Course Code: NPHI101
Course Name: Engineering Physics

Course Instructors:

Prof. Sudeshna Sen

PART 1: Classical Mechanics and Electrodynamics

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Prof. Tusharkanti Dey

PART 2: Thermal and Statistical Physics

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Prof. Amitava Adak

PART 3: Modern Physics

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Course Instruction: Course Weightage, Mode of Examination, Lecture Plan

General Guideline

General Guidelines:

1. Please check Abhikalp portal regularly. Class notes and additional necessary documents will be uploaded there.
2. According to the Academic Calendar 2025-26, the following dates will be adhered to (keep note of any updations in Academic calendar during semester):
   I. Last date of class before Mid-Sem Exam: 15 September 2025
   II. **Mid-semester Exam: 16 - 21 September 2025**
   III. Last date of class: 17 November 2025
   IV. **End Semester Examination Dates: 19 - 30 November 2025**

   Dates for quizzes will be announced later. Tentatively, **Quiz-1:** Before Mid-Semester exam and **Quiz-2:** Before End-Semester exam
3. Total Marks for exams: **Quiz-1:** 10 marks, **Quiz-2**: 10 marks, **Mid-Semester:** 30 Marks (10+10+10 Marks), **End Semester:** 50 Marks (16+17+17 Marks)
4. Marks Weightage: **Quiz-1: 10%, Quiz-2: 10%, Mid-Semester: 30%, End Semester: 50%**
5. Attendance: Minimum 75% attendance is compulsory as mandated by the Institute norms.
6. All necessary communication regarding the course will be conveyed via the CRs of the respective sections.
7. Please note that all the examinations will be conducted in **closed book** mode.

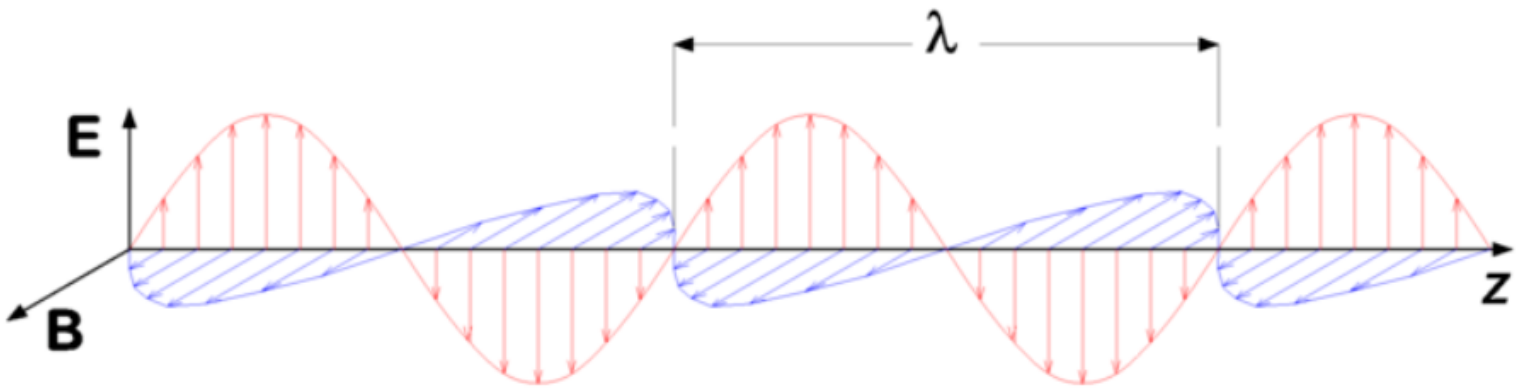
To ensure 14 weeks of classes:

- **Friday's timetable** will be followed on **Thursday, 11.09.2025** All students except Exec. MBA and Exec. M. Tech.
- **Afternoon of Monday, 15.09.2025** will be working with **Wednesday Afternoon timetable** All students except Exec. MBA and Exec. M. Tech.
- **Wednesday's timetable** will be followed on **Monday, 17.11.2025** All students except Exec. MBA and Exec. M. Tech.
- **Saturday, 02.08.2025** will be working with **Thursday timetable** *(Only for 1st year UG students)*
- **Saturday, 16.08.2025** will be working with **Friday timetable** *(Only for 1st year UG students)*

Modern Physics

Light and Laser

Light and Laser



Electromagnetic wave: Classical Picture

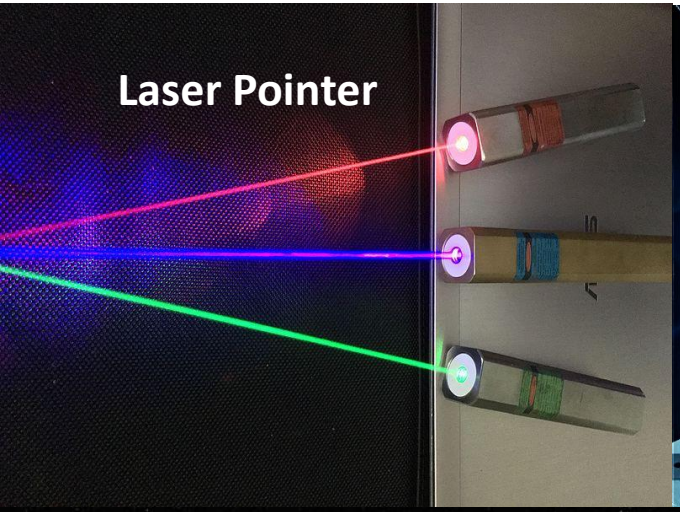
Flux of photons : Quantum Picture

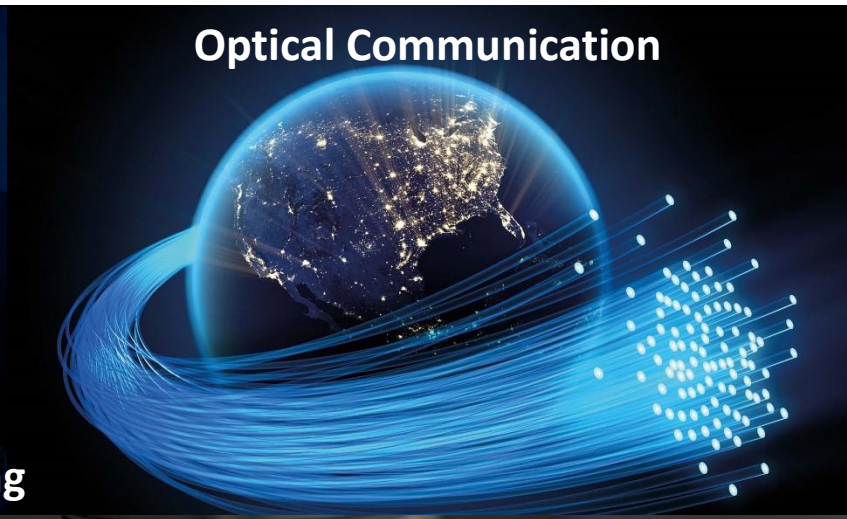
The polarization is defined as the direction of oscillation of the electric field component of light. The polarization for the above case is clearly vertical.

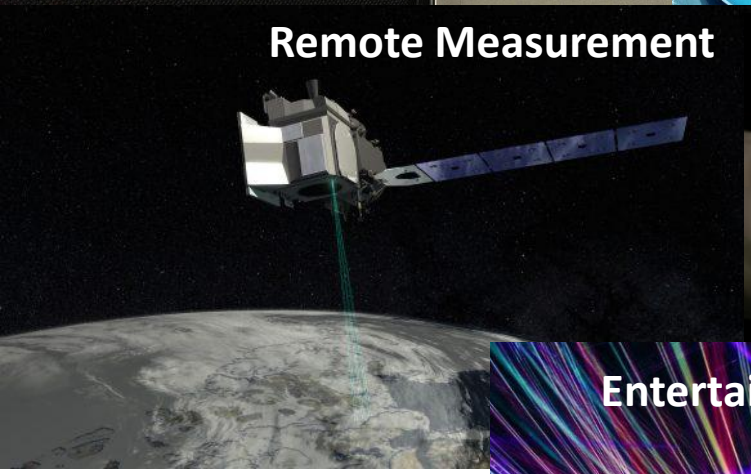
Laser is a 'very special form' of Light

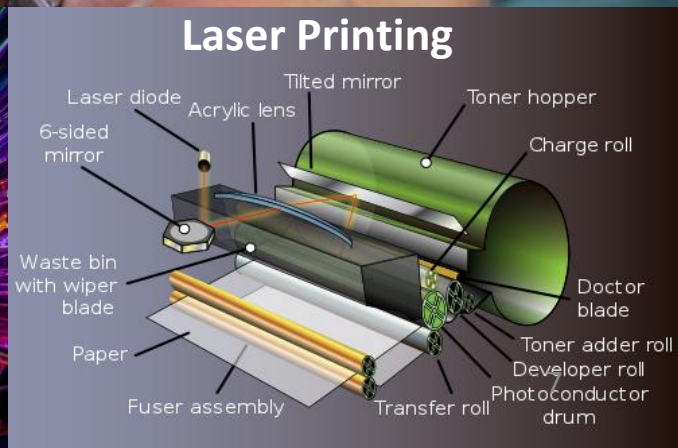
Technically, Laser is a device which generate and amplify coherent, monochromatic/near monochromatic light

LASER in General is Fascinating







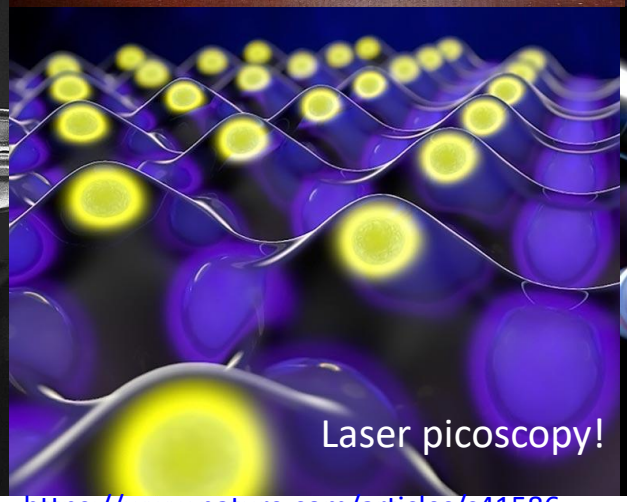


LASER

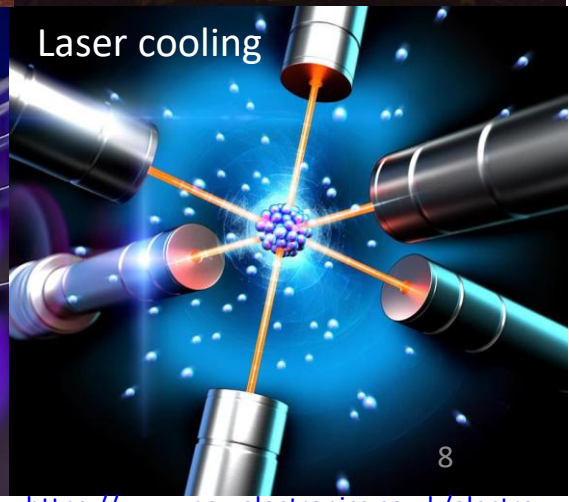
"a solution looking for a problem"

… T. Maiman, after discovering in May 16, 1960

https://abcnews.go.com/Technology/50-years-apollo-11-experiment-sending-data-moon/story?id=64339197



https://www.nature.com/articles/s41586-



https://www.newelectronics.co.uk/electro

LASER

Light Amplification by Stimulated Emission of Radiation

Essential components

(a) **Laser medium:** Collection of atoms/molecules/ions/crystals

(b) **Pumping process** to excite the laser medium

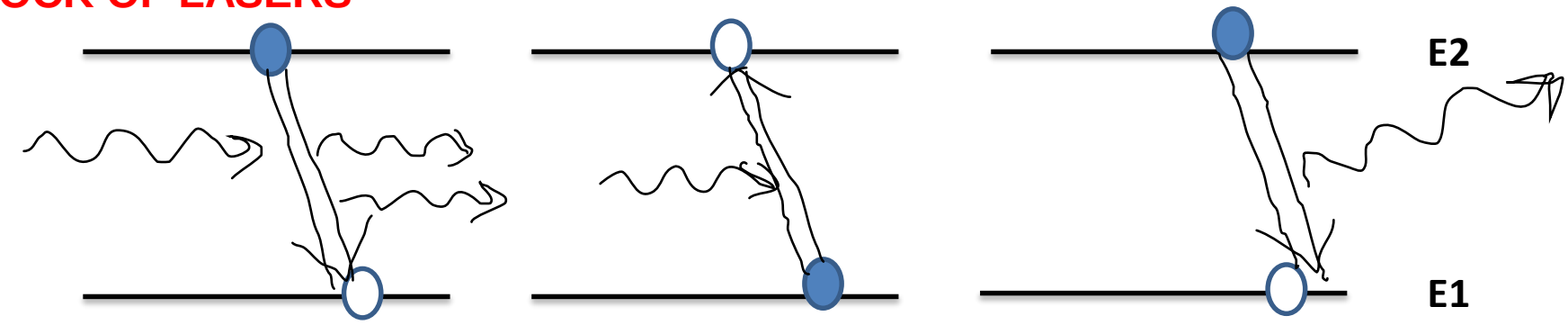
(c) **Suitable optical feedback elements:** Set of mirrors allowing a beam of radiation bouncing back and forth through laser medium

LASER

Light Amplification by Stimulated Emission of Radiation

Input light beam → Amplifying medium or Gain medium or Laser medium → **Amplified output light beam**

1916: Albert Einstein proposed that there are three processes occurring in the formation of an atomic spectral line. He calculated 'Einstein coefficients' for the rate of these processes…..CONCEPTUAL BUILDING BLOCK OF LASERS



Stimulated emission | Absorpotion | Spontaneous emission

Coherent emission

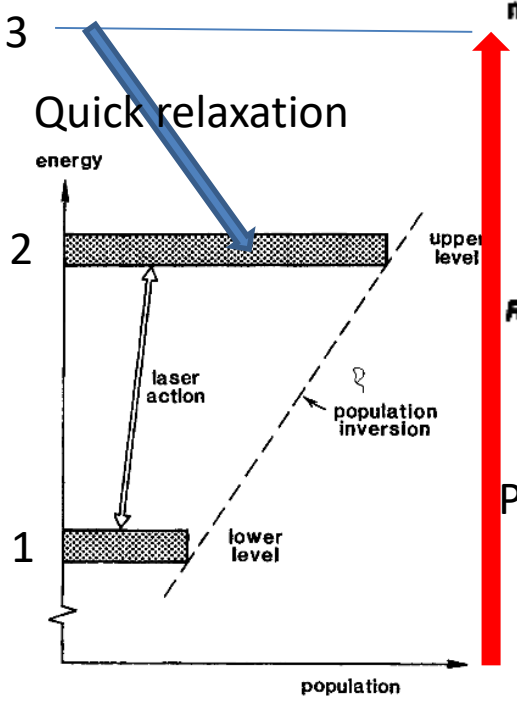
Spontaneous emission is incoherent

LASER

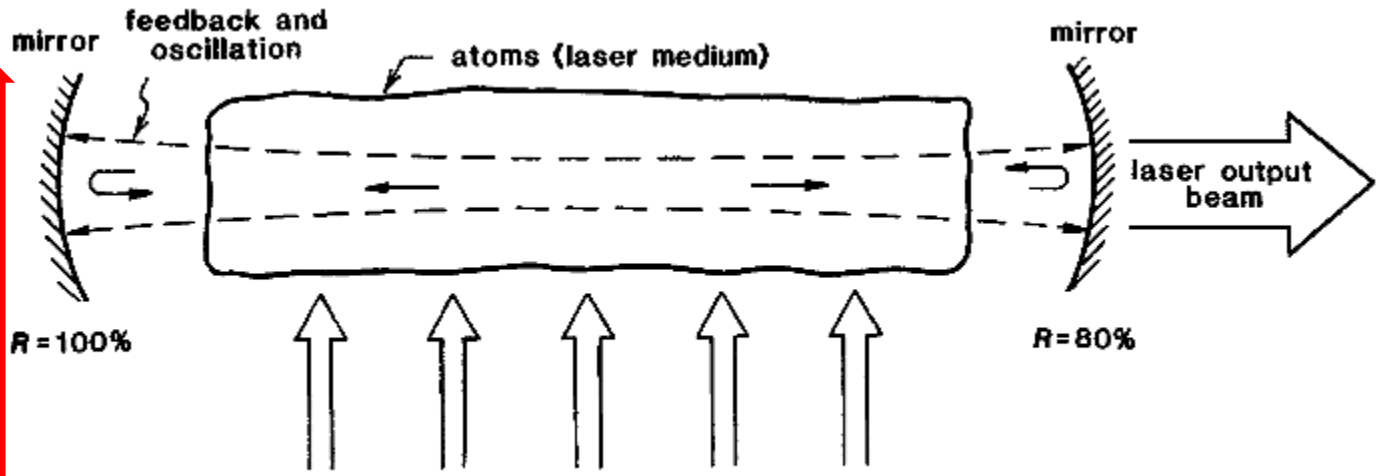
1916: Albert Einstein proposed stimulated emission

1928: Rudolf Ladenburg reported indirect evidence of stimulated emission. physicists of the time called the effect "negative absorption," and considered it of little practical importance.

After World War II, Willis Lamb, Jr., and R. C. Retherford realized that **nuclear magnetic resonance** could produce **population inversions** and Edward M. Purcell and Robert V. Pound used the effect to observe stimulated emission of 50-kHz radio waves.



Pumping



Electronic excitation from 1 to 3
For a 3-level laser system

Reference Book: "*LASERS*" by A. E. Siegman

The History Briefly

1953-1954: Townes and his student James Gordon demonstrated the first microwave maser, directing excited ammonia molecules into a resonant cavity where they oscillated at 24 Ghz.

Townes, Nikolay Basov and Alexander Prokhorov were awarded the 1964 Nobel Prize in Physics for theoretical work leading to the maser

Proposal: Townes teamed with Arthur Schawlow, a former Columbia colleague and had worked on optical spectroscopy. Together they wrote a detailed proposal for what they called an "optical maser" that Physical Review published in **December 1958**.

The race to actually build an "optical maser" began

May 16, 1960: T. Maiman tested his design of the FIRST "optical maser" or what we call today the **LASER.** A short description of the experiment was published in Nature. He revealed the Details in 1961.

The History Briefly

1960: He-Ne: 1st Continuous Wave (CW) gas laser

Javan, William Bennett, and Donald Herriott needed to make and align a high-reflectivity cavity about a meter long to get the low-gain Helium-Neon laser running, and they finally succeeded on the snowy afternoon of December 12, 1960. Operating on a **1.15-um** line chosen for its high gain, it was the first continuous-wave laser and the first gas laser.

1962: The most important of those gas-laser lines was the **632.8-nm** line of helium-neon, which **Alan White and Dane Rigden** developed at Bell Labs after building an enhanced copy of the 1.15 um helium-neon laser for the Army Signal Corps. **first continuous-wave laser with a visible beam**

…….still widely used in research and education

The History Briefly

1962: Lawrence Livermore National Lab forms groups to study prospects for **laser fusion**

1964: Joseph E. Geusic, H. W. Marcos, and LeGrand van Uitert of Bell demonstrate lasing in Nd-YAG, which would become the dominant solid state laser. [yttrium aluminum garnet ($Y_3Al_5O_{12}$)]

***Continuously many lasers have been built through out the next several years.

1982-86 Peter Moulton demonstrated Ti-sapphire laser (CW version in 1982). Later the idea of mode-locking made it possible to make ultrashort pulses. Lasers started to become more extreme.

1987 Pulses from dye laser compressed to 6 femtosecond (1 fs = 10^{-15} s) by Richard Fork at Bell Lab

1995 Pulse length of Ti-sapphire reaches 8 fs

Few-cycle laser pulse

2000 Ti-sapphire pulses compressed to 5 fs

Now a days laser-like coherent fs to as beams in EUV and soft x-ray regime are routinely achieved by High Harmonic Generation.

Nobel Prize 2023

"for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter"