Michigan Tech

# Office Memo

Office of the Provost and
Senior Vice President for Academic Affairs

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**TO:** Richard Koubek, President

**FROM:** Jacqueline E. Huntoon, Provost & Senior Vice President for Academic Affairs

**DATE:** April 22, 2021

**SUBJECT:** Senate Proposal 64-21

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Attached is Senate proposal 64-21, “A New Graduate Certificate: Frontiers in Optics and Photonics,” and a memo stating the Senate passed this proposal at their April 21, 2021 meeting. I have reviewed this memo and recommend approving this proposal.

I concur__X__ do not concur_______ with this recommendation.

Richard Koubek, President

Date: 4/26/21

Michigan Tech

***University Senate***

| | |
|---|---|
| **DATE:** | April 22, 2021 |
| **TO:** | Richard Koubek, President |
| **FROM:** | Samuel Sweitz<br>University Senate President |
| **SUBJECT:** | Proposal 64-21 |
| **COPIES:** | Jacqueline E. Huntoon, Provost & Senior VP for Academic Affairs |

At its meeting on April 21, 2021, the University Senate approved Proposal 64-21, “A New Graduate Certificate: Frontiers in Optics, and Photonics”. Feel free to contact me if you have any questions.

**The University Senate of Michigan Technological University**
**Proposal 64-21**

**A New Graduate Certificate: Frontiers in Optics and Photonics**

**Submitted by: Department of Physics**

**Co-sponsored by:**
**Department of Materials Science and Engineering**
**Department of Electrical and Computer Engineering**

1. **Version Date: March 29, 2021**

2. **Proposer Contacts:** Ramy El-Ganainy (ganainy@mtu.edu), Miguel Levy (mlevy@mtu.edu), Jae Yong Suh (jsuh@mtu.edu), Jacek Borysow (jborysow@mtu.edu), Ranjit Pati (patir@mtu.edu), Yoke Khin Yap (ykyap@mtu.edu), and Ravi Pandey (pandey@mtu.edu)

3. **Interdisciplinary Program:** Final approvals from the collaborating departments and colleges were obtained in the Deans' Council meetings before forwarding to the Provost's office and the senate. Advising and administrative duties will be housed entirely in the Physics department.

4. **General Description and Characteristics**

These 9-credit Graduate Certificate in "**Frontiers in Optics and Photonics**" are:
a) Prepare graduate students with a strong foundation in optics and photonics that allows them to explore new frontiers in non-linear optics, and emerging new phenomena in optics, photonics, and plasmonics in the future.
b) Prepare graduate students on the basics of characterizing frontier optical and photonic phenomena.
c) Enhance the credibility of graduate students with skills needed for their career in optics, photonics and plasmonics.

**Catalog Description:** The graduate certificate in "**Frontiers in Optics and Photonics**" aims at developing the foundation of: 1) Integrated photonics, 2) Nano optics, 3) Computational electromagnetics, 4) Quantum optics, 5) Optical wave propagation in complex media. Based on these skills, students can explore applications in telecommunications, biophotonics, quantum computing, sensing and imaging.

**Graduate Student Learning (GLO) Assessment**
GLO 1: Students earning this certificate will be able to solve open-ended problems in one or more of the following topics: integrated photonics, plasmonics, electromagnetism, Fourier optics, microwave engineering, antenna engineering.
GLO 2: Students earning this certificate will be able to analyze wave-materials interaction phenomena such as acousto-optic effects, electro-optic effects, and wave

gain/loss effects.
GLO 3: Students earning this certificate will be able to design some of the basic elements of integrated optical devices such as waveguides, resonators, modulators, and beam splitters.

**5. Title of Program:** "Graduate Certificate in Frontiers in Optics and Photonics"

**6. Rationale**

Optical, and photonic physics are emerging fields for telecommunication, optical computing, biophotonics, quantum sensing/communication and computing. This growing area is expected to meet many academic and industrial needs.

**7. Discussion of Related Programs**

Our proposed certificate is unique for its interdisciplinary nature and diverse topics in optics and photonics. Several other universities are offering related certificate programs with different course requirements, for examples,

***Duke University*** – http://fitzpatrick.duke.edu/education/certificate

***The University of Arizona*** – https://grad.arizona.edu/catalog/programinfo/PCECRTG

***University of Pittsburgh*** – https://catalog.upp.pitt.edu/preview_program.php?catoid=5&poid=261&returnto=137

From the information in these links, there is no evidence that these external programs are being offered online. The program in Arizona is offering some courses online but not all courses.

**8. Projected Enrollments**

Table 1 shows estimated minimum targets assuming a more aggressive marketing approach is deployed. The enrollment cap depends on the number of sections that can be allocated to each course. The certificate can be offered online in the future when online versions of the required and elective courses become available.

Table 1. Estimated minimum enrollment by year.

| Academic Year | On Campus |
|---|---|
| 2021-2022 | 2 |
| 2022-2023 | 2 |
| 2023-2024 | 3 |
| 2024-2025 | 3 |
| 2025-2026 | 4 |

**9. Curriculum Design**

This 9-credit certificate consists of one 3-credit required course and 6-credits of electives. Only three credits may be at the 4000 levels. The required and elective course list with the course descriptions are given below. It is expected that students will work with the program advisor to select courses that fit their interests and prerequisite skills.

***Required Courses - 3 credits***
PH4292 / MSE 4292– Photonic Materials (3 credits)

***Elective Courses - at least 6 credits***
PH 5210 - Electrodynamics I (3 credits)
PH 5151 / MSE 5151- Quantum Field Theory for Photonics and Materials (3 credits)
PH 5410 - Quantum Mechanics I (3 credits)
EE 5520 - Fourier Optics (3 credits)
EE 5410 - Engineering Electromagnetics (3 credits)
EE 5526 - Microwave Engineering (3 credits)
EE 5528 - Antenna Engineering (3credits)

**Course Descriptions**
PH 4292 / MSE 4292- Material properties controlling lightwave propagation in optical crystals and optical waveguides. Photonic devices are based on electrical, magnetic, and strain effects. Topics include electro-optics, magneto-optics, optoelectronic and magneto-optic materials.

PH 5210 - Electrodynamics I: Electrostatics and magnetostatics, boundary value problems, multipoles, Maxwell's equations, time-dependent fields, propagating wave solutions, radiation.

PH 5151 / MSE 5151- Quantum Field Theory for Photonics and Materials: This course will review the basics of quantum mechanics and second quantization, and cover quantum field theoretical methods, including Wick's theorem and Feynman diagram techniques, for absolute zero and non-zero temperatures (Matsubara frequencies) and their application in photonics, properties of materials and condensed matter physics.

PH 5410 - Quantum Mechanics I: Study of the postulates of quantum mechanics framed in Dirac notation, the Heisenberg uncertainty relations, simple problems in one dimension, the harmonic oscillator, the principles of quantum dynamics, rotational invariance and angular momentum, spherically symmetric potentials including the hydrogen atom, and spin.

EE 5520– Fourier Optics: Analysis and modeling of diffraction effects on optical systems, emphasizing frequency-domain analytic and computational approaches. Presents wave propagation, imaging, and optical information processing applications.

EE 5410 - Engineering Electromagnetics: A mathematically rigorous study of dynamic electromagnetic fields, beginning with Maxwell's equations. Topics include scalar and vector potentials, waves, and radiation

EE 5526 - Microwave Engineering: Basics of microwave engineering. Topics include microwave sources; wave equations and their solutions; wave propagation; reflection, and guiding; transmission line theory and practice; microwave network analysis and impedance matching; microwave resonators, filters, and dividers; left-handed materials and devices.

EE 5528 - Antenna Engineering: Topics include: basics of radiation theory, Hertzian dipole and loop antennas, near and far fields, bandwidth, gain and other antenna parameters, Yagi-Uda, bow-tie, cavity-backed and traveling-wave antennas, microstrip solutions, miniaturization, substrates, and superstrates.

**10. New Course Descriptions**
None

**11. Model Schedule Demonstrating Completion Time**
The minimum completion time is two semesters. A typical schedule is shown below.

| ***Fall Semester*** | ***Spring Semester*** |
|---|---|
| PH5210 and PH4292 | PH5151 |
| Elective (if not in fall, then in spring) | Elective (if not in fall, then in spring) |

**12. Library and Other Learning Resources**
No additional library or other learning resources are required.

**13. Description of available/needed equipment**
No additional equipment is needed.

**14. Program Costs**
No additional program costs are anticipated.

**15. Accreditation Requirements**
None

**16. Planned Implementation Date**
This program has an anticipated start in Fall 2021. The certificate program will be extended into an online program as soon as it is established and practical to do so.

**Additional Information for New Programs:**

**1. Program-Specific Policies, Regulations and Rules.**
This program will follow Senate Policy 411.1 for Graduate Certificates. No additional program-specific policies apply besides the curricular requirements described above.

**2. Scheduling Plans**
On-campus sections will not require changes in class schedule, while online sections can be implemented asynchronously.

**3. Space**

No additional space requirements are necessary for this certificate.

**4. Faculty Resumes**

The associated faculty who taught or can teach related courses are listed on the websites of the Department of Physics, and the Department of Electrical and Computer Engineering. Examples of webpages are embedded with the faculty names.

PH4292 / MSE 4292, PH 5151 / MSE 5151: Miguel Levy (Physics and MSE)
PH 5410: Ranjit Pati (Physics)
PH 5210: Jae Yong Suh (Physics)

**Approval Process**

Department approval: January 22, 2021
College of Sciences and Arts: February 15, 2021
Graduate Faculty Council: March 2, 2021
Provost's Office and Deans' Council: March 15, 2021
Approval by the Senate:
Approval by the President: