Course Number: COSC xxx

Course Title: Applied Quantum Optics & Sensing

Number of Credit Hours: 3

**Catalog Description**:

COSC xxx Applied Quantum Optics & Sensing – Three hours of lecture, 3 credits.

This course introduces students to the techniques of classical and quantum measurements, in particular the quantum advantage in sensitivity. Key concepts regarding detection & noise, use of lasers, and quantum sensing of electromagnetic fields, acceleration, squeezing, ghost imaging & spectroscopy, and sensing using entangled photons will be discussed. Associated labs will provide students with hands-on experience with quantum technologies.

Prerequisite: Physics Course, Math Course ??

**Course Objectives**

Upon completion of this course, students will be able to do the following:

• Describe the differences between classical and quantum measurements, and the unique applications using quantum sensing

• Analyze the theory and experimental requirements of quantum sensing

• Demonstrate skills by calculating quantum sensing system outputs and hands-on quantum sensing labs

**Course Content (Statement of Subject Matter):**

Unit 0: Review of classical sensing

Unit 1: Detectors

Unit 2: Quantum vacuum and noise

Unit 3: Sensing with lasers

Unit 4: Precision time measurement

Unit 5: Quantum sensing of electromagnetic fields

Unit 6: Quantum sensing of acceleration (Navigation)

Unit 7: Quantum sensing of acceleration (Gravity)

Unit 8: Quantum squeezing

Unit 9: Ghost imaging & spectroscopy

Unit 10: Quantum sensing with entangled photons

**Course Schedule**

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| **Week** | **Unit** | **Unit Name** | **Computer Lab/Project** |
|  |  |  |  |
| 1-2 | 0 | Review of classical sensing | Optics familiarization |
| 3 | 1 | Detectors | Noise measurement |
| 4 | 2 | Quantum vacuum and noise | Faraday rotation |
| 5 | 3 | Sensing with lasers | Ghost imaging 1 |
| 6 | 4 | Precision time measurement | Ghost imaging 2 |
| 7-8 | 5 | Quantum sensing of electromagnetic fields | Ghost spectroscopy |
| 9 | 6 | Quantum sensing of acceleration (Navigation) | Non-line-of-sight imaging (Experiment) |
| 10 | 7 | Quantum sensing of acceleration (Gravity) | Non-line-of-sight imaging (Code) |
| 11 | 8 | Quantum squeezing | Nonclassical Correlations Part 2 |
| 12-13 | 9 | Ghost imaging & spectroscopy | Violating Bell’s Inequality Part 1 |
| 14-15 | 10 | Quantum sensing with entangled photons | Violating Bell’s Inequality Part 2 |
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**Bibliography:**

* Farley, D.R., “Quantum Sensing and its Implications for International Safeguards”, Sandia National Laboratories, SAND2021-13677 (2021)
* A guide to experiments in quantum optics. H.-A. Bachor and T. C. Ralph. Wiley-VCH VVerlag. ISBN-13: ‎ 978-3527403936, 2009.