INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

1. **Name of the Academic Unit: Advanced Technology Development Centre**

2. **Subject Name: Photonic Quantum Information Technologies**
   L-T-P: 3-0-0 Credits: 3

3. **Pre-requisites: None**

4. **Syllabus and reference books:**

Syllabus:

Basics of quantum physics and quantum information science: Quantum states and operators, quantum measurements, quantum superposition and entanglement, classical vs. quantum bits, quantization of light, degrees of freedom of light, evolution of light field operators, physical examples of qbits, physical examples of photonic qbits and qdits.
Photonic quantum states: Coherent states, single-photon states, photon-number states, Schrodinger cat states, squeezed states, quantum superposition and entangled states, discrete- and continuous-variable representation of photonic quantum states.
Sources of photonic quantum states: Sources of coherent light, Sources of squeezed light, Single-photon sources, Sources of Schrodinger cat states, Sources photon-number states, Generation of superposition and entanglement.
Manipulation and detection of quantum light: Quantum description of optical elements (beam splitters, interferometers, cavities, polarizers, modulators, etc), quantum description of photodetection, click detectors, single-photon detectors, photon-number resolving detectors, homodyne and heterodyne detectors, correlation detection, figures of merit of various measurement strategies.
Photonic quantum communication: Quantum communication basics: no-cloning, cryptography, teleportation, photons as information carrier, photonic implementation of quantum teleportation and entanglement swapping, realization of photonic quantum key distribution, photonic implementation of communication protocols using discrete- and continuous-variable approaches, brief survey of recent practical achievements.
Photonic Quantum simulation and computation: Quantum computation basics: circuit model, cluster-state model, logical operations and gates, discrete- vs. continuous-variable approach, quantum computation with single-photons, linear-optical quantum processor, photonic implementation of quantum gates, advantages and limits of discrete-variable approach for constructing quantum computers, continuous variable quantum computation, implementation of CV quantum gates, one-way quantum computation, state-of-the-art photonic quantum computers.
Photonic quantum metrology: Quantum metrology basics: information theoretic approach to parameter estimation, Fisher information and Cramer Rao bound, optimal measurements and optimal probes, photonic parameter estimation, quantum imaging, quantum enhanced interferometry, examples of practical quantum metrology applications using light.

Reference Books:

1) Quantum Photonics by Thomas P. Pearsall (Springer, 2020).
2) Introduction to Photon Science and Technology (SPIE, 2018).
3) Quantum Photonics: Pioneering Advances and Emerging Applications by Robert W. Boyd, Svetlana G. Lukishova, and Victor N. Zadkov (Springer, 2019).
4) A Guide to Experiments in Quantum Optics by Hans-A. Bachor, and Timothy C. Ralph (Wiley, 2019).
5) Introduction to Quantum Optics: From Semi-Classical Approach to Quantized Light by Gilbert Grynberg, Alain Aspect, and Claude Fabre (Cambridge, 2010).
6) Introductory Quantum Optics by Christopher Gerry, and Peter Knight (Cambridge, 2005).
7) Quantum Optics: An Introduction by Mark Fox (Oxford, 2006).
8) Quantum Optics for Experimentalists by Zheyu J. Ou (World Scientific, 2017).
9) Quantum Information by Stephen M. Barnett (Oxford, 2009).
10) Quantum Information: From Foundations to Quantum Technology Applications by Dagmar Bruss, and Gerd Leuchs (Wiley, 2019).
11) Quantum Computation and Quantum Information by Michael A. Nielson, and Isaac L. Chuang (Cambridge, 2000).
12) Quantum Information Processing by Gerd Leuchs, and Thomas Beth (Wiley, 2005).

5. Lecture-wise break-up:

Sl. No.	Topic	No. of lectures
1.	Basics of quantum physics and quantum information science	6
2.	Photonic quantum states	5
3.	Sources of photonic quantum states	5
4.	Manipulation and detection of quantum light	5
5.	Photonic quantum communication	4
6.	Photonic Quantum simulation and computation	5
7.	Photonic quantum metrology	4
	Total number of hours	34