MS in Physical and Applied Science Annual Program Review
Calendar Year 2010

{Note, formerly: MS in Physical Science (MSPS)

Program Description

The Masters of Science in Physical and Applied Science (MSPAS) program has areas of emphasis in Chemistry, Geology, Mathematics, Physics, and Geobiophysical Modeling. The program provides opportunity for graduates from a variety of disciplines to improve the depth and breadth of their scientific and mathematical knowledge and skills through instruction and research. The approach is both specific to each discipline and integrated across disciplines with an emphasis on problem solving.

The MS in Physical Science program originated as a means for public school science teachers to increase their knowledge of science, and in many cases to add the physics, or other, certification areas to their teaching credentials. As an interdisciplinary approach to science education, the program uses faculty and research facilities from all departments within the College of Science. The program has from the beginning featured a very flexible approach to student scheduling that has allowed each student's Plan of Study to be unique to his/her needs. The graduates from the program have the technological skills to fulfill the University's mission of workforce and economic development with an interdisciplinary outlook relevant for today's society.

In 1998 the Geobiophysical Modeling option was added to the MSPS program as a natural growth process of the courses in remote sensing and image processing. The core courses (PS/BSC 410/510 in remote sensing; PS/BSC 411/511 in image processing) have grown out of coursework introduced as special topics courses in the early 1980's. A Practicum course (PS 470/570) was added later to extend the project development and problem solving capabilities of the students. This has since been changed to PS 670 with the lower numbered courses remaining in the catalog. The PS 670 numbering helps to alleviate the problems with students not having enough hours at the 600-level to meet the 50% rule. All of these courses are designed for the student to learn sophisticated software programs. The software packages are applied to satellite images, aerial images, and/or Geographic Information Systems (GIS) data to solve specific problems related to urban development, environmental pollution, ecological studies, and transportation studies, as examples. Students learn the software packages IDRISI (410/510) and ERMapper (411/511) as essential components of the coursework. Majors in this track of the MSPAS use courses from across the College of Science offerings as well as from other departments outside the College of Science when the courses have technology content to complete their Plan of Study forms. Recent graduates in this track have been very competitive as they enter the job market earning initial annual salaries up to $65k. The flexibility built into the original MS PS program for teachers has served the purposes of each new track in the program of the MS PAS program.

Special Topics PS 650-651 numbers have been added to highlight current technology topics such as sensor systems and image processing capabilities dealing with timely scientific and technical issues. During the Spring Term 2011 PS 651 will be used to teach Image Analysis and Interpretation. Successful versions of such trial courses will in the future be presented for additional specific course numbers at the 600-level. Independent Study PS 660-661 numbers are allowing individuals to work on selected high level projects suitable for the student's program. PS 670, Practicum, is a course focused on project definition, project problem solving and project presentation at the 600-level. The problem proposal and solution parts of the courses have been essential for graduates to qualify for the high paying jobs.

Note that the addition of these courses allows the faculty to present material at a higher level. They also help to resolve a long-term problem with students not having enough 600-level courses to satisfy the rule of having 50% of the graduate course work at the 600-level. With the new courses and thesis work at the 600-level students should be receiving enough credit at the higher level to eliminate the need for the waivers.

Software grants worth millions of dollars over the past several years from ERMapper in San Diego, CA.; ESRI in Redlands, CA; and IDRISI at Clark University in Massachusetts, have provided the basis of a computerized environment for the digital image processing portion of the Geobiophysical Modeling curriculum. The physical facilities and the analog optics portion of the curriculum have been an extension of the College of Science and the laboratory courses for the Department of Physics and Physical Science. The digital component is funded by software grants and limited digital instrument parts for upgrades as a one-time purchase through a Rahall Transportation Institute (RTI) grant.

An additional source of students has emerged from the growth and maturity of the undergraduate Integrated Science and Technology (ISAT) program. This program is now providing students for the MSPAS program with a background in Environmental Assessment and Policy (EAP).

Another source of students for the program is a 2+2 program with technology students from the Community and Technology College (MCTC). Some of these graduates with an Associate Degree are now completing a BS degree through the Board of Regents (BOR) program. Once they have completed the BOR program with a satisfactory GPA they are eligible to apply for admission to the Graduate School. Some of these students accepted into the MSPAS graduate program are now working to complete the Geobiophysical Modeling track.

The MSPAS program works as an umbrella for all of these tracks. The flexibility built into the program allows each student to build on his/her strengths and needs. Each of the tracks is science and technology oriented and, in particular, has a significant

component of computer technology and its applications in 21st century society. Again, the mission in workforce and economic development is served by each of the tracks. Appendix I is an Assessment of Student Outcomes for the MS in Physical and Applied Science program. Appendix II is a brief summary of the tracks and how they are used. Appendix III lists the typical requirements for students working to increase their Physics background and possibly to add the Physics teaching certification to their license. This is given as a typical example for tracks in Physics, Geology, Chemistry, and Mathematics. The Geobiophysical Modeling track would require each student to take the core courses (PS/BSC 410/510 and PS/BSC 411/511) and at least one of the Practicum courses (PS 570 and/or PS 670). Additional courses come from Physics, Geology, and Biological Sciences (where field mapping of habitat is essential, as an example) department offerings. Students are also encouraged to take relevant courses from the Geography Department (GEO 526 Principles of GIS, GEO 529 Vector Analysis, GEO 530 Raster Analysis, and GEO 531 Analysis of Digital Imagery) which directly supplement the science college offerings. Departments from outside of the College of Science from which courses are used are: EM, ENGR, ES, GEO, and IS.

The faculty Steering Committee for this degree program consists of the faculty listed below. Each of the seven faculty have specific interests in the program with one of the seven faculty acting as Chair. The current membership is:

Dr. James Brumfield, Biological Sciences and Physics and Physical Science
Dr. Wayne Elmore, Associate Dean, College of Science
Dr. Michael Little, Integrated Science and Technology
Dr. Ralph Oberly, Physics and Physical Science, Steering Committee Chair
Dr. Nicola Orsini, Physics and Physical Science
Dr. Dewey Sanderson, Geology
Dr. Charles Somerville, Biological Sciences, Dean, College of Science

There have been 60 graduates in this program since the 1999 calendar year. There were twelve graduates in the calendar year 2007, five in the 2008, and three each in the 2009 and 2010 calendar years. These graduates have been distributed among the tracks within the program. There are 10 currently enrolled students (fall 2010) working toward graduate credit and their degree. In addition, there are at least two students in the program who are working on thesis papers without being currently registered for classes. Appendix IV lists the number of graduates from this program in each calendar year starting with 1999. These graduates have full-time employment at RTI, ESRI, West Virginia state government, and industry as examples. Several are teaching physics or physical science in area high schools.

Assessment Activities:

A. Program Goals/Competencies:

1. To continue to recruit and retain students eligible for admission to the Graduate School with an interest in all tracks of the MSPAS program. To be eligible for admission to the Graduate School a student must have a baccalaureate degree from an accredited college or university and an undergraduate GPA of at least 2.5 or equivalent. Students who qualify but do not have a sufficient background in the physical sciences are required to take courses at the undergraduate level to make them eligible for the program.

2. To provide students with a firm grasp of the fundamental principles of the discipline. All degree candidates take both written and oral examinations to graduate. The written exam is comprehensive in their major track. The oral exam without a thesis is based on the coursework and the written exam. The oral exam with a thesis is based on the research work and results of the thesis. The student presenting a thesis will present a Power Point summary of the thesis work to start the oral exam. In-service teachers working to add a teaching certification are required to pass a content specialization exam administered by the state, but results of this exam do not affect graduation with MS in Physical and Applied Science.

3. To provide students with the ability to define a problem, and then to formulate and carry out a solution to the problem using physical principles, mathematical modeling and/or computer-software skills. Many of the Physical Science courses include laboratory work that illustrates physical principles and techniques for problem solving. Knowledge of the operation and capabilities of the specialized apparatus within the laboratories of the College of Science is a valuable resource in scientific problem solving. Many of the courses demand that students select, define, and formulate a problem that has a software solution. Knowledge of the software introduced in the image processing courses is a valuable resource in problem solving. Many of the students in the program elect the thesis option which is inherently a problem-solving experience.

4. To provide students in all tracks of the program extensive knowledge of computer software. Depending on the track this could include word processing, educational applications, curve-fitting software for laboratory data, image processing procedures, analysis and modeling, and/or Geographic Information Systems (GIS).

5. To provide students with extensive opportunities to express their ideas through both written and oral reports of their work. Laboratory courses routinely expect students to submit coherent and persuasive laboratory reports. Project oriented courses have written and oral reports of project work required for completion of the course. Students electing the thesis option must write the thesis and defend it to an oral committee.

6. To provide students with critical thinking and problem solving skills. Application of these skills to real problems of interest in scientific laboratories, government agencies, and industrial laboratories is an essential part of the learning process. Certainly, problem solving using GIS and image processing techniques are essential to modern data processing and analysis in formulating models and their solutions.

B. Learning Outcomes/Data Collection:

Appendix I gives a matrix representation of the expectations and results for the students competencies. This is a matrix from the March 2002 report with updated and corrected information. An evaluation form to be filled out by recent graduates has been adopted and used by the Steering Committee. Results were listed in the most recent five-year review.

As suggested by the previous review, upon completion of the MS in Physical and Applied Science, students will be able to;

1. Apply the fundamental principles of the discipline to solve problems.
2. Plan and carry out a scientific investigation.
3. Choose appropriate computer software packages for particular analysis and use them competently.
4. Communicate effectively, in the discourse of the discipline, both orally and in writing.
5. Critically evaluate data sources to frame research hypotheses and to arrive at solutions to problems.

Courses are routinely evaluated by the faculty as they are in progress and each time that a syllabus is written for an upcoming course. As an example, the core courses in the Geobiophysical track (PS/BSC 410/510 and PS/BSC 411/511) are team taught by faculty in Physics and Physical Science and Biological Sciences. Grades in the two courses are arrived at by two exams during the semester each worth 25% of the course grade. One of the exams has a practical exam component over the software exercises that are part of the weekly activities for the students. The software (IDRISI and ERMapper) packages have exercise books that the students are expected to work through. The pace of a student doing the exercises is up to the individual, but they must have the book completed by the end of the semester. The rest of the course grade is based on the student's presentations on his/her project. The student is to select a software oriented project of interest to the student and his/her major area. For example, a student with an environmental assessment background may chose to define the habitat of a crayfish with a critical dependence on water quality for survival. In the first semester course, remote sensing, the students are expected to write a formal grant proposal defining the project and specifying the data needed to complete the project. In addition, they must propose what software and other procedures are needed to manipulate the data, and then to analyze the results. Typically, during the second semester the student would pursue the project, work with faculty help to obtain the appropriate data and then present the results. In each semester, the written final project report is 25% of the grade and the student's oral (power point required) report and defense of the project is 25% of the grade. The faculty in

these courses work together to revise the syllabus sheets each year. The revisions reflect changes in textbook materials, updates of software packages, and availability of image data.

The course content and the revision process is judged on the success of the graduates in obtaining jobs utilizing the skills gained in the courses. To the knowledge of the program faculty all recent graduates, but two, from the program are currently employed in jobs with a direct connection to the technical training in the program. (The two exceptions are a graduate who is disabled because of being legally blind and a graduate who has kept his job from before his graduate program.) This is consistent with the mission of the University to promote workforce and economic development. An additional survey of graduates is planned before the completion of the upcoming five-year review in 2012.

It is impossible to write a single exam to evaluate students as they complete their program. The range of academic backgrounds for the students in the program is very broad. Some students have been Physics majors with mathematics beyond differential equations and have taken advanced mathematics courses during their tenure in the program. Some students were undergraduates in non-science disciplines that did not require advanced rigorous mathematics. Yet, both extremes work through the program with individual Plans of Study that satisfy the goals of the program and the mission of the State. For the written comprehensive exam a student's committee has three faculty members. These faculty members could be from three academic disciplines. Each would submit questions from their discipline suitable for the student's background. Within the Physics Department the program coordinator keeps a file of past exams for Physics and Geobiophysical Modeling. These are recycled as appropriate.

C. Results:

Recommendations for Improving the Program:

1. The program has been created, and has grown to its current status while never having a budget for its operation. Operation of the program is based on using space from the participating departments for courses and research activities. In particular, Science 253, 258, and 259 are used every year as the classroom for the core courses in the Geobiophysical Modeling track. Research projects are also completed using the computers and software located in this laboratory. Graduate student assistantships are funded through RTI grants and one University Teaching Assistantship through the Department of Physics and Physical Science. Some of the major software packages have been obtained on a *maintenance only* grant from the software providers. Operation of the program would be much smoother and less stressful if a modest line item budget existed through the COS. The Interim Dean in 2005 inserted a line item in the upcoming budget request for the COS, but the administration deleted the request. The College of Science Dean has provided

funds to purchase a digital scanner for use with the image processing data. The Physics and Physical Science Department provides office type materials such as paper and copier services for the functioning of the program.

2. The Steering Committee has been meeting only in terms of selected members discussing coursework and research projects for students.

3. Additional courses at the 600 level need to be added in response to the successful use of the new Special Topics course numbers.

4. The high school teacher component of the program needs to have course offerings reinstated during the summer terms in order to revitalize the original program tracks. Summer teaching budgets in recent years have eliminated this segment of the curriculum. The courses are needed during the summer months when teachers are available for career enhancement and upgrading certification. Without the addition of these summer courses this component of the program could soon be lost. This would reduce our effort toward providing properly certified science teachers for schools in West Virginia. **The need for Physical Science, Chemistry, Physics, and Mathematics teachers is critical within the State of West Virginia.**

5. The administration needs to look ahead to the age of the faculty contributing to this program. The faculty in the image processing core courses are near or past retirement age. Adding new faculty to the departments who would be qualified to step into these core courses is a timely need. The program would be greatly strengthened by the addition of such faculty and continuity for the students would be assured. It has been suggested that current COS faculty could be recruited to teach segments of the core courses as a transition measure. The current Dean and Associate Dean of the College of Science have shown recognition of this need and are looking for ways of achieving the transition. The Dean and Associate Dean have expressed the need to strengthen the program so that it will grow.

II. BOT Initiative 3 Compliance:

Pertains to undergraduate programs only.

III. Plans for the current year:

1. Generation of a program publicity brochure that will inform students potentially interested in the program of its existence and outline the requirements for students in the program. An information sheet is currently available for this. The initiation of a website to publicize the program and the activity of students in the program has been suggested. It is anticipated that a great deal of flexibility will remain in each track so that students can continue to develop a curriculum that is suited to each student's background and needs. This has been a part of the plans for the past couple of years. Progress is being made toward listing specific requirements for each track within the degree program.

2. Circulation of the evaluation document to the recent graduates from the program. Update the data given in the recent five-year review to include responses from the recent graduates.

3. Continue to evaluate each course within the program as it is offered. The individual required courses and tracks are basically set. The success of the curriculum will continue to be based on faculty-student consultation between a student and his/her adviser, or a faculty advisory committee.

4. As mentioned above, create new courses at the 600-level to provide additional course topics for students in the program.

5. Continue on-going discussions with the Chair of the Department of Biological Sciences. These discussions are directed at ways to use resources efficiently between the MSPAS program and the graduate program within the Biological Sciences.

IV. Assistance Needed:

Each year time is needed to collect data from graduates. A line item budget for the program would allow more flexibility in hardware and software development.

V. What one most important thing has the department/program learned through this process?

The program is in great need of its own budget.

MSPAS graduates are entering the job market with skills that are in great demand. They are being offered highly competitive salaries by government, education and industrial employers.

Partial release time for the person responsible for the report would be of great value.

Appendix I

MS in Physical and Applied Science Program

Assessment of Student Outcomes

Component Area/Program/Discipline: Master's of Science in Physical and Applied Science

Student Outcome	Person or Office Responsible	Assessment Tool or Approach	Standards/Benchmark	Results/Analysis	Action Taken
A good grasp of fundamental principles of their discipline.	Instructors/advisers	Comprehensive exam for those students in the course option. Defense of thesis for those students in the thesis option.	Students should be able to answer questions covering a range of important topics in the emphasis area and do so in some depth. Student should be able to organize and write a complete report of a significant research problem validate hypotheses and defend the thesis to experts in the subject.	Of the 58 students who entered the program during the review period, 7 completed the degree within that period and 37 continue to progress toward degree completion. A half dozen completed teacher certification without earning a degree and approximately equal numbers left for a variety of other reasons includi9ng acceptance of full time employment.	
Ability to plan and carry out an investigation or research project.	Course instructors/thesis supervisors.	Reports on project type laboratory exercises, independent study projects and/or a research thesis.	Successful completion of a number of courses requiring an open-ended project, independent study project and/or successful defense of a thesis.	Most students completing the degree program have selected thesis option.	Inclusion of several courses with project type assignment requirement, and/or independent study courses in each student's degree program.

Student Outcome	Person or Office Responsible	Assessment Tool or Approach	Standards/Benchmark	Results/Analysis	Action Taken
Computer skills	Course instructors/thesis advisers	Regular course assignments, independent study projects, thesis	Must be able to use general (i.e. word processing, spreadsheet, database) and discipline specific computer software to archive and retrieve data, analyze information and present it effectively to professionals as well as the general public.	All students completing the program have a level of computer skills appropriate to their discipline.	Acquire and maintain appropriate computer hardware and software and integrate its use into all aspects of the curriculum. All emphasis areas require at least one computer intensive course such as PS 510, 511 and 520
Communication skills	Course instructors/thesis advisers	Regular course assignments, independent study projects, thesis	Students must be able to communicate their thinking and defend their answers to questions, both orally and in writing, and to faculty as well as other students.	All students completing the program have an appropriately high level of communication skill	Courses require written and oral reports. Instructors take WAC training and departments are encouraged to develop WAC courses and include them in every student program. Students are encouraged to present research at professional meetings and write up results for publication.
Critical thinking skills	Course instructors/thesis advisers.	Regular course assignments, written and oral reports on independent study projects, comprehensive exam or thesis research	Students must demonstrate critical thinking skills in completing regular class assignments, independent study projects, comprehensive exam or thesis.	Students completing the degree program have demonstrated their ability to think critically about the subject matter in their emphasis area.	Inclusion of several courses with project type assignment requirement, and/or indepedendent study courses in each student's degree program. Encourage students to select thesis option.
		Content specialization test for teacher recertification	Passage of test on first sitting		

Appendix II

MS in Physical Science Program Review

Brief Summary of MSPAS Tracks

Appendix II

Areas of emphasis for the MS in Physical and Applied Science:

Physics:
Students in this emphasis area are often high school teachers looking for extension to the depth and breadth of their science background. This often means the student is looking to add an endorsement to their teaching license, such as becoming certified to teach in the Physics 9 – Adult Comprehensive program. Some students are satisfied to simply extend their teaching certification, others continue on to obtain the MS in Physical Science degree. This degree for a working teaching can give them a substantial raise to their base salary because it is an advanced in-field degree. Some students in the emphasis area simply take courses to extend their background in physics and the mathematical sciences. These courses could include the topics of Optics, Electronics, Modern Physics, Quantum Mechanics, Thermal Physics, and others. This can be a means of enhancing their chances of doing well in a Ph.D. in Physics program at another institution.

Geobiophysical Modeling:
Most students in this emphasis area are planning on a career in a field where mapping and correlating information on a geographic scale is important. For example, the fields of geology, biological sciences with field studies, medical sciences where the spread of disease can be charted, and geography are all concerned with the spatial distribution of information. For example, projects on transportation corridors within the Appalachian region are often studied by students with financial support through the Rahall Transportation Institute on the Marshall University Huntington campus. Students in this emphasis area have core courses in remote sensing, image processing, and geographic information services (GIS). Students learn how to use current software and hardware

to collect, analyze, and present the spatial distribution of data. Satellite and aerial data are available for the entirety of the State of West Virginia and many neighboring areas. International students in this area have done projects on involving data from their home countries, such as China and India.

Geology:
Students in this emphasis area have the opportunity to do a rigorous course at the MS level in Geology. With the absence of a stand-alone MS in Geology on campus this emphasis area allows students to obtain an MS degree which might be a step on the way to a Ph.D. degree in Geology. One of the options within this area of emphasis is to take some of the

Geobiophysical Modeling core courses that are of critical use in mapping of geologic structures. Courses in areas such as hydrology are of critical importance when weather systems are changing and reaching severe levels. Mapping of earth surface features can lead petroleum geologists to areas that may have petroleum reserves.

Chemistry:
Students in this area of emphasis could be teachers looking to extend the depth and breadth of their science background. In this regard the comments in the Physics section are all relevant to this section. A rigorous stand-alone MS in Chemistry exists on the Marshall University campus for those considering going on for a Ph.D. in Chemistry.

Mathematics:
Students in this area of emphasis could be teachers looking to extend the depth and breadth of their mathematics and statistics background. In this regard the comments in the Physics section are all relevant to this section. A rigorous stand-alone MS in Mathematics exists on the Marshall University campus for those considering going on for a Ph.D. in Mathematics.

Appendix III

MS in Physical and Applied Science Program

Typical Coursework for Physics Emphasis

Students doing the Physics track for the MSPAS program would typically fall into two categories. The first category would be for working science teachers to enhance their science background and possibly add the Physics 9-Adult Comprehensive certification. The second group would be for individuals who want to extend their knowledge of physics in a rigorous mathematical way. For example our current laboratory manager within the department finished the MSPS program a couple of years ago. He is now applying for admission to graduate physics programs for the purpose of earning a PhD degree.

Typical Physics Education Course Selection: (Note: 300/400 level courses taken as graduate independent study courses.)

PHY 320 Modern Physics
PHY 521 Modern Physics Laboratory
PHY 304 Optics
PHY 505 Optics Laboratory
PHY 308 Thermal Physics
PHY 314 Electronics
PHY 515 Electronics Laboratory
PS 500 Astronomy
PS 500L Astronomy Laboratory
PHY 447 Mechanics for Teachers
PHY 550 radiation Physics in the Life Sciences

Note: all courses listed above are required or recommended on the certification list. Students can also select any other courses in physics, chemistry, geology, and mathematics for which they have the prerequisites.

PHY 547 Mechanics for Teachers
PS 525 Development of Scientific Thought

Typical Physics Courses for further Graduate School Preparation:

PHY 542 Quantum Mechanics
PHY 545 Mathematical Methods in Physics
PHY 644 Atomic Physics

PHY 600 Electricity and Magnetism
PHY 630 Classical Mechanics
PHY 608 Statistical Mechanics
PHY 625 Condensed Matter Physics
PHY 443 Quantum Mechanics

MSPAS students in the Chemistry, Geology and Mathematics tracks would have similar selections from within their department course offerings. Students are also encouraged to take courses from any of the departments to diversify their scientific knowledge.

Appendix IV

MS in Physical Science Program Review

Annual Number of Graduates

The data below show the numbers of graduates from the MS in Physical Science program per calendar year. The data starts with the year 1999 because it shows the level of graduates before and after the introduction of the Geobiophysical Modeling track as a major contributor to the program.

Year	Number of Graduates
1999	2
2000	2
2001	3
2002	7
2003	3
2004	6
2005	8
2006	5
2007	12
2008	6
2009	3
2010	3