LEVEL II BOARD OF REGENTS ITEMS

Curriculum Proposals

1. Overview

A Minor in Optics at MSU-Bozeman is sought

We propose a new Minor in Optics for undergraduate students most likely majoring in Electrical Engineering, Computer Engineering, Physics, and Chemistry and Biochemistry at Montana State University - Bozeman. The Minor will complement and encourage cross-disciplinary activities among three departments (Electrical & Computer Engineering, Physics, Chemistry & Biochemistry) and two colleges (Engineering and Letters & Sciences).

2. Need

a. To what specific need is the institution responding in developing the proposed program?

Since 1980, the Gallatin Valley has become home to an impressive and growing number of companies in technologies involving optics and lasers. Figure 1 is a timeline illustrating this exponential growth. Many of these companies were formed by MSU graduates or faculty, and others moved here for the quality of life or to become part of the growing Montana optics community. During this same time period, MSU-Bozeman transitioned from employing two faculty members who worked in optics in 1980 to more than two dozen in 2012. As part of the synergistic growth of the Montana optics community, MSU established the Regents-approved Optical Technology Center (OpTeC) in 1995. The activities undertaken through this center have strengthened public-private collaboration and increased the transfer of optical technology from the university to the private sector. The Bozeman area is increasingly recognized as an area of activity with international significance in the broad field of optics. Because of this growth, the local optics industry is now reaching the state of maturity where it needs an increased number of employees with highly technical training in optics. The proposed optics degree is an overdue step that will significantly improve the ability of MSU to train top talent for the growing Montana optics industry.
b. How will students and any other affected constituencies be served by the proposed program?

Optics has been called an “enabling technology” by the National Academy of Science (Harnessing Light: Optical Science and Engineering for the 21st Century, 1998; Optics and Photonics: Essential Technologies for Our Nation, 2012). These reports identified numerous ways that optical technologies benefit our nation and the world, including optical fiber communication networks that enable the Internet, tiny laser diodes that enable CD and DVD players and recorders, compact imaging modules that enable the world’s tiniest cell phones to the world’s largest telescopes, and infrared imagers that enable night-vision superiority for our military. This rapidly growing range of optical applications corresponds to a rapidly growing need for engineers and scientists who are ready to create tomorrow's optical technologies. The proposed optics minor is an important step that MSU can take now to address this national and regional need, which will lead to growth in the number of graduates qualified to get and create new optics jobs in Montana.
c. What is the anticipated demand for the program? How was this determined?

We estimate that one-to-two dozen students will graduate each year from a fully implemented optics minor. Many of these will become employees of local companies. The ongoing and growing demand for students trained in optics from the undergraduate and graduate graduates was identified in discussions with the leaders of more than one dozen local optics companies, such as Bridger Photonics, Resonon, Quantel USA, ILX Lightwave, S2 Corporation, Altos Photonics, and others. Many of these discussions have taken place over multiple years during our annual OpTeC meeting held at MSU each summer (attended by MSU faculty, students, and local optics company leaders and employees). A more recent discussion occurred in fall 2012 at a Bozeman meeting to discuss economic development opportunities in optics. Similar discussions have occurred in phone conversations between the OpTeC Director and leaders of local optics companies, and during our weekly OpTeC colloquia, which are attended regularly by company members in addition to the academic audience.

Beyond Montana, there also is strong demand throughout the western U.S. (and beyond) for students with formal training in optics, especially ones trained in the process of designing and building optical systems. This practical focus is, in fact, a feature of our program that will greatly increase demand for our graduates over those from schools that focus only on a few academic sub-areas of optics. For example, recent discussions have identified strong interest from large companies in Colorado (Ball Aerospace and Lockheed-Martin Coherent Technologies) for graduates trained in optical design, especially in one of our strongest specialty areas, optical sensor systems. Similar interest has been found in discussions with companies from Quebec to San Diego.

Rapidly growing demand for optics professionals with cross-disciplinary training also motivates this new program at MSU. For example, MSU currently has faculty members who design state-of-the-art optical sensor systems, and others who use such systems for research in fields including agriculture, ecology, biochemistry, space sciences, and other diverse applications. The new optics minor will provide enhanced opportunities for these faculty members to work together with undergraduate students who are trained to work and communicate across these disciplines.

3. Institutional and System Fit

a. What is the connection between the proposed program and existing programs at the institution?

The proposed minor is a combination of electrical and computer engineering, physics, and chemistry. Current students often take a few optics electives during their undergraduate program, but the minor will help us offer and help the students identify the best selection of classes to prepare for either advanced studies in graduate school or immediate employment in the field. There is no similar program at MSU or at any university in Montana or surrounding states.
b. Will approval of the proposed program require changes to any existing programs at the institution? If so, please describe.

No changes are required to begin the optics minor, which is designed to use existing courses, instructors, and lab facilities as a cross-departmental option. However, we have identified two classes that would greatly benefit students, especially in meeting the needs that have been expressed to us by local employers. These are undergraduate courses in 1) Nonlinear optics, and 2) Optical design. The first has been taught recently as a special topics course and will be phased more permanently into the curriculum as demand and opportunity allows. The second will be provided by creating a co-convened undergraduate version of an existing graduate class (EELE 582).

c. Describe what differentiates this program from other, closely related programs at the institution (if appropriate).

There is no counterpart of this minor at MSU or within Montana and the surrounding states.

d. How does the proposed program serve to advance the strategic goals of the institution?

The optics minor directly addresses the following goals within the Montana University System (MUS) 2012 Strategic Plan:

Goal 2.1 Increase responsiveness to workforce development needs by expanding and developing programs in high-demand fields in the state.

Goal 2.2 Establish collaborative programs among institutions, the private sector, and the state to expand research, technology transfer, the commercialization of new technologies, and the development of our entrepreneurs.

The proposed optics minor also directly addresses the following goals, objectives, and metrics in the Montana State University (MSU) 2012 Strategic Plan:

Goal (Learning): MSU prepares students to graduate equipped for careers and further education.

Objective L.2: Increase graduation rates at MSU

Objective L.3 Increase job placement and further education rates

Goal (Integration): By integrating learning, discovery and engagement, and by working across disciplines, the MSU community will improve the world.

Objective I.1: Increase the integration of learning, discovery and engagement.
Metric I.1.4: By 2019, faculty scholarly products with undergraduate and graduate students will increase 50%.

Objective I.2: Increase work across disciplines.

Metric I.2.1: By 2019, the number of students completing interdisciplinary programs will increase 30%.

Metric I.2.2: By 2019, MSU will increase interdisciplinary research and creative projects on campus.

Furthermore, MSU’s College of Engineering has three strategic areas in the 2009 five-year plan: 1) global connections, 2) cross-disciplinary collaboration, and 3) technological leadership. The proposed optics minor addresses all these areas.

Based on the cooperative design of the optics degree program, and the enabling nature of optical technology, the proposed optics degree is in direct alignment with the cross-disciplinary goals at the College, University, and System level.

e. Describe the relationship between the proposed program and any similar programs within the Montana University System. In cases of substantial duplication, explain the need for the proposed program at an additional institution. Describe any efforts that were made to collaborate with these similar programs; and if no efforts were made, explain why. If articulation or transfer agreements have been developed for the substantially duplicated programs, please include the agreement(s) as part of the documentation.

There is no similar program in the Montana University System or in surrounding states.

4. Program Details

a. Provide a detailed description of the proposed curriculum. Where possible, present the information in the form intended to appear in the catalog or other publications. NOTE: In the case of two-year degree programs and certificates of applied science, the curriculum should include enough detail to determine if the characteristics set out in Regents’ Policy 301.12 have been met.

The undergraduate non-teaching minor in optics is designed to provide undergraduate students a core set of knowledge and skills to prepare them for rapidly growing opportunities in optical science and engineering. Requirements include courses in optics, electrical engineering and physics, as well as electives chosen to match the interests and needs of each student. To earn this minor a student must complete the following:
12 core credits

EELE 334  Electromagnetic Theory I  3
or PHSX 423  Electricity and Magnetism I  (3)
EELE 432  Applied Electromagnetics  3
or PHSX 425  Electromagnetic Theory II  (3)
EELE 482  Electro-Optical Systems  3
PHSX 427  Advanced Optics  3
or PHSX 437  Laser Applications  (3)

9 credits optics electives:

PHSX 427  Advanced Optics  3
PHSX 437  Laser Applications  3
PHSX 444  Advanced Physics Lab (optics offering)  4
EELE 408  Photovoltaic Systems  3
EELE 484  Laser Engineering  3
CHMY 371  Physical Chemistry  3
EELE 488  EE Capstone Design I\(^1\)  2
EELE 489  EE Capstone Design II\(^1\)  2
PHSX 499  Senior Capstone Seminar\(^1\)  1
XXXX 490  Undergraduate Research\(^1\)  \(\leq 3\)
XXXX 491  Special Topics\(^2\)  \(\leq 3\)
XXXX 492  Independent Study\(^2\)  \(\leq 3\)
XXXX 494  Seminar/Workshop\(^1\)  \(\leq 2\)

TOTAL  21

\(^1\) A maximum of four (4) credits of these classes may be used if the topic is directly related to optics, on approval by academic advisor and research advisor/instructor.

\(^2\) Maximum of three (3) credits of these classes may be used if the topic is directly related to optics, on approval by academic advisor and research advisor/instructor.

Note: The following 500-level classes can be taken as electives in the Optics minor by seniors with a cumulative grade-point average \(\geq 3.25\) (by petition to the Registrar) and provided all prerequisites are met.

EELE 538  Advanced Topics in Electromagnetics & Optics
EELE 581  Fourier Optics & Imaging
EELE 582  Optical Design
EELE 583  Remote Sensing Systems
PHSX 515  Advanced Topics in Physics (if topic is directly optics related)
CHMY 527  Optical Spectroscopy
CHMY 557  Quantum Mechanics
CHMY 560  Symmetry, Orbitals, and Spectroscopy

Students pursuing the BS in Electrical Engineering at MSU-Bozeman can earn the optics minor with no extra credits with careful selection of electives and by completing an optics-related capstone design project.
Students pursuing the BS in Physics Professional Option at MSU-Bozeman or the BS in Physics Interdisciplinary Option at MSU-Bozeman can earn the optics minor with no extra credits with careful selection of physics electives, by taking EELE 482 as one of their university or declared area electives, and by completing optics-related research (490R and 499R) as their required senior project.

b. Describe the planned implementation of the proposed program, including estimates of numbers of students at each stage.

Immediately upon approval of the degree program, advertisements will be distributed throughout MSU and the local and regional optics companies. A new OPTI rubric will be established and existing courses that will become a core part of the optics curriculum will be cross-listed with the OPTI rubric, while maintaining their original home department (e.g., EELE, PHSX, CHMY). One faculty member from each of the three participating departments will be identified to serve on the Optics Program Committee that oversees the optics minor and overall optics program.

While filing the Application for Baccalaureate Degree for the major, students pursuing the optics minor also will submit the Application for a Non-teaching Minor by the deadlines set forth in the University Catalog. Department heads will serve as the minor certifying officers, but the optics program committee will advise them as needed. They will certify that students have completed the required course credits for the optics minor.

5. Resources

a. Will additional faculty resources be required to implement this program? If yes, please describe the need and indicate the plan for meeting this need.

No new faculty members are required for implementing the optics minor.

b. Are other, additional resources required to ensure the success of the proposed program? If yes, please describe the need and indicate the plan for meeting this need.

The proposed optics minor requires limited additional resources, principally to accommodate the inevitable increase in administrative overhead necessary to publicize the program, advise students, and process the Application for a Non-teaching Minor paperwork when a student is ready to graduate. These efforts will be handled in the three participating departments with cooperation from the interdisciplinary Optical Technology Center (OpTeC).
6. Assessment

How will the success of the program be measured?

All departments in the MSU College of Engineering use a systematic assessment plan (http://www.montana.edu/wwwprov/assessment/assessmentplans.htm) for all academic programs and courses. We continually assess objectives and outcomes at the program and course levels. This same assessment plan will be used for the optics minor.

In addition, we will provide annual assessment based on student, employer, and alumni satisfaction, and input provided by Montana optics industry leaders, including feedback provided during the annual OpTeC meeting. Student enrollment, graduation rates, and employment trends will be recorded and reviewed annually at an annual meeting of the OpTeC. Appropriate revisions will be determined from all these sources.

7. Process Leading to Submission

Describe the process of developing and approving the proposed program. Indicate, where appropriate, involvement by faculty, students, community members, potential employers, accrediting agencies, etc.

OpTeC faculty members (from ECE, Physics, and Chemistry & Biochemistry) have gathered several times in recent years to discuss national trends in undergraduate and graduate optics education, existing MSU optics course offerings, and needed courses. A working group, comprising one faculty member from each of the three participating departments, designed this optics minor proposal. Input was gathered from leaders of many of the local optics companies at a fall 2012 meeting, and a public meeting was held in January 2013 during the weekly OpTeC Colloquium time for faculty and students to hear about and comment on the proposal. Finally, input has been solicited from the faculty of the participating departments and the proposal is presently making its way through the relevant MSU committees.