# Physics for Computer Engineers

Course Details

# Course Details

**Course Code**: PHYS1023

**Course Name**: Physics for Computer Engineers

**Number of Lectures per week**: 04

**Course Instructor**: Dr. Santosh Dubey, Professor & Program Leader (Physics)
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UPES Page: Santosh Dubey- School of Advanced Engineering | UPES
Google Scholar Profile: https://scholar.google.com/citations?user=LqpiRlwAAAAJ&hl=en&oi=ao

**Seating Location**: AB1, 2$^{nd}$ Floor Faculty Block

**Office Hours**: Any time I am available at my seat

# Course Details

**Course Objectives**

- To demonstrate the principles of LASER and its applications in holography as well as in fiber-optic communications.
- To determine gradient of scalar fields and divergence & curl vector fields.
- To develop understanding of electromagnetics, which forms the basis of several contemporary communication systems such as fiber optics communication and it, is also a prerequisite for forthcoming semesters.
- To utilize fundaments of quantum mechanics in various areas of Material Science and engineering.
- To understand and apply semiconductor materials in various applications.

**Course Outcomes**

**CO1**. Understand the significance of lasers and its application in holography and optical fiber communication.
**CO2**. Illustrate the electric field for different charge geometries.
**CO3**. Outline the magnetic field due to different current geometries.
**CO4**. Utilize the fundamentals of Quantum Mechanics and analyze the behavior of particle in a box.
**CO5**. Apply and analyze the apply various applications of semiconductor materials in different instruments.

# Syllabus

**Unit I: Lasers & Fibre Optics** **14 lecture hours**

**Lasers**: Introduction, Spontaneous and Stimulated emission of radiation, Relation b/w Einstein’s A and B coefficients, Population inversion & types of pumping, Main components of a Laser, Construction & working of Ruby Laser and its applications, Construction & working of Helium-Neon laser and its applications.

**Holography**: Elementary idea of holography and constructive and reconstructive of holography.

**Fiber Optics**: Fundamental ideas about optical fiber, Types of fibers, Acceptance angle and cone, Numerical aperture, Propagation mechanism and communication in optical fiber, Attenuation and losses.

# Syllabus

**Unit II: Electro-Magnetics:** **16 lecture hours**

**Electro-statics**: Coordinate systems, Del operator, Gradient, Divergence, Divergence Theorem, Stoke's Theorem, Introduction to electrostatics, calculation of electric field, potential and energy due to charge distribution by vector approach, Gauss law electric flux density.

Polarization in Dielectrics, Bound charges, Dielectric Constant and strength, Continuity equation and relaxation time Boundary Conditions.

**Magneto-statics:** Introduction, Biot-Savart's law, Ampere's Circuit Law; Applications, Magnetic flux density

**Electromagnetics**: Faraday's Law, Transformer and motional EMF. Displacement current, Maxwell's Equations in Final form.

# Syllabus

**Unit III: Quantum Mechanics 15 lecture hours**

Introduction to Quantum Mechanics, photoelectric effect, Compton Effect, Pair production & Annihilation, Wave particle duality, De Broglie waves, Davisson Germer experiment, phase and group velocities and their relations, Thought experiment- Heisenberg's Gamma ray microscope, Uncertainty principle and its applications, Wave function and its interpretation, Normalization, Schrodinger time independent & dependent wave equations, Particle in a 1-D box; generalization to 3-D box.

**Unit IV: Semiconductor Physics 15 lecture hours**

P and N type semiconductors, Energy Level Diagram, Conductivity and Mobility, Concept of Drift velocity, Hall effect, Barrier Formation in PN Junction Diode, Static and Dynamic Resistance, Current Flow Mechanism in Forward and Reverse Biased Diode, Avalanche breakdown, Zener breakdown, Two-terminal Devices and their Applications: Half-wave Rectifiers, Full-wave Rectifiers, Ripple Factor and Rectification Efficiency, Zener Diode and Voltage Regulation, Principle and structure of LED, Photodiode and Solar Cell

# Text Books/Reference Books

**Text Book**s

- **Laser, Holography & Fiber Optics**: Malik H.K, Singh A.K. (2011) Engineering Physics, TMH, New Delhi. ISBN: 9780070671539
- **Quantum Mechanics**: Beiser A. (2002) Concepts of Modern Physics, McGraw Hill Education. ISBN: 9780070495531
- **Electromagnetics**: Sadiku M.N.O. (2007) Elements of Electromagnetics, Oxford University Press. ISBN: 0195300483
- **Semiconductor Physics**: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India.
- **Electronic Devices & circuits**: S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc- Graw Hill.

**Reference Books**

- Griffith D.J. (2012) Introduction to Electromagnetics, PHI Learning, 4th edition, ISBN:9780138053260.
- Ghatak A. (2012) Optics, McGraw Hill Education. ISBN: 978-1259004346.
- Sahni V., Goswami D. (2008) Nano Computing, McGraw Hill Education Asia Ltd., ISBN:978007024892.

# Evaluation Scheme

| Components | Lab | Theory | | |
| --- | --- | --- | --- | --- |
| | Continuous Evaluation | IA (Class test + Assignment) | Mid Semester | End Semester |
| Weight % | - | 50 | 20 | 30 |

# Why Physics is Important?

Physics provides an analytic problem-solving outlook and basic understanding of nature, while computer science enhances the ability to make practical and marketable applications

Physics provides a foundation for understanding more advanced concepts in computer science, such as artificial intelligence and quantum computing

Computer science sits somewhere between physics and mathematics…computer hardware works is in the realms of electronics - which is physics; algorithms are developed with the help of logic/maths.

Computer Graphics & video games – understanding Newton's laws of motion, friction, hydrodynamics , etc. might be crucial. Interaction of light with the atmosphere, objects in the world, the human eye, etc. needs physics understanding

Internet Of Things (IoT) - need lots of physics.
Robotics: physics matters

"Scientific visualization" – a very promising field in computer graphics, need very intimate understanding of Physics

# Why Physics is Important?

- India has millions of software engineers, but where is all the innovation coming from?
- Has any major software language like Python, Ruby, Perl, or C been created by Indians?
- What about libraries like Numpy or Pandas?

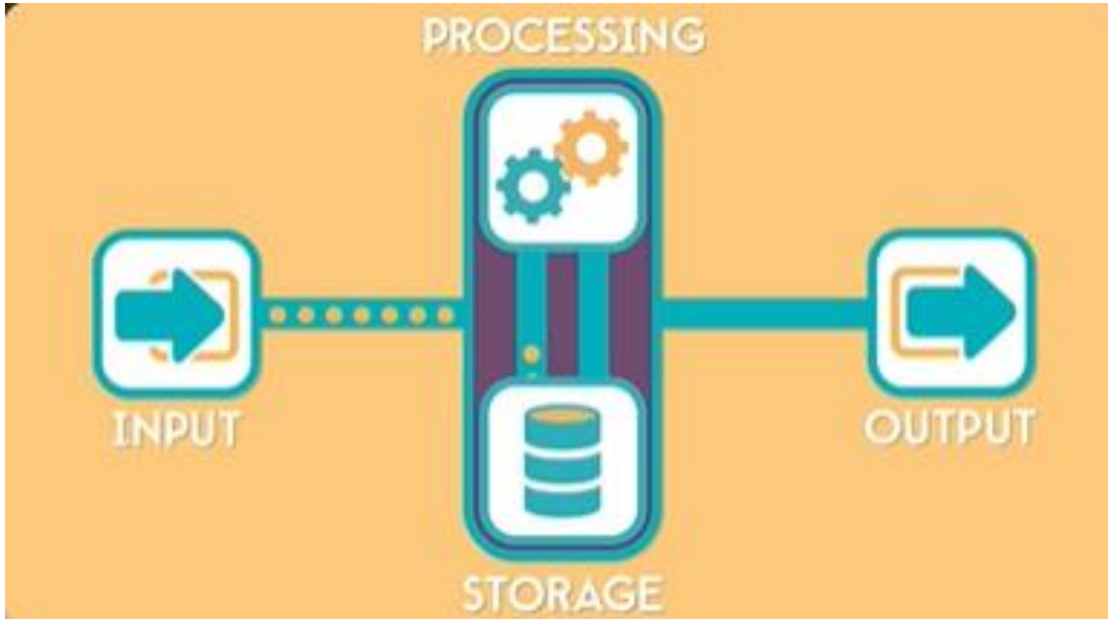
**Why Innovation is so difficult??**

- Because it needs an ability to think out of the box and solve physical problems from different perspectives
- How did you get the ability to think? → Physics → while solving real-life problems based on Physical concept

# Lasers, Fiber Optics in Computing

**Digital Computers**

*Main Components*:
- Data transfer →Electrical wires → information transfer via drifting electrons → limit on information transfer depends on how fast electrons move
- Processing →CPU→Logic gates → Transistors (semiconductor-devices)
- Storage →Memory → Electronic Transistors
- Transistor switching speed: around $10^{-12} – 10^{-15}$ second




**Optical Computers (still under research)**

*Main Components*:
- Data transfer →Fiber optic cables→ information transfer via Laser light
- Processing →Optical processor →Optical Logic gates → Optical Transistors (non-linear Optical crystals used to manipulate light beams)
- Storage →Optical storage → Optical Transistors

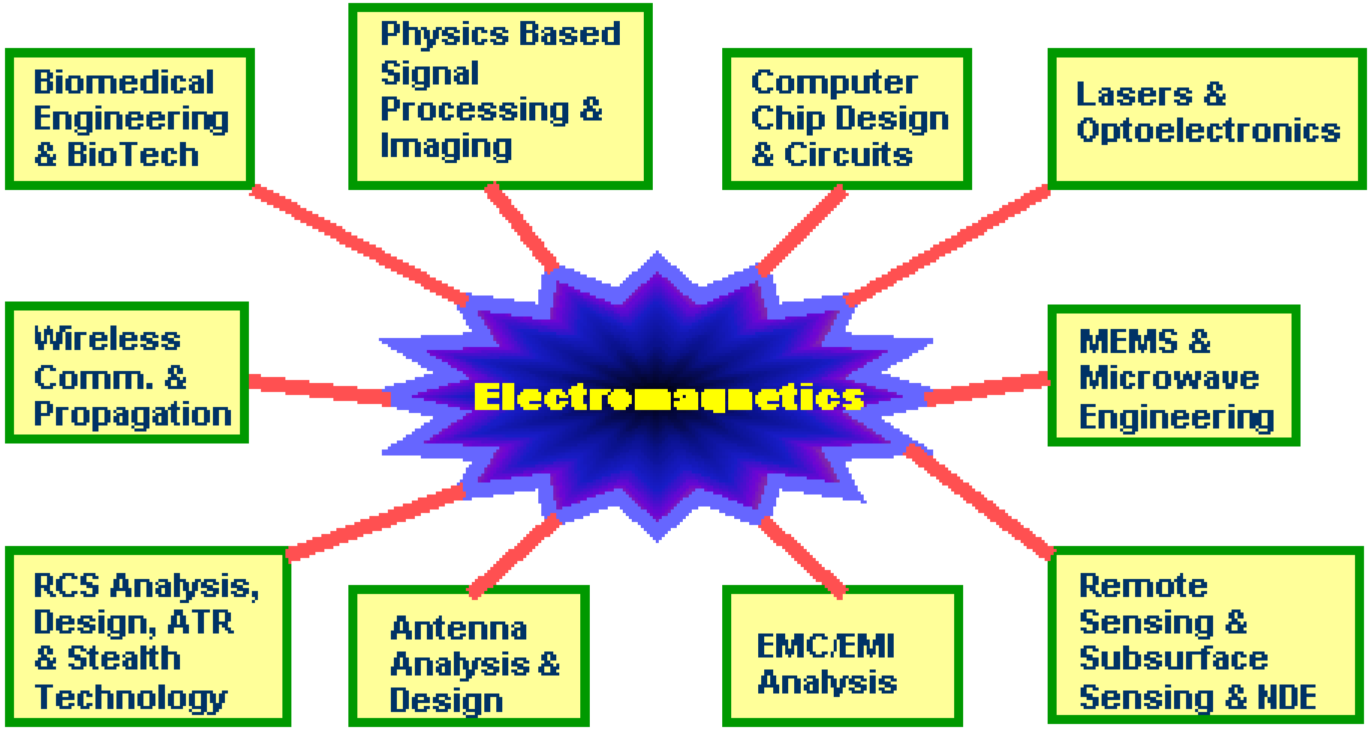
Optical transistors:
- Switches or amplifies optical signals
- Switching speed → less than $10^{-18}$ s→ optical transistors are way faster

# Electromagnetics in Computing

- Hardwares & circuits used in computer → employ electromagnetics concepts

- Communication systems → electromagnetics

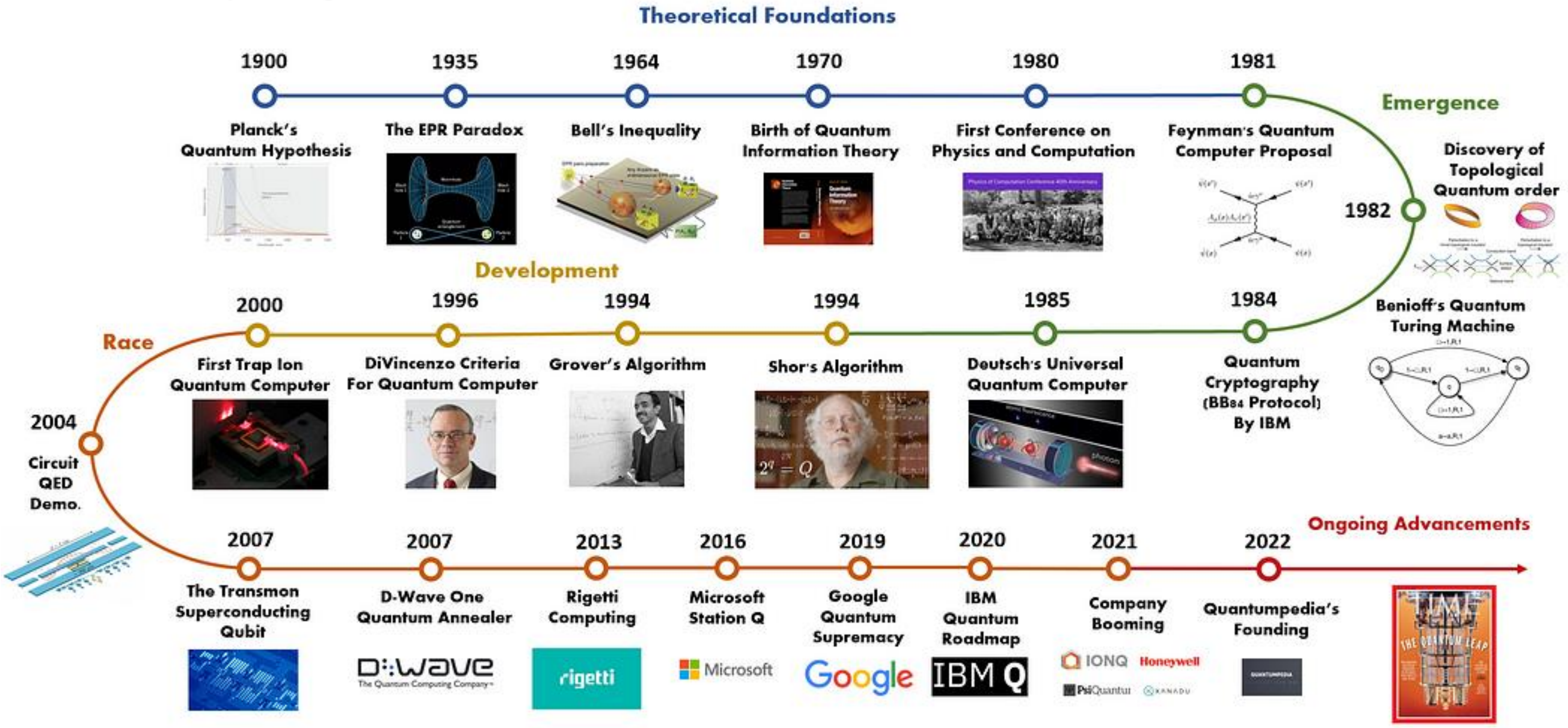
- Needed for people work on real life projects:
  - sending satellites
  - inter-planetary, inter-galactic missions
  - automation in industries
  - developing smart defense technologies
  - Data science in energy industry



# Quantum Mechanics in Computer Science

## Quantum Computing:

A brief history of Quantum Computing




https://quantumpedia.uk/a-brief-history-of-quantum-computing-e0bbd05893d0

# Quantum Mechanics in Computer Science

**Einstein-Podolsky-Rosen (EPR) Paradox [1935]:**

EPR paradox questioned the completeness of quantum mechanics due to the phenomenon of entanglement (very important in quantum computing).

Entanglement implies that the properties of two or more particles can be correlated in such a way that the state of one particle instantly affects the state of the other, regardless of the distance between them.

**Bell Inequalities**:

This provided a way to test the validity of the EPR paradox experimentally.

The violation of Bell inequalities in subsequent experiments confirmed the existence of entanglement, a key resource for quantum computing.