the physics department is to provide high-quality instruction in physics at the undergraduate level. This includes providing courses in the general education area of physical science, pre-professional and pre-engineering courses in physics, and courses and programs for those who want to major or minor in physics. Further activities of the department include providing advising for the students served by the department, providing opportunities for research and other scholarly activities of both faculty and students, and serving as a resource for the campus and the state of Utah in the areas of physics and astronomy. The department also has a very active outreach program. This year more than 16,000 people visited the department's Layton P. Ott Planetarium. Physics faculty, in collaboration with the Ott Planetarium and the Ogden City School District, created a summer science enrichment program in conjunction with Ogden's free lunch program for children in the city's parks. The department subscribes to the Discipline-Specific Competencies for Physics developed by the physics department chairs of the institutions in the Utah System of Higher Education.

The Physics Department fulfills its service role by offering the following introductory (general education) courses for diverse majors:

- Elementary Physics
- Elementary Astronomy
- College Physics
- Physics for Scientists and Engineers

The department awards four bachelor's degrees in

- Physics
- Applied Physics
- Physics Teaching
- Physical Science Composite Teaching

and offers minors in

- Physics
- Physics Teaching

The Physics Department graduates about 10 majors per year, with half going on to graduate school and the rest finding employment in physics or a related area. Graduates of the Physics Department report their successful transition to the next stage of their careers, and express appreciation for the education they have received at WSU and for the Physics Department's programs and faculty.

Southern Utah University Physics Program Profile

University Mission

Southern Utah University is a comprehensive, regional institution offering graduate, baccalaureate, associate, and technical programs. SUU is committed to providing an excellent education through a diverse, dynamic and personalized learning environment. The university educates students to be critical thinking, effective communicators, lifelong learners and individuals who demonstrate integrity and empathy as they pursue their lives' ambitions.

Physics at SUU

Physics is housed within the Department of Physical Science and offers the following programs:

- Minor in Physics
- Minor in Physics Teacher Education

In additional to offering General Education courses, physics courses are utilized as prerequisites for the following majors:

- Chemistry
- Geology
- Computer Science
- Elementary Education
- Integrated Engineering and Technology
- Pre-Health Professions

The physics faculty consists of 2 tenured/tenure track faculty and 1 full-time staff member. In addition to teaching the physics courses offered, they maintain the endowed Ashcroft Observatory – utilized for both student laboratories and weekly viewing nights for the public – as well as a darkroom for image processing. The mission of the physics faculty is to ensure academic excellence while demanding integrity and building self-esteem in our students. Our mission is met through the following:

The Learning Environment – to provide students with quality, current, comprehensive, rigorous courses of study; to prepare successful students by stimulating curiosity and instilling a lifelong love of learning; and to develop within the students communication skills and creative, analytic information gathering and processing skills.

The Faculty – to develop excellence in teaching by fostering the pedagogical development of our faculty, to maintain strong professional commitment and development, and to promote excellence within the faculty through involvement in scholarly activities, developments in our respective fields, and service to the university and the communities of southern Utah.

Snow College Physics Program Profile

Snow College, founded in 1888, is one of the oldest two-year colleges in the West. The main campus is located in Ephraim in rural central Utah. The enrollment is a few thousand students.

Physics is the study and application of the fundamental laws of nature. "Science is the systematic enterprise of gathering knowledge about the world and organizing and condensing that knowledge into testable laws and theories. (AAPT)"

The Snow College Physics Department has a solid reputation. Five faculty members (two with PhDs) teach some physics, but each also teaches in other departments. Most of the students who take physics are planning to major in engineering, math, or some other science; very few plan to become physics majors. Consequently, the physics department is largely a service department, teaching classes that students need for general education and other majors.

Students cannot officially major in physics at the two-year level; they get an associate's degree with the normal physics coursework required to transfer into a physics major program as a junior at a 4-yr college or university. Students who complete the recommended physics curriculum at Snow College will be expected to demonstrate that they

- know how to approach a problem and solve it;
- know how to apply physics to everyday situations;
- know about the basic laws that govern the universe and the world around us;
- understand that physics is useful in many areas of life;
- understand that physics is a fundamental science that underlies the other natural sciences;
- understand the methods scientists use to do science;
- can do elementary problems in mechanics, electricity & magnetism, gravitation, optics, waves, etc.;
- can set up an experiment to test an idea;
- can work with various kinds of physical and electrical equipment including computers comfortably;
- appreciate the pervasiveness of physics in the world;
- appreciate technological innovations that result from applied physics; and
- feel confident in their abilities to deal with the world.

Students who complete the recommended physics curriculum at Snow College will be well prepared to continue in a physics major program at a 4-yr college or university. Most Snow College physics students transfer to USU or BYU.

Dixie State College of Utah Physics Program Profile

Program Description

The physics program is part of the Physical Science Department in the Arts, Science, and Letters Division. It adheres to the institutional mission statement and goals as set forth by the administration.

Type of Program

The physics program at Dixie State College (DSC) does not offer degrees or certificates. The physics program helps students achieve their academic, career, and life goals by providing introductory physics courses required by a variety of baccalaureate degrees, both at DSC and at the transfer institutions, and by providing general education experiences.

Support Function

Physics is the most basic of all the sciences. Consequently, physics courses are required for a variety of baccalaureate degrees in physical science, life science, mathematics, and engineering. All of the sciences, health sciences, and engineering have their foundation in the fundamental principles of physics.

The physics program supports the Physical Science mission statement to provide students with knowledge and skills necessary to understand, assess, and utilize elements of the physical sciences they will encounter in the 21st century, and provide students with the skills and opportunities necessary to make independent, empirical inquiries about the natural world, apply scientific principles, develop critical decision-making abilities, and understand the roles physical sciences play in technological advancement.

The physics program supports the DSC mission statement to provide personalized and excellent teaching in a learning environment where all students can become passionate about their individual educational endeavors. The physics program is committed to offering quality general education courses and contributing to student success.

The physics program supports the students by providing courses designed to contribute to a well-rounded educational experience, expand understanding of the physical world, and help students develop problem solving skills that apply to all walks of life. These courses include a basic introduction to physics course, a basic astronomy course, a basic physical science course for elementary teachers, and a basic weather and climate course.

The physics program provides two semesters of College Physics to meet the requirements of a variety of majors, including pre-dental, pre-medical, pharmaceutical, biological, architectural, and computer science degrees.

The physics program also provides two semesters of Physics for Scientists and Engineers. This course meets the requirements for a variety of majors at the transfer institutions, including physics, chemistry, geology, mathematics, and engineering.

Physics Program Mission Statement

To teach physics and assist students in obtaining a conceptual and analytical understanding of the laws that govern the physical universe. To help students gain an appreciation of the physical world in which they live. To help students improve skills of critical thinking and problem solving which will carry over and apply to all learning and decision making in their everyday lives.

Physics Program Goals

1. Students will be empowered by gaining an understanding and a comprehension of the laws of physics and the application of these laws for the benefit of mankind including environmental concerns.
2. Students will understand their scientific heritage, ideas that shaped the past and will shape the future.
3. Students will improve skills of critical thinking and problem solving.
4. Students will understand and appreciate the historical and philosophical development of the basic scientific theories that are at the foundation of all disciplines of science.
5. Students will know (from many practical examples) the role of physics in other disciplines and in their everyday lives.

Physics Program Student Learning Outcomes

After completing a physics course at DSC, students can:

1. demonstrate the ability to use problem solving skills by solving a variety of conceptual and analytical problems.
2. demonstrate a conceptual understanding of the major concepts in physics through written assignments, and/or multiple choice or free response test questions.
3. demonstrate the ability to apply mathematical concepts to analyze physical problems and express the solutions in mathematical form through written assignments, and/or multiple choice or free response test questions.

Faculty:

	Tenure	**Contract**	**Adjunct**
Number of faculty with Doctoral degrees	0	0	2
Number of faculty with Master's degrees	1	0	3
Number of faculty with Bachelor's degrees	0	0	0

Other Faculty	0	0	0
Total	**1**	**0**	**5**

Students: Distinct Headcount by Academic Year of Students Enrolled in Physics Courses

		2004	**2005**	**2006**	**2007**	**2008**
PHYS 1010	Elementary Physics	150	168	155	147	175
PHYS 1020	Intro to Weather	28	17	28	17	12
PHYS 1040	Elementary Astronomy	93	86	63	29	54
PHYS 1360	Prin of Physical Science	0	0	0	0	21
PHYS 2010	College Physics I	34	33	28	26	35
PHYS 2020	College Physics II	22	19	17	18	21
PHYS 2210	Phys for Scientists/Engin. I	11	21	19	11	16
PHYS 2220	Phys for Scientists/Engin. II	10	19	19	6	10

College of Eastern Utah Physics Program Profile

The College of Eastern Utah is the youngest community college in Utah. Since 1937 it has grown from Carbon College, with an enrollment of 146, to College of Eastern Utah, with an enrollment of over 2500 students. In 1959, the college became a branch of the University of Utah. In 1965 it became College of Eastern Utah, and four years later its relationship with the University of Utah was terminated. In 1969, it became a full-fledged member of the Utah State System of Higher Education.

The College of Eastern Utah has 3 campuses. The main campus is in Price, UT. Price has a population of about 10,000 people and is located 2 hrs from Salt Lake City. This campus has 16 buildings as well as campus housing for students. The second campus, the San Juan Campus, is in Blanding. It was established in 1976. The San Juan Campus is located about 4 hrs south of the Price Campus. The third campus is at the Emery Center in Castle Dale, UT. It was established in 1997.

Students cannot get an associate's degree specifically in Physics at College of Eastern Utah. As such a recommended program of courses needed for transfer to a four year college or university has been developed. Most of students taking the physics courses required in this program are not actually physics majors but engineering, math, or other science majors. The physics department is a service department

to the college, teaching general education and the required courses for other majors. The few students that have been physics majors have transferred to Utah State University.

The physics courses in the recommended program are currently only taught at the Price Campus. There is only one full time professor (with a Ph.D.) in the Physics Department at the Price Campus. Due to the small nature of the classes at the college, physics students are expected to complete 2 projects as part of the regular course work. The fall semester projects have included rocket launches and trebuchets, while the spring semester course has used speaker design and windmill construction as projects. The students give presentations on their projects to faculty, students and practicing engineers at the end of the semester.

Students who complete the coursework recommended for Physics majors are expected to demonstrate that they can:

- Look at a solution and determine if it is a reasonable solution
- Develop the ability to learn on their own
- Present solutions in public, by problem solving on the board, laboratory reports, and student lectures on a topic
- Apply basic physics principles to more complicated problems or novel situations
- Apply physics to everyday situations
- Use information stored in graphs
- Determine the relationships between different quantities
- Solve physics problems:
  - By describing and diagramming the situation
  - By determining what is known and unknown, relevant and irrelevant.
  - By determining where to find other relevant information
  - By applying the appropriate physics concepts
  - By making use of graphs
  - By checking the physical sense of the answer
- Set up experiments to test an idea
- Use a variety of test equipment, e.g. computers, oscilloscope

Students who have completed the recommend physics program at College of Eastern Utah have been well prepared to continue in a physics or engineering major program at 4 year colleges or universities.

Utah Valley University Physics Degree Profile

College Overview:

Utah Valley University is a teaching institution which provides opportunity, promotes student success, and meets regional educational needs. UVU builds on a foundation of substantive scholarly and creative works to foster engaged learning. The university prepares professionally competent people of integrity..." - UVU Mission Statement, 2009

UVU serves a student body of approximately 25,000. UVU is accredited by the Northwest Commission on Colleges and Universities. It is an open-enrollment university, facing the challenge of serving a traditionally prepared and adept student body while welcoming students that come to higher education under-prepared. UVU is committed to exacting a high level of performance from all its students. These challenges call for teachers with well developed and broad skills to reach and teach both the best and worst of students.

Physics department:

The UVU physics program began in 2001. It offers the following degrees:

- Bachelor of Science in Physics
- Bachelor of Science in Physics/Chemistry Secondary Education

Department makeup:

- 9 Tenured and tenure track faculty
- 3 Professional staff and lab managers
- 75 student majors
- 40 graduates in the last 6 years

Service courses:

- Introductory Astronomy, Physical Science, Conceptual Physics, for general education
- College Physics, for medical-related, and other professional majors
- University Physics, for science and engineering majors
- Introductory Acoustics, for multimedia students

Physics degree requirements:

- 26 general education credit hours
- 71 discipline core credit hours
- 23 elective emphasis credit hours in physics or physics-related courses.

The small size of our department means that a physics major will benefit by working closely with faculty and fellow students. The faculty often act as personal tutors and mentors, providing opportunities in research and problem solving that may be more difficult to obtain in a larger department. Access to all the requisite computing facilities is available, and many of our faculty work closely with students on a variety of undergraduate research projects.

Our program seeks to match our students' interests and meet the requirements of future employers. While the degree program is designed to provide a traditional physics student with all the skills required to promote their success in a graduate physics program, we have implemented an "emphasis" component that consists of a set of courses that would allow a physics major to direct their education

toward a career path of their interest and choosing. For instance, a set of courses in geology might be incorporated into the degree program of someone wishing to pursue geophysics, or environmental science. A student in pursuit of biophysics or medical physics, could complete their degree with an appropriate set of courses from biochemistry or anatomy, and so on.

The skills learned by a physics student in our program, that would serve them well in any employment outcome include:

- Rational problem solving and logic,
- Computational skills,
- Computer programming,
- Numerical Analysis,
- Instrumentation, data collection and analysis,
- Electronics,
- Writing and presentation skills.

The department holds the following to describe the nature of its program and purpose:

The whole of the universe is a fair topic for study in physics. No facet is too small or too big to be considered. Physics is the investigation, assembly and application of the rational rules by which nature operates. Every action is played out according to its rules. Physicists seek to learn these rules and often apply them in solving problems in technology, the environment and society.

Physicists are valued for their ability to rationally approach complex problems and to construct practical solutions. They find fulfilling and satisfying employment not only in the academic world of teaching and research, but in engineering, business, industry, consulting and government. Those trained in physics have been extraordinarily successful in the development and invention of many of the technologies, both hard and soft, found in electronics, computation and communication. They are responsible for many of the key measurements that monitor and characterize our environment which have led to a greater awareness and appreciation of humanity and its relationship to our planet Earth.

Salt Lake Community College Physics Program Profile

COLLEGE OVERVIEW

Salt Lake Community College is an accredited, multi-campus college serving the diverse needs of the Salt Lake City community. With an open-door enrollment policy, the College serves more than 60,000 students through credit and non-credit courses and workshops each year, making it the largest institution of higher education in Utah. To accommodate student needs, SLCC has fourteen locations plus distance learning options that allow students to take classes virtually anywhere. Courses are offered in both traditional and accelerated semesters, during the day, at night and on weekends.

Students receive personal attention from faculty as the College maintains an average student-to-faculty ratio of 19 to 1.

PHYSICS DEPARTMENT

The Physics Department at SLCC offers courses in physics and astronomy. The mission of the physics department is three-fold:

1. Provide elementary survey courses in physics and astronomy to satisfy the physical science general education requirement for either an Associates of Science Degree or transfer to another institution.
2. Provide a non-calculus, two-semester series required for students preparing for a professional or technical transfer program.
3. Provide a calculus based series which will prepare students with a strong foundation for their further education in a scientific field, particularly students wishing to pursue careers in physics and engineering.

The Physics Department serves primarily a service role at SLCC, teaching 200 to 300 students a semester. Only a few of these students desire to pursue physics as a major. Instead, the majority of students taking physics classes are pre-engineering or pre-professional students pursuing careers in other scientific fields. The rest of the students take the elementary survey courses required for their Physical Science general education requirement. The Physics Department at SLCC is aggressively applying industry standard assessment practices to ensure that its educational practices adapt to national trends and remain competitive with 4-year institutions.

ASSOCIATE (AS) DEGREE

Students are able to receive an associate's degree with the normal physics coursework required to transfer to a physics major program as a junior at a 4-year college or university. Students who complete the recommended physics curriculum at SLCC will be expected to demonstrate that they

- Can identify physical laws and how they apply to the world around them.
- Can use the scientific method as a tool for understanding a wide and ongoing variety of physics concepts.
- Know how to apply appropriate mathematical techniques and problem solving strategies to solve a variety of physics problems.
- Can solve fundamental physics problems in mechanics, thermodynamics, electromagnetism, wave optics, and modern physics.
- Know how to organize, present, and explain – both orally and in writing – solutions to physics problems.
- Know how to collect, organize, and present data in a laboratory setting and connect the data to physics principles.

Students who complete the recommended physics curriculum at SLCC will be prepared to continue in a physics program at a 4-year college or university. Most SLCC students transfer to the University of Utah, Weber State University, Utah State University, and Brigham Young University. Reports from these

universities tell us our students are competitive with other students in the program and are excelling in their work.

a. **What lessons were drawn from this exercise?**
   We saw how much more information we can convey to our students, faculty and other audiences by focusing on learning outcomes rather than credit hours.

   Comparison of degree or program profiles among institutions was interesting, both for revealing the healthy diversity of our institutions and for sharing ideas among institutions.

b. **What challenges did this exercise present?**
   We continue to work on the challenge to express these profiles in terms of learning outcomes.

12. **Summary of the merit Utah sees in developing a national Qualifications Framework.**

The Utah Team discussed the idea of a national Qualifications Framework as well as Qualifications Frameworks in physics and history. The Physics Team felt that the benchmarks they were drafting would provide a foundation for a Physics Qualifications Framework, and they were willing to return to this topic after making more progress on the physics issues. Both teams had difficulty understanding the importance of a national QF, which primarily sets common language to describe levels of expectation for qualifications (degrees).

a. **What lessons were drawn from this exercise?**

It would help to see what positive impact qualifications frameworks have had in areas where they have been developed. The whole concept is nebulous for faculty in US higher education.

b. **What challenges did this exercise present?**

Clarifying the concept and its value is already a big hurdle and needs more background information for the groups considering it.

13. Appendices

A. Utah Team Meeting Agendas

Lumina Tuning Project Team
IP-Video, Monday, March 30, 3-4 pm
AGENDA

1. Stipends and Expenses for Team Members
2. What is Tuning?
3. The Process and Schedule
4. Goals of the Disciplinary Teams—sample template
5. Discipline Documents
6. Tuning Reference Information
7. Chicago Meeting

Utah Tuning Project
BoR Office, May 14, 2009
Agenda

1. Joint history and physics teams
    a. Surveys
    b. Plans and schedule
    c. Meeting time with video crew in October
    d. Other
2. Separate into discipline teams
3. Preliminary mapping of "employment" at various levels, remembering that "employment" will include moving into a bachelor's program from a 2-year program, graduate school, other professional schools, and anything else we are handing our students off to
4. Discipline-specific competencies for our degrees
5. Describe levels of expectation for 2-yr, BS, and MS
6. Refine discipline-specific competencies to measurable outcomes
7. Consider assignments for work outside the meetings
8. Overview of the project expectations and other issues

Utah Tuning Project
Board of Regents Office
September 18, 2009, 10 am – 3 pm
Agenda

1. **<u>Joint history and physics teams (10-12)</u>**
    1. Review of expectations for final reports (Bill)
    2. Reports on status of the project for each discipline (led by Kathryn & Bill)
    3. Report on surveys of general and discipline-specific competencies (Bill)
    4. Schedule for further work
    5. Discussion of strengths and weaknesses of this project
    6. Recommendations so far
    7. Introductions to Degree Profiles and Qualifications Frameworks (Bill)
    8. Questions from the group
2. **<u>Lunch – 12-12:30</u>**

    Note: One or two team members will be interviewed on video during lunch. Our schedule will be flexible enough to accommodate these interviews, as necessary.
3. **<u>Separate into discipline teams – about 12:30</u>**
    1. Review status of employment maps

       Note that "employment" includes moving into a bachelor's program from a 2-year program, graduate school, other professional schools, and anything else we are handing our students off to
    2. Review status of disciplinary Reference Points (i.e. competences and learning outcomes / benchmarks at 2-yr, BS, and MS levels)
    3. Discuss Degree Profiles of our academic programs "grounded in explicit learning outcomes"
    4. Discuss feasibility of Qualifications Frameworks
    5. Review status of student input to the process through our student team members and their investigations with student groups

B. Utah Team Meeting Notes

Utah Tuning Project

September 18, 2009 – Meeting Notes

1. **Introductions:** We welcomed Kevin Corcoran from the Lumina Foundation for Education and Mei Zhou from the Carnegie Foundation for the Advancement of Teaching. We also acknowledged the presence of a video team from Catalytica Corp. who were with us throughout the day.

2. **Review of Expectations for Final Reports:** Bill Evenson reviewed our status and what we still need to accomplish. Final report expectations include reviewing the process and its potential in the USA context, considering the feasibility of developing Qualifications Frameworks, carrying out and evaluating surveys of students, recent graduates, employers, and other stakeholders, mapping employability of graduates in each of our focus disciplines, agreeing upon reference points (learning outcomes), providing draft degree/program profiles for each institution, providing benchmarks at the two-year, bachelor's, and master's levels for assessing the learning outcomes, and proving an overview and assessment of the process and recommendations for future work.

3. **Reports on Status of the Work in the Discipline Teams:** Kathryn MacKay reported that the History team started from the American Historical Association outcomes for history majors. They have asked team members to carry out departmental conversations on these learning outcomes and expectations, both to achieve agreement on the competencies and to explore institution-specific issues that should be incorporated or included in the context for requiring these outcomes of history students in each institution. They have carried out some of the student surveys, but not all. (Bill will follow up as described below.) Employability is problematic since history majors go in so many different directions. Phil Matheson asked whether we should articulate a level of expectation for incoming students. No one knew how to do this in a meaningful way. (Norm Jones asked if there should be "remedial history" at the college level.) Dan McInerney explained what he and the Utah State History Department have done in the development of rubrics to evaluate the achievement of the learning outcomes. Thus far, they have agreed upon a rubric for their capstone course. They will develop rubrics course by course as they are able to in the future. Dan distributed their capstone course rubric and the learning outcomes for history.

   Bill reported that the Physics team has had in depth discussions of physics competencies and has agreed upon a list that seems practical and useful. They are now working on benchmarks to define expected levels of achievement of the competencies. They have carried out student surveys. They have touched on the question of employability and have considerable information from the American Institute of Physics (AIP). They have contacted employer groups but have yet to address employer perceptions in detail.

4. **Surveys:** Bill suggested that he should work with staff to pursue the surveys that are still needed, consulting and informing the team as necessary. He has come to see that the disciplinary teams should think deeply about their disciplines and avoid getting bogged down in the detail work of the surveys. The History team has proposed that departmental discussions could be more effective than faculty surveys at developing priorities for the discipline-specific competencies. These discussions

will also lead to exploration of what experiences we must offer to achieve the outcomes, beginning the translation of competencies to pedagogy, which will be different for each campus. Dan reminded us to be very careful how we talk about competencies and learning outcomes so that a general audience will understand – see his framing of the student survey of general competencies.

5. **Schedule for Further Work:** We seem to be on track. We'll "keep on keeping on."

6. **Strengths and Weaknesses of the Project:**
   - Phil noted that employer and alumni inputs through surveys or interviews are one of the most attractive aspects of the project, going beyond other efforts at improving our programs.
   - Bill noted that the surveys diverted our focus from issues within our disciplines at the beginning and in some sense derailed us from starting with more central matters.
   - Charlie Torre commented that surveys are a very blunt instrument, and discussions are much more useful.
   - Jim Chisholm noted that we were slowed down (as will be our faculty colleagues) by unfamiliar language developed in Europe for this process.
   - Norm asked why we should do our own surveys; could we not use the very professional employer surveys like those done by AAC&U?
   - Team members noted that employability must be kept in perspective; discussions of how curriculum and policy affect the employability market give only one input to the academic decisions we make in our disciplines (an input that some disciplines have neglected more than others and that needs to be in the mix).
   - Charlie suggested that we should be driven more by the analysis of our programs by alumni than by employers, who have a necessarily limited view of what is needed.
   - Susan Neel suggested that we need to articulate our values more carefully and fully to help employers have a more complete picture of our disciplines.
   - Jim Lehning noted that control over our academic programs is in the hands of the faculty, and it is the faculty responsibility to keep the proper balance.
   - Jim Chisholm noted that we also need to take responsibility to educate employers, explaining what outcomes we provide (hard to do if we have not yet made those outcomes explicit and if we do not assess the achievement of the advertized outcomes).
   - Brad Carroll noted that we have taken the project and made it our own. This is a very important strength of the process, which has reinforced both faculty ownership of and faculty responsibility for our disciplines.
   - John Macfarlane noted that through our conversations we have given each other places to start in our own departments.
   - Norm noted that a significant strength of the project has been to further the System-wide conversation.
   - Larry Smith reminded us that our colleagues will ask how this work differs from what we are already doing. One response is that through tuning we provide more of a guarantee of student learning outcomes.
   - Dan noted that this process brings us into participation with an international discussion, leading to much greater confidence in our results.
   - Phil suggested that a weakness of the process was the initial presentation to the participating faculty members: a huge amount of information that was difficult to contextualize. It is essential to articulate carefully what is truly unique about this process in the initial explanations.

7. **Recommendations:** In addition to the recommendations implicit in the comments listed above, the following specific recommendations were suggested:
   - Dave Kardelis recommended that more tools be developed to help us guarantee outcomes.
   - Phil recommended greater focus on unique aspects of this project.
   - John recommended that exploring how to prepare diploma supplements that will be useful to employers.
   - Jeff Hodges recommended making an inventory of what we are already doing well and what is not working in the current approaches.
   - Phil recommended connecting educational resumés and e-portfolios more explicitly.
   - Jim Lehning recommended more attention to workload issues. He noted very strong differences between USA and European higher education, so everyone involved in this process must be committed to making it our own, appropriate for the USA context.
   - Norm recommended the development of an educational resumé for individual students. Students should build these by giving evidence that they have accomplished the learning outcomes.

8. **Introductions to Degree Profiles and Qualifications Frameworks:** Bill outlined the degree/program profiles we will need to prepare for each institution. He provided examples from the European work and will email copies of these to team members. Bill also reviewed the idea of Qualifications Frameworks, with emphasis on the ratchet principle – defining increased expectations and sophistication at each level of education. The discipline teams will discuss the feasibility of developing qualification frameworks in their separate groups and make recommendations.

9. **Divided to Discipline Groups**

C. <u>Physics Team Meeting Agendas</u>

Utah Tuning Project
IP-Video, June 22, 2009, 1-4pm
Agenda

1. Review Status
    a. Surveys
    b. Plans and schedule
    c. Meetings with video team, Sybille, other consultants
    d. Other
2. Discipline-specific competencies – review and complete
3. Student input
4. Describe levels of expectation for 2-yr, BS, and MS
5. Measurable outcomes
6. Assignments; Review of what we need to accomplish and schedule

Utah Tuning Project – Physics Team
IP-Video, July 17, 2009, 1-4pm
Agenda

1. Discipline-specific competencies
2. Student input – status, help needed?, SPS advisors & other contacts identified?
3. Report on status of employer survey list
4. Benchmarks and levels of expectation for 2-yr, BS, and MS
5. Assignments; Review of what we need to accomplish and schedule

Utah Tuning Project – Physics Team
IP-Video, August 25, 2009, 3-5 pm
Agenda

1. Review of where we are, what we still need to accomplish, and schedule
2. Discipline-specific competencies
3. Benchmarks and levels of expectation for 2-yr, BS, and MS
4. Student input – status, help needed
5. Report on surveys
6. Plans for September 18 meeting

Utah Tuning Project
Board of Regents Office
September 18, 2009, 10 am – 3 pm
Agenda

1. **<u>Joint history and physics teams (10-12)</u>**
2. **<u>Lunch – 12-12:30</u>**
3. **<u>Separate into discipline teams – about 12:30</u>**
   1. Review status of employment maps
      Note that "employment" includes moving into a bachelor's program from a 2-year program, graduate school, other professional schools, and anything else we are handing our students off to
   2. Review status of disciplinary Reference Points (i.e. competences and learning outcomes / benchmarks at 2-yr, BS, and MS levels)
   3. Discuss Degree Profiles of our academic programs "grounded in explicit learning outcomes"
   4. Discuss feasibility of Qualifications Frameworks
   5. Review status of student input to the process through our student team members and their investigations with student groups

Utah Tuning Project – Physics Team
IP-Video, October 19, 2009, 3-5 pm
Agenda

1. Review of Project Final Report Template
2. Benchmarks
3. Degree/Program Profiles
4. Feedback to Lumina Foundation; Use of the Project Results
5. Next Meeting

Utah Tuning Project – Physics Team
IP-Video, November 13, 2009, 3-5 pm
Agenda

1. Comments on Discipline-specific competencies, Benchmark reviews?
2. Degree/Program Profiles
3. Student input
4. Draft Final Report
5. Next?

D. <u>Physics Team Meeting Notes</u>

Utah Physics Tuning Project

June 22, 2009 – Meeting Notes

1. Need **input** on whom to include in employer surveys of general competencies.

2. Everyone should **go through the test surveys** on the web at the URL Marcus posted on the Ning under "Generic competences, history and physics competences" -- email Bill Evenson if you cannot find this. **Please respond** to the full Physics Tuning email list with comments and suggestions for making this work well for our audience.

3. Reminder: **meeting of both teams on September 18 at Board of Regents office, 10-3**. Helen Lowe will be here and do video recording and interviews. Some of you will be asked to come early or late for interviews. She will also do some video recording at nearby campuses (Orem to Ogden) on September 17.

4. Physics Discipline-Specific Competencies (raw notes for reference – see attached report with reorganized listing of discipline-specific competencies; note that some of the comments below are actually teaching or assessment suggestions).

Categories

Knowledge
Skills
Social Responsibility
Communication
Miscellaneous

Dublin Descriptors

A - Knowledge and understanding
B - Applying knowledge and understanding
C - Making judgments
D - Communications skills
E - Learning skills

Physics Discipline-Specific Competencies

<u>Nature of science, nature of physics</u>

- Role of evidence
- Understand cause vs. effect
- Understanding physics as an experimental science {Evaluate through analysis of student essays}
- Scientific ethics

<u>Modeling skills and problem solving</u>

- Organize problems: identify physical principles, relevant vs. irrelevant quantities, make appropriate diagrams
- Organize quantitative information: clearly step through the mathematics of the problem solution
- Estimation skills
- Modeling skills and limitations: build a model, be able to cast story problems into mathematical models, recognize the physics in a model, understand how much one can learn from simple models, recognize the differences between problem solving and modeling

<u>Mathematical skills</u>

- Identification of physical quantities with algebraic symbols
- Understanding the contexts for equations
- Mapping problems to new problems with related mathematics or physics
- Mathematical modeling skills
- Manipulation skills
- Computer algebra – secondary (first understand the algebra)
- Know what the math means, physical meaning of vector algebra
- Graphical skills and interpretation
- Numerical analysis

<u>Physics concepts</u> (see existing literature, e.g. Force Concept Inventory)

- Threads: conservation laws, forces (gravity, e&m), Newton's laws, work and energy, optics, thermodynamics
- Historical relevance: stories behind the physics
- What is **not** necessary to teach?
- Applications: acquired skills, come later in programs
- Contexts of applications: identify key elements in the functioning of an arbitrary physical system
- Layered development of concepts and applications

<u>Laboratory skills</u>

- Safety
- Error analysis, what errors mean
- Primacy of data
- How to evaluate data quality; why?
- How things get measured
- Connections between what you measure and how you infer physics
- How to collect and organize and present data and connect to physical principles
- Perhaps eliminate black box labs? Graphs by hand first half semester?

<u>Scientific communication</u>

- Written, oral, and visual communication
- Writing: complete, punctuated sentences, organization, good logic. Scientific writing -- be able to explain in words rather than equations
- Writing on homework problems, on exams, on papers
- Presentation skills: informal presentations to peers, formal presentations

- Teaching at 4-year and 6-year levels; how to impart their knowledge to others

<u>Computer skills & literacy</u>

- Using scientific packages intelligently
- Rudiments of scientific programming
- Excel or similar; Maple, MatLab or similar

<u>Information literacy</u>

- General education IL at 2-year level, more specific to physics at higher levels

<u>Independent research</u>

- Projects (survey what is being done in BS programs in the state), out of classroom
- Applying the physics competencies semi-independently, synthesis of physics principles and applications, require presentations, students begin to teach themselves

5. AP credit in physics: discipline faculty or departments must be responsible to assess appropriate credit for AP or other external exams.

6. Student input on Tuning: everyone **please send Bill Evenson and Jeff Hodges contact information** for someone on your campus whom Jeff can contact to get in touch with physics students at each school. An SPS advisor or officer would be helpful for this -- possibly in addition to a faculty member or advisor who can assist with the contacts. Please put Jeff in contact with all active SPS chapters. Possibility to arrange student discussion and response to Tuning in its status in October at the APS Four Corners Section meeting (October 23-24, Colorado School of Mines).

7. Levels, benchmarks for 2-year, 4-year, 6-year levels. We will need to define benchmarks at these levels for assessing the competencies.

8. Measurement, assessment of outcomes: to be defined.

9. Sybille Reichert: consensus of this group that it will be most profitable to arrange to meet or interact via Skype or other technology later in the project. E.g. late October, early November.

10. **Next meeting, Physics Tuning Team: Friday, July 17, 1-4, IP-Video**

Utah Physics Tuning Project
July 17, 2009 – Meeting Notes

1. Bill Evenson will be out of the country from July 21 to August 3. He will respond to email, but there may be some delay.

2. **Discipline-specific competencies:** We discussed priorities among our eight draft discipline-specific competency themes for the 2-year, BS, and MS levels. As an initial exercise, we polled the group on the top three priorities for each level. We noted that some of the ambivalence (e.g. between themes 2 and 3 on the 6/22/09 competencies list) might be resolved by including more than three competency themes.

   Our group consensus on the highest priorities was
   Two-Year Level
   4 – Physics Concepts
   1 – Nature of Science/Physics
   2 – Modeling Skills & Problem Solving

   BS Level
   4 – Physics Concepts
   5 – Laboratory Skills
   2 – Modeling Skills & Problem Solving

   MS Level
   6 – Scientific Communication
   7 – Computer Skills & Literacy
   4 – Physics Concepts

   It was noted that at the MS (and PhD) students specialize in either experiment or theory. The priorities are somewhat different for these two groups of students.

   It was also noted that themes 2 (Modeling Skills & Problem Solving) and 3 (Mathematical Skills) overlap appreciably, and theme 8 (Information Literacy) is hanging out on its own but might be included with theme 7 (Computer Skills & Literacy). We agreed to move themes 3 and 8 into other existing themes, bullet point (competency) by bullet point.

   In discussion we agreed that, as the list stands now, theme 3 (Mathematical Skills) would be a likely fourth priority for BS, and perhaps for the other two levels as well.

3. **Benchmarks for Levels of Expectation:** We agreed to review individually the descriptions of levels of expectation. We circulated the document "Physics, astronomy and astrophysics 2008" from The Quality Assurance Agency for Higher Education for reference. At all three of our levels we will define "Threshold" and "Proficient" (instead of "Typical") benchmarks.

4. **Student Activities:** Jeff Hodges reviewed the contacts for each USHE institution. He will request student contacts and set up group discussions within types of institutions (two-year, BS, graduate programs). They will review our competencies, offer suggestions, and consider priorities. He will organize these student groups in August and set up meetings with them in September.

5. **Employer Survey of General Competencies:** Bill reported that he has requested that Utah Technology Council (UTC) work with us on a survey of their membership (copy of memo appended below). Brad will provide a list of physics department chairs in the APS 4Corners Section. Hill Air Force Base should be added. Brian and Bill will check on the membership of UTC to avoid duplicate requests. Bill will consolidate the list of employers suggested so far and send around for comment.

6. **Next meeting:** Tuesday, August 25, 3-5 pm (IP-Video available)

Email to Rich Nelson, UTC (sent 7/14/2009)
Subject: Consulting potential employers -- USHE project

Dear Rich,

I am currently directing a project for the Utah State Board of Regents, funded by the Lumina Foundation for Education, about defining educational outcomes in specific disciplines in higher education. Utah has chosen to work on outcomes at the 2-year, BS, and MS levels for history and physics. Accordingly, we have two teams, one for each of these disciplines, with faculty representatives from the nine USHE institutions, students, and representatives of the System.

This project is an experiment initiated by Lumina to explore how a process begun in European and Latin American higher education might be adapted in the USA. One aspect of their process that we want to include in our exploration is a survey of what employers need when they hire students from these disciplines.

UTC seems an ideal group to interact with employers about their needs, especially with respect to physics majors. We have a survey instrument (about one page of questions ranking the importance of various competencies) to which we could point employers on the web. There would be no identifying information for the respondents. They would only be known to be included in the employer survey group.

I wonder if UTC would be willing to send an email (whose content we would agree upon together) to your membership requesting that they follow a link included in the email and respond to this survey? We would not ask for email addresses or other means of contacting the membership if you could send the message and web link to them directly.

At the end of this project (early 2010) we would be happy to share our report and the results of the employer survey with UTC members and others.

Thanks for considering this,
Bill

Utah Physics Tuning Project

August 25, 2009 – Meeting Notes

1. **Review:** Bill reviewed our status, what we have accomplished and what we still need to accomplish. He suggested that he should work with staff to pursue the surveys that are still needed, consulting and informing the team as necessary. This will allow the team to focus on the discipline – competencies, benchmarks, employability of graduates, and eventually Qualifications Frameworks. Our responsibilities to the Lumina Foundation for Education include surveying relevant stakeholders, mapping employability, providing a set of agreed-upon reference points for the discipline, drafting degree profiles of our academic programs that are grounded in explicit learning outcomes, and writing an overview and assessment of the project. [A summary, "Tuning Project: Responsibilities of State Teams," is attached to these notes.]

2. **Discipline-specific competencies:** We reviewed the Discipline-Specific Competencies from June 22, 2009, using Jim Chisholm's comments of August 24, 2009. Extensive and lively discussion led to revisions of the competencies as given on the attached list. Each team member is requested to review the attached revised set of Discipline-Specific Competencies and respond to the entire team by email by September 11.

3. **Benchmarks and levels of expectation for 2-yr, BS, and MS degrees:** We accepted Jim Chisholm's August 24, 2009 suggestion to clarify the levels of expectation using an easily understood specific example from the discipline for each category of Discipline-Specific Competencies. Bill will ask each team member to work on an example for a specific competency category. Bill will send the summary of Degree Descriptions provided by Lumina Foundation with these notes. These degree descriptions can suggest some general language we might use to broaden the application of our examples for levels of expectation. In addition, Phil Matheson suggested some possible ways to address levels of expectation: e.g. two-year level might be recognizing how to apply a textbook formula in a pre-defined problem; threshold four-year level might be recognizing constraints on validity and more general analysis of a problem or being able to apply a concept (like resonance) to a new area (like from e&m to mechanics); proficient four-year level and threshold MS level might involve applying general principles in novel situations. After the meeting Phil proposed a draft list of levels of sophistication through which students evolve during their study of physics (see attached).

4. **Student Input:** Jeff Hodges requested that each team member respond on the Ning to his request for information.

5. **Surveys:** Bill reported that the Utah Technology Council (UTC) has agreed to work with us on a survey of their membership. He will send the cover memo for the employer survey to this team for comment when it is ready. Bill will also send out an email report on the status of the other surveys we need to carry out.

6. **Next meeting:** Friday, September 18, 10-3, Board of Regents Office, Salt Lake City. We need everyone to arrange their schedules so they can be in Salt Lake City for this meeting. It will combine the Tuning Project and the annual Physics Major's Meeting – Bill will work with Larry Smith, the Major's Meeting Chair, to set up a time to address the Major's Meeting agenda. Bill will send out an email about travel arrangements. The video team working with Lumina Foundation will be with us

on September 18, as will the History Team. Bill indicated that several members of this group will be asked for either interviews on Friday, September 18 or on-campus video shoots (for the four close-by campuses) on September 15-17. Participants will be contacted by email to make arrangements. Bill emphasized that Lumina Foundation wants candid responses, and we have been asked specifically to include skeptics as well as those who are enthusiastic about the project.

Utah Physics Tuning Project

September 18, 2009 – Meeting Notes

1. **Employment maps:** Bill will compile relevant data from the American Institute of Physics (AIP) and send it around for review. Phil will compile a common data pool showing where our graduates go. Each member should provide Phil with as much information as they can get from their departments about where recent graduates have gone for work or additional education. Alumni associations on our campuses should be good sources for this kind of information.

2. **Discipline-Specific Competencies and Benchmarks:** We accepted the latest version of the Discipline-Specific Competencies (dated August 25, 2009 – and, of course, subject to later revision as we work with these). We divided up assignments to write benchmark example statements using Jim Chisholm's comments of August 24, 2009 and Phil Matheson's suggested hierarchy of sophistication. Bill will email copies of the documents from Jim and Phil, along with a list of assignments. Each team member will respond with his or her draft benchmark statement as soon after September 25 as possible. These responses should be sent by email to the entire team. The assignments given were

    1. Nature of Science, etc. – Larry Smith
    2. Math, Modeling, Problem Solving – Bill Evenson, Steve Sullivan, Trina Van Ausdal
    3. Physics Concepts – Brad Carroll, Phil Matheson, Brian Saam
    4. Lab Skills – Dave Kardelis
    5. Scientific Communication – Jim Chisholm
    6. Computational and Information Skills – Jeff Hodges
    7. Research – Charlie Torre

3. **Draft Degree/Program Profiles:** We discussed the form of degree/program profiles we need to draft for each of our institutions. These need only be a page or two. Bill will email two examples of European physics degree profiles. Each team member is requested to respond with his or her draft degree/program profile by October 9. These responses should be sent by email to the entire team.

4. **Feasibility of Qualifications Frameworks:** The Qualifications Framework, as it applies to our work with physics, will be built upon the benchmarks we are working on. We will discuss the Qualifications Framework more when the benchmarks work is complete.

5. **Student Input:** Jeff reported on a successful discussion with students yesterday at U of U for the video team. He is also arranging a discussion of physics competencies with students from several institutions by IP-video. He will send a list of possible questions for these students to the physics

team for comments and suggestions. Tentative date for the IP-video meeting is Thursday, October 8, 12-1pm.

6. **Next Meeting:** Monday, October 19, 3-5, IP-video or Board of Regents Office, Salt Lake City.

7. **Physics Major's Meeting:** Larry Smith conducted the Physics Major's Meeting, following the agenda provided by Teddi. He will report to Teddi on the issues raised and consensus reached.

Utah Physics Tuning Project

October 19, 2009 – Meeting Notes

1. **Review of Project Final Report Template:** Bill reviewed the Project Final Report Template. The report is due on November 20. Bill will draft the report and ask team members to review it before it is submitted.

2. **Benchmarks:** We discussed the draft benchmarks submitted by team members. We received draft benchmarks for each of the eight discipline-specific outcome themes. We discussed how specific out examples should be and agreed that the benchmarks should be introduced with a clear statement setting out that the benchmarks are provided as illustrations of levels of expectation and should not be taken as curricular prescriptions. The Matheson/Saam list of levels of sophistication provides the general statement of levels of outcomes, and the benchmark examples make these general statements more specific, but are not to be taken a prescriptive. We will refine the levels of sophistication so they can be taken to discussions in our individual departments as a framework for curricula. We are seeking to develop a mode of thought about our expectations of students. Phil suggested that we share the benchmarks among team members for individual critiques. Bill will send a request to each team member to review one benchmark other than the one they wrote.

3. **Draft Degree/Program Profiles:** We discussed the form of degree/program profiles we need to draft for each of our institutions. We agreed that the draft sent by Charlie Torre is a good model for these. Each team member is requested to provide a draft degree/program profile appropriate for their institution by Wednesday, October 28. These responses should be sent by email to the entire team.

4. **Feedback to Lumina; Use of the Project Results:** We each need to consider what recommendations should be sent to the Lumina Foundation in our final report. Please send your thoughts by email to the entire team. We also need to think through how we can each use the results of our discussions in our own departments to strengthen our degree programs and graduates.

5. **Next Meeting:** Friday, November 13, 3-5, IP-video or Board of Regents Office, Salt Lake City.

Utah Physics Tuning Project

November 13, 2009 – Meeting Notes

A. **Discipline-Specific Competencies and Benchmarks:** We discussed the benchmark reviews submitted by team members. Bill will send out a file containing all the benchmarks in the form he now has them. Many of these need some revision in light of reviewer comments. Bill asked that team members edit and revise as necessary this weekend so he has a final version to include in the report for Lumina Foundation. Please email edited versions to Bill by early Monday.

B. **Degree/Program Profiles:** We discussed the variety in the degree/program profiles we have drafted and concluded that this is not problematic since it reflects the variety in our institutions. Bill indicated that he will draft an introduction to the set of profiles noting that they are couched in terms of credit hours and courses, the US higher education currency. Nevertheless, our goal will be to develop profiles in terms of our physics learning outcomes, as we continue our work in the coming semester. Bill will correct a few typos he has noticed and then insert these profiles into the report. Team members were invited to edit and revise their profiles as they desire and email any revised versions to Bill by early Monday.

C. **Student Input:** Jeff reported on his meetings with students from University of Utah, Weber State University, and Utah Valley University. He will provide a written report to Bill for the report to Lumina. Jeff met with about 15 students. All were quite happy with their physics major programs. Their primary concern was "not knowing what is expected." This had to do with priorities among topics in the course, not with expectations for particular exam questions or homework problems. Program level expectations seem to be clearer at some institutions than at others.

D. **Draft Report to Lumina Foundation:** We reviewed the report outline and the major sections dealing with the physics team's work in draft form. The team expressed continued skepticism about the Tuning *Process*, but not at all about the work we have done together in Utah. What was valuable was to take the goals of Tuning and pursue them according to our own needs and context. It was not so much following the European process that mattered. They suggested that a short summary of Tuning with emphasis on the goals would have alleviated anxiety at the beginning of the project and allowed us to move forward more efficiently, rather than so much detail about what the Europeans have done, the terminology, and procedural elements. In sum, the European *process* is not necessarily relevant to us because what we need to improve and correct in our system is not entirely the same as what motivated the Europeans (although there is overlap). So we have naturally done what we thought was best for us. We agreed that what we are doing, especially if we continue and complete this work, could help greatly with accreditation and assessment. Furthermore, we are very pleased to have had the opportunity and support to carry out this project. The ideas from Europe provided a useful impetus for discussions that have been very valuable. These discussions have been explicit and detailed about what we are each doing in our programs.

   We noted that the relatively small size of the Utah System has contributed greatly to our ability to make as much progress as we have in 7.5 months. We agreed that the diversity of our institutions shows through appropriately in our degree / program profiles.

It was suggested that we add for future plans the possibility of considering the Ph.D. level. We are eager to work on the idea of Educational Resumés; these will be essential to demonstrating our learning outcomes. We want to emphasize that the project has developed a framework for faculty to work with in curriculum development.

There were several suggestions about specific editing of the draft sections we have reviewed so far. Bill will follow up on those.

We agreed to work with the final report early next semester to produce a summary version that will be useful for our individual departments. This will provide a document that can be used as a springboard for departmental discussions of learning outcomes, assessment, and curricular reform.

E. **Next Meeting:** We will plan another IP-video or Board of Regents Office meeting after January 18 (Martin Luther King Day). Each team member should email Bill during the coming week about his or her constraints for meeting times in January.

E. <u>Physics Student Report</u> (Submitted by Jeffery Hodges.)

The following is a report of student interviews regarding physics education in the state of Utah. While all universities tried to participate, the opinions expressed come mainly from students who have or are attending the University of Utah, Weber State University, and Utah Valley University. This report is rather informal, although I believe the information is useful.

When asked how pleased the students were with their physics programs, the overwhelming response was positive. The physics majors seem pleased with their programs, even though the programs differed in many ways.

When asked how the majors would change their programs, the response came in two general forms. First, students wished professors would be more clear as to what topics were important to know and which were less useful. I discussed this subject to some extent with the students and have come to believe the students are asking to know which topics are unnecessary for permanent retention versus topics which will be crucial to progress in the program, or in their future careers.

The second suggestion of changes in a general program was not so much regarding a program outline or process, but mostly concerns with specific professors. Not all students agreed on which professors were difficult to deal with.

When asked if professors were accessible, the answers differed directly with the size of program. For example, students in their first couple of years at the University of Utah seemed to deal more with TA's than directly with professors, while at Utah Valley University the professors handled the majority of student interactions directly.

When asked how physics majors expected to utilize their degrees, the majority of students at the BS/BA level did not expect to continue on into a graduate program in physics. Only ~20% of those nearing graduation expressed intent to proceed in physics. However, nearly 80% (which includes the above 20%) of all students expressed a desire to continue on into some form of graduate school education in a variety of fields. Medical, legal, computer science, and engineering were the most common. The remaining 20% or so expressed intent to enter the work force. Many expected to obtain jobs in computer science or engineering positions, but some believed they would be continuing in scientific capacities.

When asked if physics majors had a difficult time navigating the bureaucratic components of a college education, none claimed to have any difficulty. It is my opinion, for what it is worth, that the personality types drawn to a physics program are usually problem solvers, and the problems related to navigating a college bureaucracy are not difficult for such a person. Additionally, everyone I spoke with claimed the support of the departments in helping them through the process.

Physics majors in Utah do not appear to have any insurmountable problems in their programs. In general they are pleased with what they are doing. I am sure there are students who

disagree, but they seem to be in the minority. All students I spoke with recognized the difficulty of the task they are undertaking, and they vary in ability to achieve their goals, but they are remarkably loyal to their programs.

F. Utah State University History Department Elaboration of Learning Outcomes

BACHELORS PROGRAM

(1) Learning outcomes:

HISTORICAL KNOWLDEGE

1. (Range of historical information)

Pursue coursework that examines a broad range of historical experience through:

-surveys of pre-modern, modern, and U.S. history, as well as

-upper-division classes that provide greater focus and analytical rigor in specific subject areas,

-leading up to a capstone course focused on the construction of a senior thesis.

The coursework explores: how change occurs over time; the complex issue of historical causation; the influence of political ideologies, economic structures, social organization, cultural perceptions, and natural environments on historical events; and the ways in which factors such as race, gender, class, ethnicity, region, and religion create "histories" rather than a monolithic past.

HISTORICAL THINKING

2. (Recognize the past-ness of the past)

The ability to understand how people have existed, acted, and thought in the always-different context of the past. History often involves encountering and sensing the past's otherness and of learning to understand unfamiliar structures, cultures and belief systems. These forms of understanding also shed important light on the influence which the past has on the present.

3. (Emphasize the complex nature of past experience)

The appreciation of the complexity and diversity of situations, events and past mentalities. This emphasis is central to history's character as an anti-reductionist discipline fostering intellectual maturity.

4. (Emphasize the complex and problematic nature of the historical record)

The understanding of the problems inherent in the historical record itself: awareness of a range of viewpoints; appreciation of the range of problems involved in the interpretation of complex, ambiguous, conflicting and often incomplete material; a feeling for the limitations of knowledge and the dangers of simplistic explanations.

HISTORICAL SKILLS

5. (Develop skills in critical thinking and reading)

$ Critical thinking: a recognition that statements are not all of equal validity, that there are ways of testing them, and that historians operate by rules of evidence which, though themselves subject to critical evaluation, are also a component of intellectual integrity and maturity.

$ Critical reading: The ability to read and analyze texts and other primary sources, both critically and empathetically, while addressing questions of genre, content, perspective and purpose.

$ Primary sources include visual and material sources like topographical evidence, paintings, coins, medals, cartoons, photographs and films.

6. (Develop research skills)

Intellectual independence: a history program is not simply or even primarily a preparation for research in the subject, but it should incorporate the general skills of the researcher, namely the ability to set tasks and solve problems. This involves: bibliographic skills; the ability to gather, sift, select, organize and synthesize large quantities of evidence; the ability to formulate appropriate questions and to provide answers to them using valid and relevant evidence and argument. It should develop reflexivity, i.e. an understanding of the nature of the discipline including what questions are asked by historians, and why.

7. (Develop the ability to construct reasonable historical arguments)

In written and oral form, drawing on and presenting all the above skills. Such argument should have structure; it should be relevant and concise.

$ In the case of written argument it should be expressed in clear, lucid and coherent prose.

$ Orally, it should involve the capacity to sustain a reasoned line of argument in the face of others, to listen, to engage in sustained debate, and amend views as necessary in the light of evidence and argument.

(2) Achieving goals set out in “learning outcomes”

Larger curriculum reorganization:

The Department is currently in the process of revising its undergraduate program, creating changes that reflect both the “learning outcomes” model we have adopted *and* the changed circumstances at our institution (budgetary constraints + reduced personnel + increased student enrollment).

The changes proposed will, we anticipate, create a more structured, coherent, and incremental model of course organization, one in which students will:

$ -first, (in a new “pre-major” program) demonstrate their academic abilities in lower-division History surveys and a range of other Gen Ed courses in the humanities, arts, and social sciences;

$ -second, seek formal admission to the department – with new requirements for:
-higher GPA and
-mandatory, focused academic advising;
$ -third, follow a logical, sequential, and diversified set of upper-division course offerings;
$ -fourth, completing their work with a capstone course
-HIST 4990: a research-oriented class for History majors
-HIST 4850/60/70: a pedagogically-oriented class for the History Teaching Emphasis.

Individual course reorganization:
As the Department proceeds with its assessment program (inspired by the Tuning model), we will next move to individual classes where faculty will develop more specific "learning outcomes" for their particular courses and "rubrics" to measure student achievement.

MASTERS PROGRAM

(1) Learning outcomes

Source: Philip M. Katz, *Retrieving the Master's Degree from the Dustbin of History: A Report to the Members of the American Historical Association*, Washington D.C.: American Historical Association, 2005; http://www.historians.org/projects/cmd/2005/Report/index.cfm

Historical knowledge
1. A base of historical knowledge, combining both a breadth and depth of knowledge, a familiarity with more than one historiographic tradition, and the ability to synthesize different types of historical knowledge (such as might be required to construct a survey course). Master's programs should incorporate a comparative, if not a global, perspective on history. Program graduates should be "educated history generalists."

Historical thinking
2. Learning to think like a historian, which includes, among other attributes, "historical habits of mind" and "historiographic sensibilities" (i.e., a critical and self-conscious approach to the constructed nature of historical knowledge). Although it is very hard to specify the cognitive and intellectual maturation which indicates that a student is "thinking like a historian," most of the focus group participants agreed that it was a defining element of effective graduate education.

3. The foundations for a professional identity as a historian, including a familiarity with the historical development of the discipline, an introduction to ethical standards and practices, and an awareness of the multiple contexts of professional practice. Master's programs should promote collaboration and provide a model for collaborative work among historians.

Historical skills

4. Research and presentation skills, evidenced by the completion of a substantial research project. This project does not have to take the form of a traditional thesis, as long as it demonstrates content mastery, a familiarity with primary research, and competent historical analysis. (A challenge for history departments is making sure that different projects are comparable in quality and rigor, and are seen to be comparable by other graduate students, other history departments, and potential employers.) Master's degree recipients should be familiar with the tools of bibliography, a foreign language, and the differences between academic and non-academic writing. They should also be conversant with new information technologies, as tools for both research and public presentation.

5. A solid introduction to historical pedagogy, in the broadest sense of the term: what are the cognitive processes involved in teaching and learning history, how do learners of all ages attain their understanding(s) of history, and how do historians present the past to different audiences. If possible, master's programs should include a teaching component—or, better yet, practical training in the "presentation of history to non-specialists," which encompasses classroom instruction at all levels as well as public history. This would require graduate programs "to take teaching seriously," which many do not seem to do at present.

(2) Achieving goals set out in “learning outcomes”

Four key elements distinguish the masters program from the bachelors program.

(a) The masters program cultivates a **“professional identity”** among students (an element that is not as clearly and continually emphasized in the undergraduate program)

- -identity with the discipline, not simply with course material
- -participation in the activities of professional societies
  - -strongly encourage conference presentations
  - -attend guest lectures
  - -dues-paying membership in organizations
- -consistent attention to details of evidence, argument

(b) The masters program emphasizes the **primacy of research**.

-The student's work in developing a focused project requires rigorous, sustained research, not simply partial, sporadic, course-connected research (that occurs in the undergraduate program)

-Students immerse themselves in both primary source material AND the secondary literature that defines the "state of the question" that they intend to explore.

-Far greater (and practical) attention to methodological questions also serves as a distinguishing mark of the masters program.

(c) The masters program, in its course requirements, emphasizes the **seminar model** of learning rather than the lecture model adopted in most undergraduate classes.

-The seminar provides for a forum to enhance collaborative learning, disciplined contributions to discussion, and oral communication.

(d) the masters program, while offering specific, graduate-level seminars for its students, moves closer to the **"tutorial" model** of education. -The program *does* contain required courses:

HIST 6000. Historical Methods and Research. Introduction to the historical profession, emphasizing research and writing skills, as well as the critical assessment of scholarly works. Should be taken at the beginning of a student's graduate program.

HIST 6010. History and Theory. Examination of major works that have influenced the theory and practice of historical writing. History master's students are required to complete HIST 6010, HIST 6020, or another theory-enriched course.

-However, much of the student's remaining "schedule" involves graduate research and continual consultation with faculty advisors.

G. Utah State University History Department Learning Outcomes Rubric Example

Learning Outcomes Rubric Example:
Implementing the Learning Outcomes in History Courses

HIST 4990: Senior Capstone
Learning Outcomes Rubric

Name_____
Date_____

LEARNING OUTCOME	Excellent mastery 5	Good mastery 4	Some mastery 3	Minimal mastery 2	No mastery 1-0
HISTORICAL KNOWLEDGE					
Student demonstrates an understanding of the key historical events related to the thesis 10%	The paper displays: clear chronological understanding of events; complex grasp of causation; analyzes a range of factors shaping the sequence and outcome of events; situates issues within larger contexts; reflects on larger themes informing specific events.	Sound chronological framework; good grasp of causation; omits some key informing factors shaping events; some effort at contextualizing the question; proposes a sufficient range of larger themes.	Some chronological confusion; weak causal analysis; narrow range of informing factors in the discussion; weak contextualization; little discussion of broader themes.	Many chronological errors; simplistic causal analysis; few informing factors tied to the discussion; little to no discussion of wider context of events; thin discussion of wider themes.	Paper explores its subject in a historical vacuum with little commentary on causation, context, and larger themes
HISTORICAL THINKING					
Student frames historical questions in a thoughtful, critical manner 10%	The paper addresses a clearly-stated and significant historical question. Focuses on critical analysis rather than mere description. Key terms defined. Student clarifies the significance of the question. The question is of manageable scope and logically formulated.	The paper addresses a significant historical question that is clearly stated. Focus rests largely on critical analysis. Key terms usually defined. Question is of manageable scope, posed with minimal logical flaws in framing of the question.	The paper addresses a historical question that can be identified with some difficulty. Focus shifts between critical analysis and mere description. Some key terms left undefined. Significance of question unclear; serious logical lapses in framing of the question.	Significance of question not demonstrated; commentary is largely descriptive rather than analytical; key terms often undefined; the central question in the paper is of inappropriate scope or illogically presented.	No identifiable historical question.
Student evaluates and analyzes primary sources 15%	Demonstrates thorough awareness of origins, authors, contexts of all primary sources; consciously employs verification strategies as needed	Demonstrates some awareness of contexts of primary sources; employs some verification strategies	Offers partial evaluation of primary sources; spotty verification	Offers little to no evaluation of primary sources; no verification.	Is not aware of need to evaluate or verify sources.
Student evaluates and analyzes secondary sources, demonstrating an awareness of interpretive differences	Demonstrates careful reading from all relevant historiographical traditions; offers thorough, fair-minded, and informed assessment of historiography,	Has read widely in several historiographical traditions; assesses and summarizes those read; places his/her own work within the historiography; at	Cites at least two different interpretations; makes an effort to place his/her own work in reference to these two interpretations; critiques often unfair,	Minimal discussion of interpretation in secondary works. No effort to place his/her own work within historiography; critiques commonly unfair, irrelevant, or misinformed.	No awareness of interpretive differences.

10%	summarizing main ideas clearly and accurately; places his/her own work within the historiography; raises historically legitimate critiques concerning the strengths and weaknesses of the studies.	some points, critiques either inappropriate or unsubstantiated	irrelevant, or misinformed		
LEARNING OUTCOME	**Excellent mastery 5**	**Good mastery 4**	**Some mastery 3**	**Minimal mastery 2**	**No mastery 1-0**

HISTORICAL SKILLS					
Student employs a range of primary sources appropriate to the informing thesis of the paper 15%	Makes thorough use of all relevant online and print databases to identify primary source literature; all available primary sources identified. All sources in bibliography used thoroughly in text.	Makes good use of relevant online and print databases; some gaps in primary source base. A few sources in bibliography not fully used.	Makes some use of online or print databases; significant gaps in source base; paper based on only a few of cited sources.	No evidence of using databases to establish source base; source base very limited. Major sources unknown or not employed. Little evidence that author has used works listed in bibliography.	No evidence of using databases; sources entirely insufficient and inappropriate to paper topic.
Student employs a range of secondary sources appropriate to the informing thesis of the paper 10%	Makes thorough use of all relevant online and print databases to identify secondary literature; uses classic and most recent secondary literature; no major secondary sources omitted. All sources in bibliography used thoroughly in text.	Makes good use of relevant online and print databases; some gaps in secondary source base. A few sources in bibliography not fully used.	Makes some use of online or print databases; significant gaps in source base; paper based on only a few of cited sources.	No evidence of using databases to establish source base; source base very limited. Major sources unknown or not employed. Little evidence that author has used works listed in bibliography.	No evidence of using databases; sources entirely insufficient and inappropriate to paper topic.
Organization of argument 10%	Thesis announced --and argument previewed for the reader -- at the start of the paper in a succinct and comprehensible manner; clear framework for analyzing the thesis; argument unfolds through a logical sequence of points	Statement of thesis --and preview of argument -- are clear, but do not appear in the opening of the paper. Structure of the argument is sound, understandable, and appropriate to the project.	Thesis stated, but not at the start of the paper. Argument previewed; but the paper moves in a different direction. Difficult to detect a logical sequence to the points raised in the paper.	Difficult to determine the meaning, appropriateness, or significance of the thesis. No clear preview of the argument's direction. Sequence of points raised in the argument remains confused and puzzling.	Thesis either severely flawed or simply not offered; organization of argument remains incomprehensible

Well-substantiated argument; proper citation of evidence 10%	The writer correctly and thoroughly cites sources using Chicago Manual of Style format in footnotes or endnotes; the paper includes a separate bibliography listing all sources consulted for the paper.	The writer cites sources using the Chicago Manual of Style format in footnotes or endnotes and provides a separate bibliography; however, the paper displays some gaps in citation, errors in their construction, and inaccuracies in the bibliography.	Offers partial evaluation of primary sources; spotty verification	Offers little to no evaluation of primary sources; no verification.	Is not aware of need to evaluate or verify sources.
Mechanics	Spelling, punctuation, grammar all correct; proper sentence and	Occasional errors in spelling, punctuation, grammar, sentence &	Weaknesses in spelling, punctuation, grammar, sentence &	Problems in spelling, punctuation, grammar, sentence &	Problems in spelling, punctuation,

10%	paragraph construction	paragraph construction; not severe enough to hinder an understanding of the paper's main points.	paragraph construction make sections of the paper unintelligible.	paragraph construction make sections of the paper unintelligible.	grammar, sentence & paragraph construction so severe as to make the paper unintelligible.

TOTAL POINTS _____

500-450 "A" range

449-400 "B" range

399-350 "C" range

349-300 "D" range

299- 0 "F" range