Nanyang Technological University  
Division of Physics and Applied Physics

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<th>Course Code</th>
<th>PH3404</th>
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<tr>
<td>Course Title</td>
<td>Physics of Classical and Quantum Information</td>
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| Pre-requisites| PH2101 - Quantum Mechanics I  
MH1402 - Algorithms and Computing II |
| No of AUs | 3 |
| Contact Hours | 26 hours  
12 hours |

**Course Aims**
This interdisciplinary course aims to arm you with the knowledge required to appreciate rapidly growing cross-disciplinary research frontiers that interface physics, information science and computation. You will be introduced to the fundamentals of classical and quantum information science and their underlying physical principles, which will give you the necessary expertise to follow and initiate research in the blossoming fields of information physics, quantum information, and quantum computation.

**Intended Learning Outcomes (ILO)**
By the end of this course, you (as a student) would be able to:

1. Describe uncertainty and correlations in terms information entropy, and apply these tools analytically to related problems in thermodynamics and computation.

2. Describe the fundamental conceptual differences between classical and quantum information (e.g. quantum non-realism), and show how these can lead to new technologies (e.g. quantum bomb detection).

**Course Content**
The 21st Century has seen a string of profound discoveries that interface physics, information theory and computer science. This course will introduce undergraduate students these exciting ideas. On completion of the course, students will appreciate how information theory has led to new understanding in physics, and how the discovery of new physics – such as quantum mechanics - has led to complete new ways of processing and transferring information.

Topics include

- *Computation and its physical consequences*: Turing machines, the physical Church-Turing thesis, Halting problem, computational complexity, emergence.

- *Introduction to information theory*: Quantifying information, Shannon entropy, correlations and mutual information.

- *Thermodynamics of information*: Maxwell’s Demons, Szilard Engines, Landaur’s Erasure, energetic limits of computation.

- *Introduction to quantum Information*: Quantum bits, quantum gates, quantum non-locality, quantum entanglement

- *Quantum technologies (time permitting)*: A sampling of iconic quantum technologies, e.g. Quantum bomb detection, quantum teleportation.
Reading and References
