Indian Institute of Technology
Department of Physics
Kanpur

PHY313a: "Physics of Information Processing"

Instructor: Saikat Ghosh (FB-475, gsaikat@iitk.ac.in)

1. **Course Objectives**:

In physics, the notion of information has caused a paradigm shift in the way we look at the universe: a large fraction of physicists, starting from high energy to quantum technologists are starting to believe that probably all of physics is fundamentally a study of information, its generation, flow and detection and probably all traditional laws of physics can eventually be cast in the language of information theory. In this course we will learn why information is emerging as such a central concept in physics. We will also learn physical theories and tools that are used to generate, transmit and detect information, as a quantifiable quantity.

2. Prerequisites: PHY 103/PHY113

3. Course Contents:

Module 1:
Review of probability theory; Stochastic systems and noise; Noise in electromagnetic fields Introduction to Shanon information; Theory of estimation: Fisher information and Cramer-Rao bound; Theory of inference, Jayne's interpretation, Bayesian and frequentist notions of probability theory.
(~ 7 weeks, 14 Lectures)

Module 2:
Information theory applied to classical, quantum and statistical mechanics: Maxwell's demon, Boltzmann entropy, Thermalization, Open systems and Noise, von-Neumann entropy.
(~6 weeks, 12 Lectures)

Module 3:
Applications and special topics: elements of telecommunication technology and Shanon's theorems, introduction to quantum information theory: no-cloning theorem and elements of quantum cryptography
(~2 weeks, 4 Lectures)

4. Lecture: Wednesday: 9:00 am till 10:15 pm (L-13)
Friday: 9:00 am till 10:30 am (L-13)

5. **Office Hours:**
Friday: 11:00 am till noon (FB 475)
Please email the instructor for a meeting regarding course related questions.

6. Evaluation Components & Policies:
Exams:
End-sem:40%
Mid-sem: 30%

Quizzes: 20 %

Assignments, Attendance, Participation: 10%

7. Course Policies:

We follow a zero-tolerance policy (granted a F grade) for any unfair means adopted plagiarism, copying and using other people's work without proper acknowledgement.

8. Books (References to papers will be added/updated):

a) "Physics of Information Technology" by Neil Gershenfeld
Cambridge University Press, (2000)

b) "Detection of Signals in Noise", Anthony D. Whalen, Academic Press, (1971)

c) "Electromagnetic Noise and Quantum Optical Detection Measurements", Hermann A. Hauss, Springer, (2000)

d) T. M. Cover and J. A. Thomas, Elements of Information Theory,
Wiley Interscience (2006)

e) C. E. Shannon and W. Weaver, The Mathematical Theory of Communication,
University of Illinois Press (1962).

f) Lectures on probability, entropy and statistical physics, Ariel Caticha:
https://arxiv.org/abs/0808.0012