IIT Mandi

Proposal for a New Course

Course Number :

Course Name : Introduction to Quantum Superposition, Quantum Entanglement and Quantum Computing

Credits : 1

Prerequisites : $3^{rd}/4^{th}$ year B.Tech, MSc, PhD

Intended for : Senior students of science and engineering will benefit from this course. Students of Physics, electrical engineering and computer science are especially encouraged to attend, though students from other branches who have an aptitude to learn these topics are also welcome.

Distribution :

Semester : Even

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1. **Preamble:** As the world is witnessing the second quantum revolution, it is very necessary for students of all branches of science and engineering to have at least a rudimentary knowledge of quantum theory, quantum entanglement, quantum information, and quantum computation. This 1-credit course will not go into depths, but provide a broad introduction to fundamental concepts of the quantum theory, including the path integral formulation. The course would then build on the fundamental principles to introduce quantum entanglement, and rudiments of quantum gates and lay the foundation for learning the principles of quantum computing. The course will prepare students from a wide range of background and empower them to take specialized studies in quantum information theory and quantum computations.

2. **Course Modules with Quantitative lecture hours :** 14 lectures, 50 minutes each

Topics

Feynman Path Integral Approach to Quantum Physics (1 lecture)
Sum Over all Paths/Histories; Nested Gaussian Integrals (1 lecture)
Free Particle Path Integrals (1 lecture)
Superposition States of Feynman Particles (1 lecture)
Dynamic and Geometrical Phase. BERRY PHASE (1 lecture)
Feynman Path Integral analysis of BERRY PHASE (1 lecture)
Path Integral analysis of AHARONOV-BOHM effect (1 lecture)
Einstein-Podolsky-Rosen Paradox (1 lecture)
Classical vs. Quantum Uncertainty (1 lecture)
Quantum Entanglement (1 lecture)
Correlations in Results of Measurements: Bell Inequality (1 lecture)
Bits and Qubits (1 lecture)
Computing: from Classical to Quantum (1 lecture)
Physical Qubits – Spin-half Particles; Multi-qubit quantum Gates (1 lecture)

3. **Text book :**
   1) Quantum Mechanics and Path Integrals by R.P.Feynman and A.R.Hibbs
   2) Quantum Computation and Quantum Information by M. A. Nielson and I.L.Chuang

4. **References :**
   1) Introduction to Quantum Mechanics by David J. Griffiths
   2) Quantum Entanglement by Paul F. Kisak

5. **Similarity Content Declaration with Existing Courses :**

S.N	Course Code	Similarity Content	Approx. % of Content
			1-5%

6. **Justification for new course proposal if cumulative similarity content is > 30%:**

Approvals :

Other Faculty interested in teaching this course:

Proposed by : School : SBS

Signature :____________________ Date :

Recommended/Not Recommended, with Comments:

______________________________ Date :

Chairman, CPC

Approved / Not Approved

______________________________ Date :

Chairman, Senate

Proposal for a 1-Credit Course

Introduction to Quantum Superposition, Quantum Entanglement, and Quantum Computing (14 Lectures; ~50 minutes each)

- Professor P C Deshmukh
  Department of Physics, IIT Tirupati

Preamble: As the world is witnessing the second quantum revolution, it is very necessary for students of all branches of science and engineering to have at least a rudimentary knowledge of quantum theory, quantum entanglement, quantum information, and quantum computation. This 1-credit course will not go into depths, but provide a broad introduction to fundamental concepts of the quantum theory, including the path integral formulation. The course would then build on the fundamental principles to introduce quantum entanglement, and rudiments of quantum gates and lay the foundation for learning the principles of quantum computing. The course will prepare students from a wide range of background and empower them to take specialized studies in quantum information theory and quantum computations.

Target audience: Who is this course for?

Senior students of science and engineering will benefit from this course. Students of Physics, electrical engineering and computer science are especially encouraged to attend, though students from other branches who have an aptitude to learn these topics are also welcome.

Prerequisites:

The subject will be developed in a pedagogical manner from ground up. The background in Mathematics and Physics which senior science and engineering students have should be enough.

Text:

1) Quantum Mechanics and Path Integrals by R.P.Feynman and A.R.Hibbs
2) Quantum Computation and Quantum Information by M. A. Nielson and I.L.Chuang

References:

1) Introduction to Quantum Mechanics by David J. Griffiths
2) Quantum Entanglement by Paul F. Kisak

Lecture Number	Topic
01	Feynman Path Integral Approach to Quantum Physics
02	Sum Over all Paths/Histories; Nested Gaussian Integrals
03	Free Particle Path Integrals
04	Superposition States of Feynman Particles
05	Dynamic and Geometrical Phase. BERRY PHASE.
06	Feynman Path Integral analysis of BERRY PHASE
07	Path Integral analysis of AHARONOV-BOHM effect.
08	Einstein-Podolsky-Rosen Paradox
09	Classical vs. Quantum Uncertainty
10	Quantum Entanglement
11	Correlations in Results of Measurements: Bell Inequality
12	Bits and Qubits
13	Computing: from Classical to Quantum
14	Physical Qubits – Spin-half Particles; Multi-qubit quantum Gates

NOTE: In case the students need a few more lectures to develop acquaintance with the fundamentals of quantum theory, such as discussion on the quantum uncertainty principle and the Schrodinger equation, then a few lectures on these topics can be given instead of the more specialized lectures on the Feynman path integral approach to quantum mechanics. Contents of the first seven lectures may then be altered to address the needs of the students. The last seven lectures cannot be dropped if the students are interested in gaining acquaintance with quantum entanglement and quantum computation.

Request: The instructor will like to know at least a week in advance if the first set of seven lectures need to be replaced by more basic lectures on introduction to quantum uncertainty principle and the Schrodinger equation.