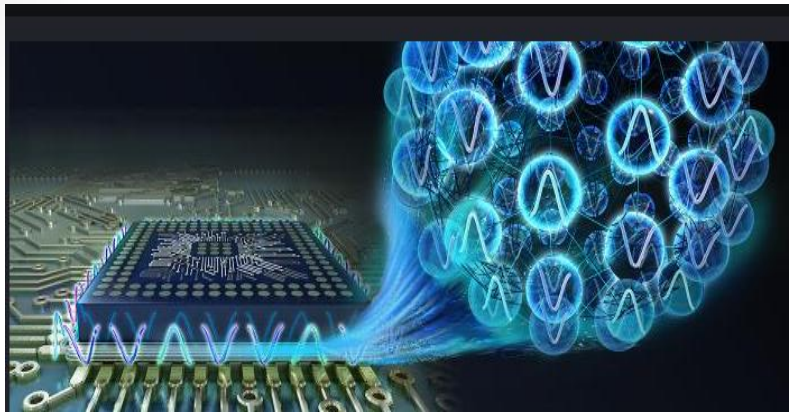
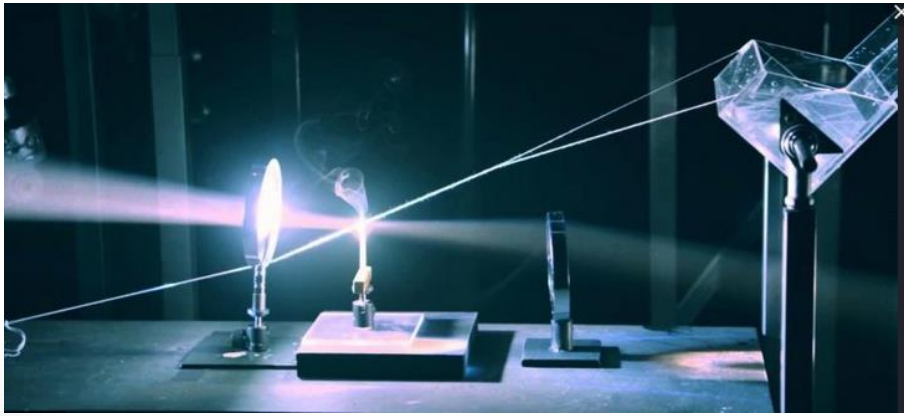


Engineering Physics (PHY109)



Zero Lecture

KYT

Dr. Dipal B. Patel

Assistant Professor (Physics)

BSc, MSc (Physics)

PhD (Solar Photovoltaics) 2010-2015

UGC-CSIR-NET (Physics)

ISRO (Ahmedabad) 2008-2010

Postdoc researcher (Incheon National Uni.) South Korea

Postdoc researcher (Nagoya Inst. Of Technology) Japan

Dr. Dipal B. Patel (23830)

What is Engineering Physics???

- ✓ **The study of the combined disciplines of physics, mathematics and engineering**
- ✓ **By focusing on the scientific methods, it seeks ways to apply, design, and develop new solutions in engineering**
- ✓ **Engineering physics provides a more thorough grounding in applied physics for some specialized branch *viz.* optics, quantum mechanics, materials science, applied electronics, nanotechnology, photonics, etc**
- ✓ **It is devoted to create and optimize engineering solutions through enhanced understanding and integrated application of principle of mathematics, science, statistics, and engineering.**

Why Study Engineering Physics???

- ✓ **It gives you a nice blend of *Physics* and *Engineering*, which is not possible if you go only with either Physics or Engineering**
- ✓ **It prepares you to apply physics to tackle 21st century engineering challenges, and to apply engineering to address 21st century questions in physics**
- ✓ **Industries that need people with very strong *scientific backgrounds* consider the understanding in *Engineering Physics* a big plus.**

Why Study Engineering Physics???

- ✓ **With knowledge in *engineering physics* you can work on the forefront ideas in technology and science, in either industry or academia**

- ✓ **Areas might include aerospace, biophysics, medical physics, renewable energy, transportation, quantum information science, semiconductors, or materials development.**

- ✓ **The preparation in *engineering physics* is essential for almost any career, *because it teaches us how to analyze complex problems and gives you a strong quantitative background that can be applied in any technical field***

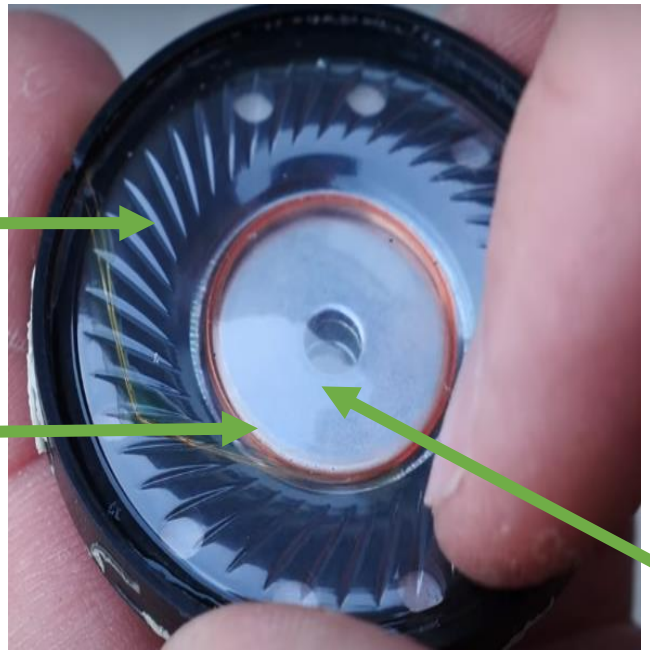
How do I blend Physics and Engineering together???

Working of a ‘Ball point’ pen ?

Gravity: As your pen moves across the paper and the ball turns, the gravitational force on the ink pulls the ink down onto the top of the ball where it is transferred onto the paper.

How do I blend Physics and Engineering together???

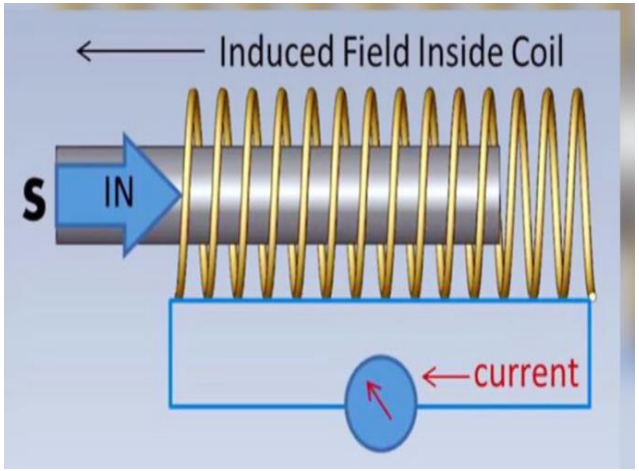
Music (decorated sound) is created by *vibrating Air column* and we use this technique in all musical instruments to produce sound



Diaphragm (Plastic)

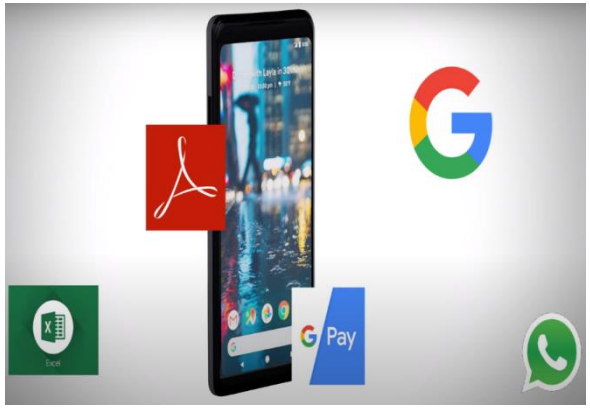
Copper Ring (Voice Ring)
Please Note, It is attached to the Diaphragm

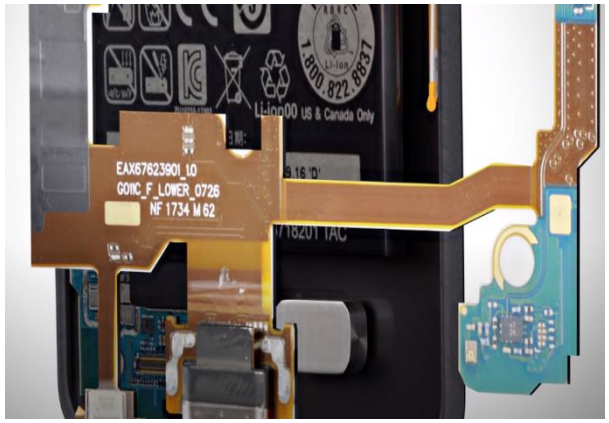
Permanent Magnet

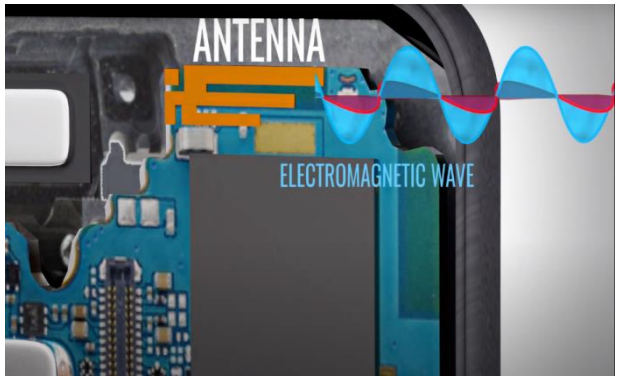


- ✓ **Current through the wire from your device reaches to the copper ring**
- ✓ **Based on theory of electromagnetism, it makes the copper ring an electromagnet**
- ✓ **This electromagnet changes it's polarity as current flows through it and starts vibrating inside the permanent magnet and thus the diaphragm vibrates, attached to it, producing sound wave**

How do I blend Physics and Engineering together???



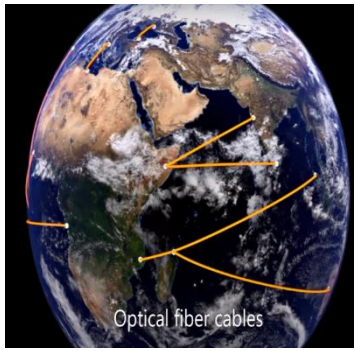




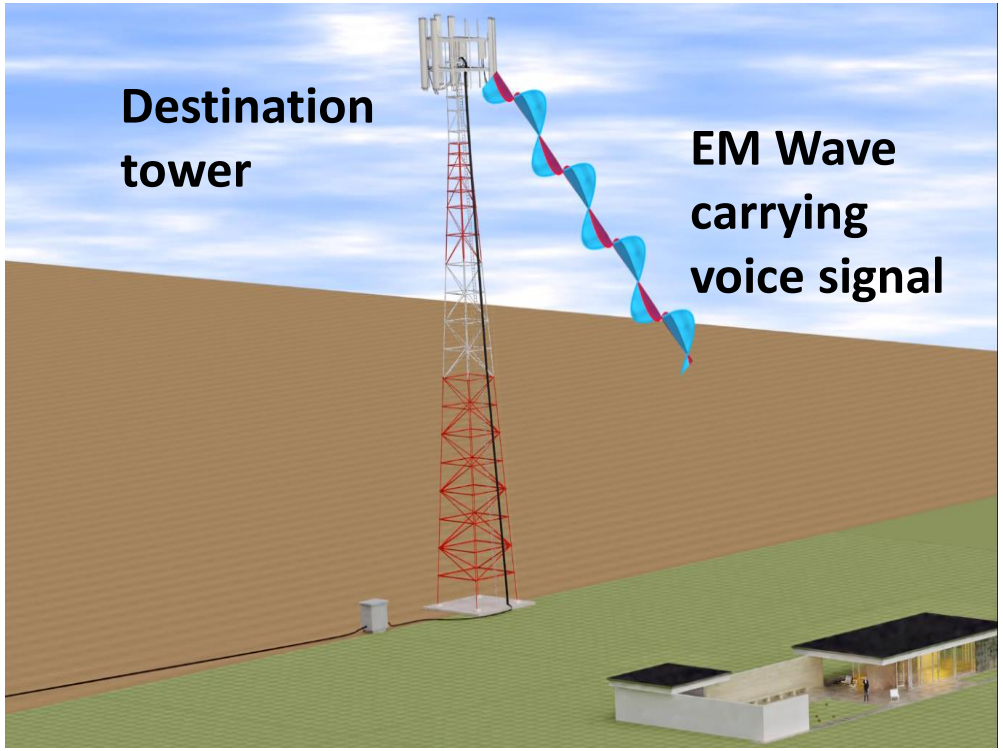
How does a Mobile phone work?

- When we talk over phone, our voice is picked up by the phone's microphone and then converts it into a digital signal (0s and 1s) with the help of Mems (Micro-Electro-Mechanical Systems) sensor and ICs

- An antenna inside the phone converts this digital signal in the form of radio wave, which is an EM wave and transmits it. It also acts as an receiver of incoming radio waves too.



- A geographic area is divided into hexagonal cells and each cell has it's own cell tower and frequency range, at which it operates
- These cell towers are interconnected with each other by fiber optic cable, globally/regionally
- The EM wave transmitted by your cell phone's antenna is picked up by the nearest cell tower and it converts these signals to light pulses which again goes through some more signal processing and then sent to the destination tower



PHYSICS: Electromagnetism, Modulation/De-modulation, Principle of Optical fiber communication, etc.

- The destination tower transmits the signal and it could be picked up by the antenna of your friend's cell phone
- Here the optical fiber connection and satellite comes in handy, if your friend is in different country or in another continents
- But the basic working is based on transmission of EM waves.

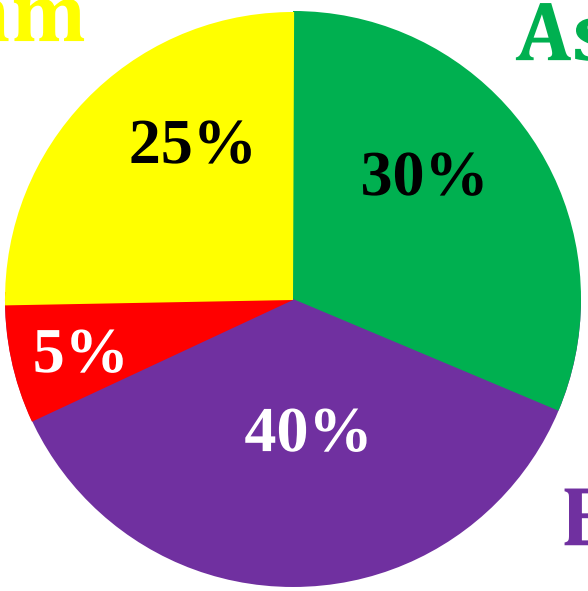
Suggestive Books

Text Book: ENGINEERING PHYSICS by HITENDRA K MALIK AND A K SINGH (MCGRAW HILL)

References:

- ENGINEERING PHYSICS by B K PANDEY AND S CHATURVEDI, (CENGAGE LEARNING)
- ENGINEERING PHYSICS by D K BHATTACHARYA, POONAM TONDON (OXFORD UNIVERSITY PRESS)
- FUNDAMENTALS OF PHYSICS by HALLIDAY D., RESNICK R AND WALKER J (WILEY)

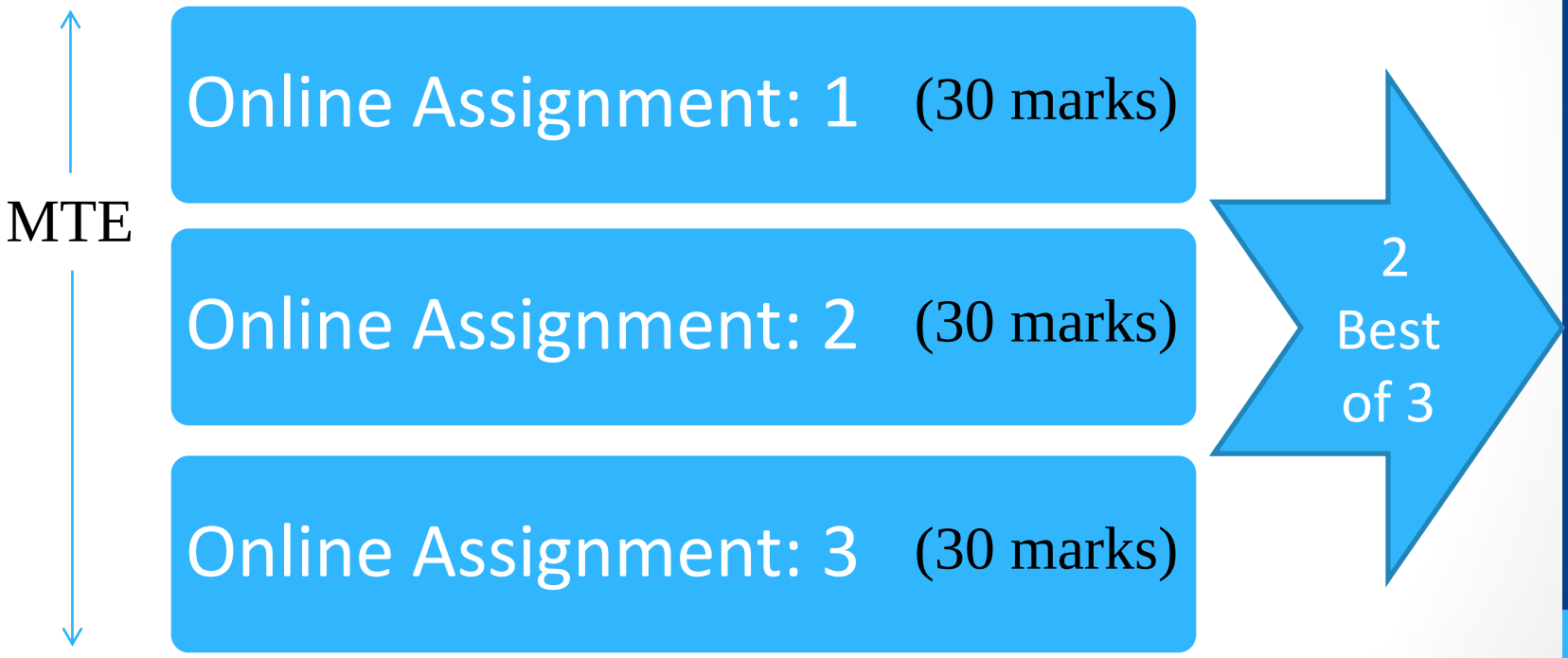
Course Assessment Model



MTE: Online (Viva)

ETE: Online

Scheme for Continuous Assessment (30%)

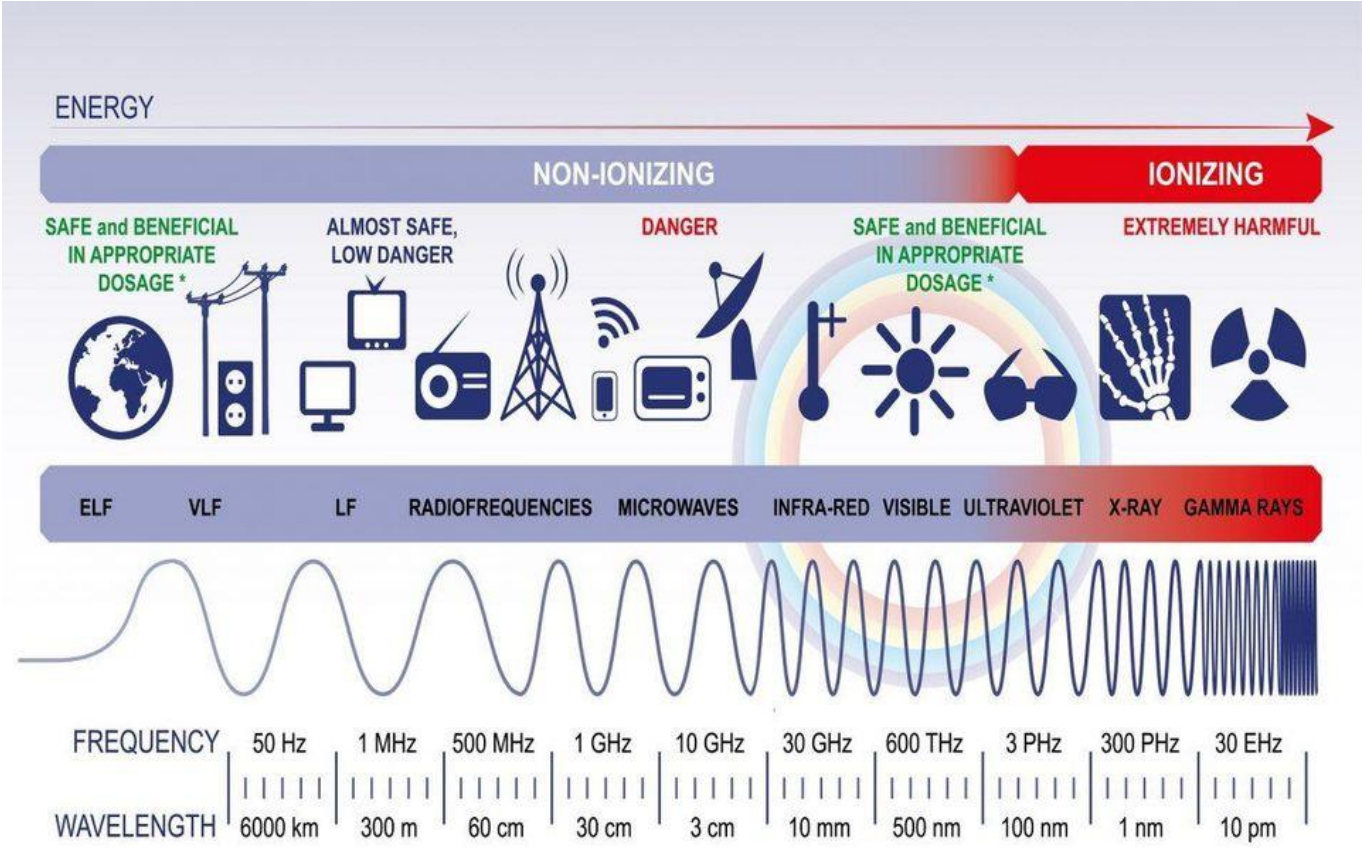


Course overview

L: 3 T:1 P:0 Credits:4

- **Unit 1: Electromagnetic theory**
- **Unit 2: Lasers and applications**
- **Unit 3: Fiber optics**
- **Unit 4: Quantum mechanics**
- **Unit 5: Waves**
- **Unit 6: Solid state physics**

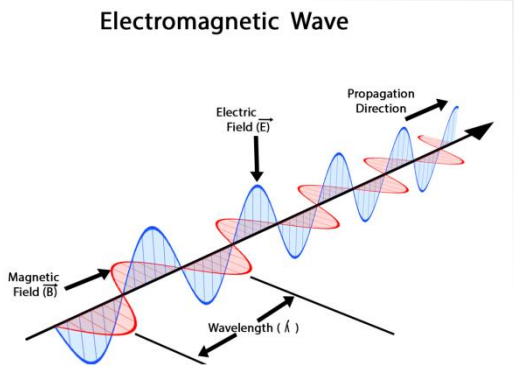
Unit-1: Electromagnetic Theory



Unit-1: Electromagnetic Theory

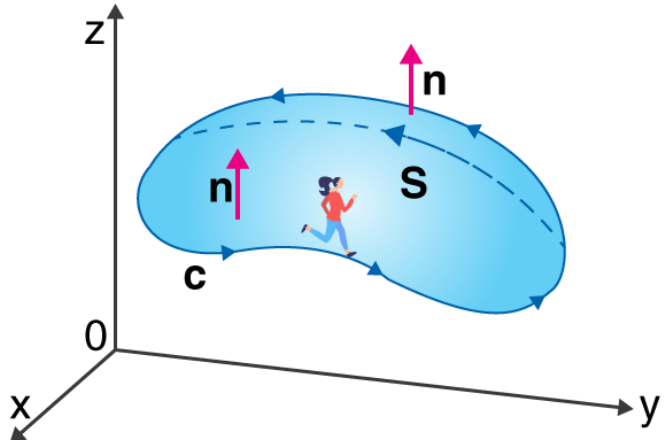
- Scalar and vectors fields
- Concept of gradient, divergence and curl
- Dielectric constant
- Gauss theorem and Stokes theorem (qualitative)
- Poisson and Laplace equations
- Continuity equation
- Maxwell electromagnetic equations (differential and integral forms), physical significance of Maxwell equations
- Ampere Circuital Law
- Maxwell displacement current and correction in Ampere Circuital Law

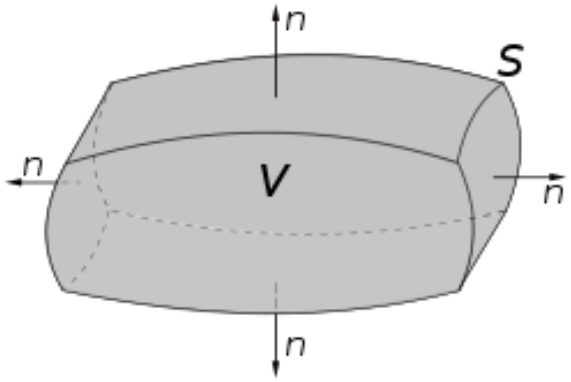
Electromagnetism



- The phenomenon which deals with the *interaction between an Electric field and a magnetic Field*.
- Stationary charges in a system lead to an electric field and moving charges in a system lead to a magnetic field.
- The direction of electric field and Magnetic field is always <u>perpendicular</u> to each other, and *the wave travels at the speed of light.*

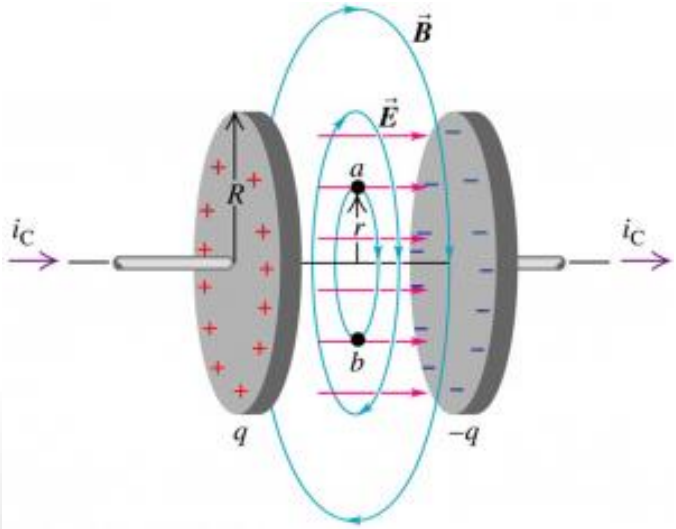
Stokes theorem





Gauss theorem

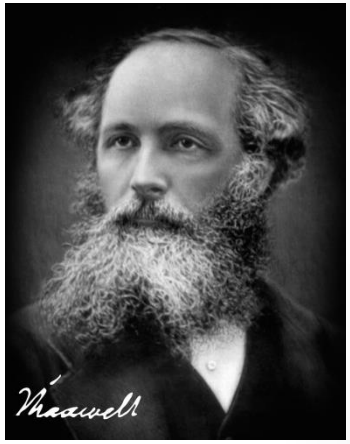
Displacement current



Maxwell's equations

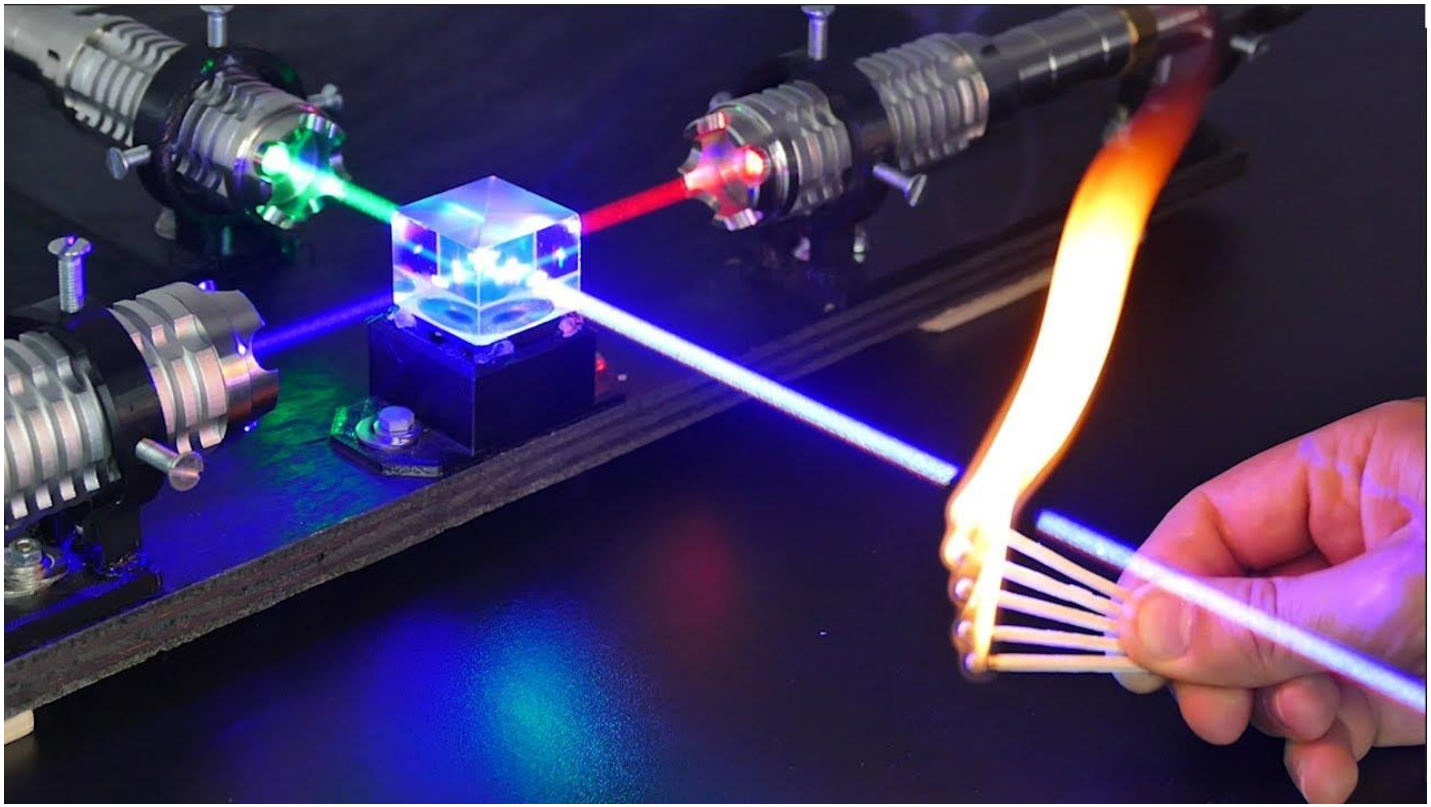
- The Scottish scientist and mathematician James Clerk Maxwell, brought the *correlation between electricity and magnetism* for the first time using Maxwell's equations

1. $Gauss\ Law : \nabla \cdot E = \frac{\rho}{\varepsilon_0}$
2. $Gauss\ Magnetism\ Law : \nabla \cdot B = 0$
3. $Maxwell - Faraday\ Equation : \nabla \times E = -\frac{\partial B}{\partial t}$
4. $Ampere\ Circuital\ Law : \nabla \times B = \mu_0 \left(J + \varepsilon_0 \frac{\partial E}{\partial t} \right)$



CO1: extend the knowledge on electromagnetic theory

Unit-2: Lasers and applications

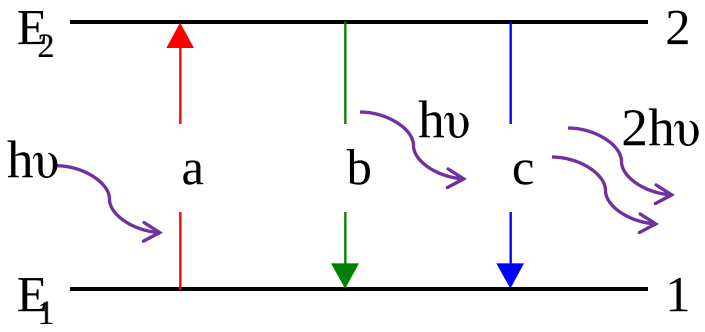


LASER: Light Amplification by Stimulated Emission of Radiation

Unit-2: Lasers and applications

- Fundamentals of laser- energy levels in atoms
- Radiation matter interaction
- Absorption and emission of light (spontaneous/stimulated)
- Population inversion
- Einstein A and B coefficients
- Metastable state and lasing action
- Excitation mechanisms
- Nd - YAG, He-Ne Laser, Semiconductor Laser
- Properties of laser
- Applications of laser in engineering
- Holography

Absorption and emission processes



a absorption

b spontaneous emission

c stimulated emission

Absorption

Molecule absorbs a quantum of radiation (a photon) and is excited from 1 to 2.

$$M + h\upsilon \rightarrow M^*$$

(state 1) (state 2)

Spontaneous emission

M* (in state 2) spontaneously emits a photon of radiation.

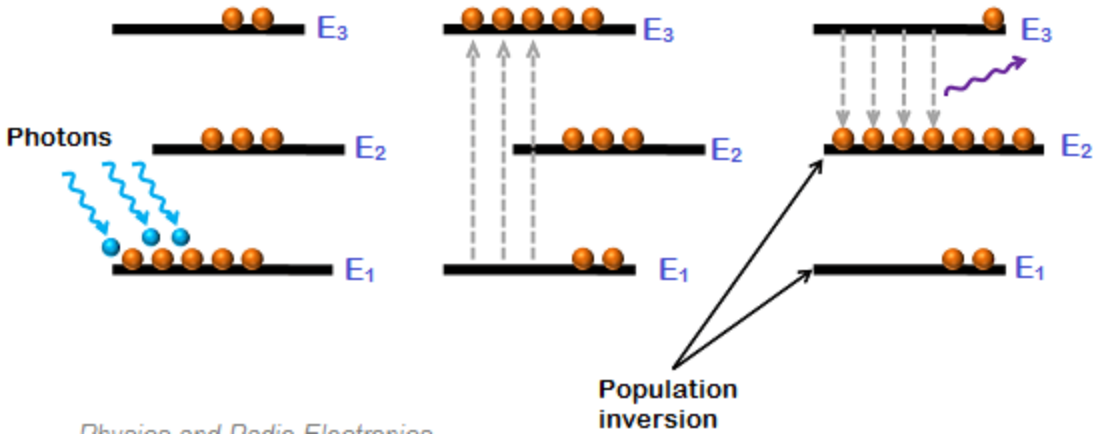
$$M^* \rightarrow M + h\upsilon$$

Stimulated emission

A quantum of radiation is required to stimulate M* to go from 2 to 1.

$$M^* + h\upsilon \rightarrow M + 2h\upsilon$$

Population inversion/Metastable state



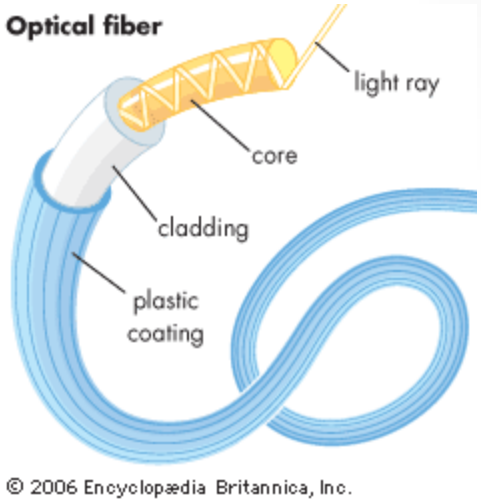
Holography

CO2: articulate the concepts of laser and its application

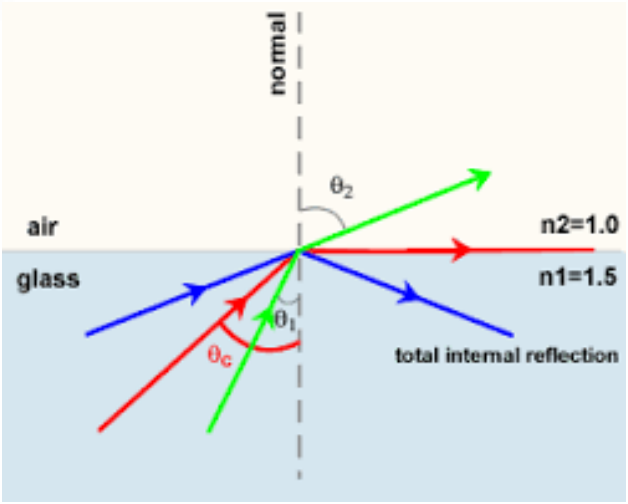
Unit-3: Fiber optics

Unit-3: Fiber optics

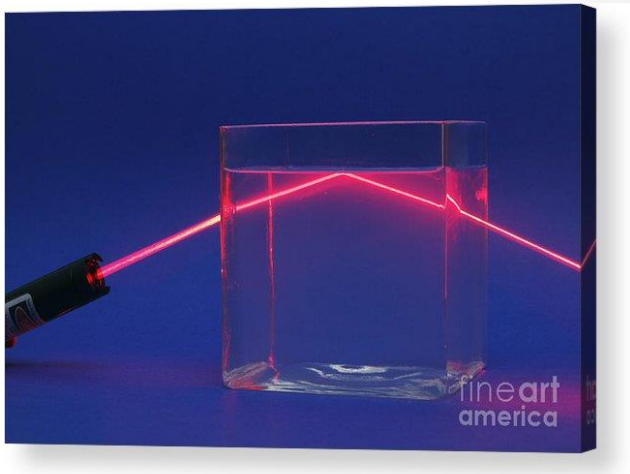
- Introduction to optical fiber
- Optical fiber as a dielectric wave guide
- Total internal reflection
- Acceptance angle & Numerical aperture
- Relative refractive index
- V-number
- Step index and graded index fibers
- Losses associated with optical fibers
- Application of optical fibers

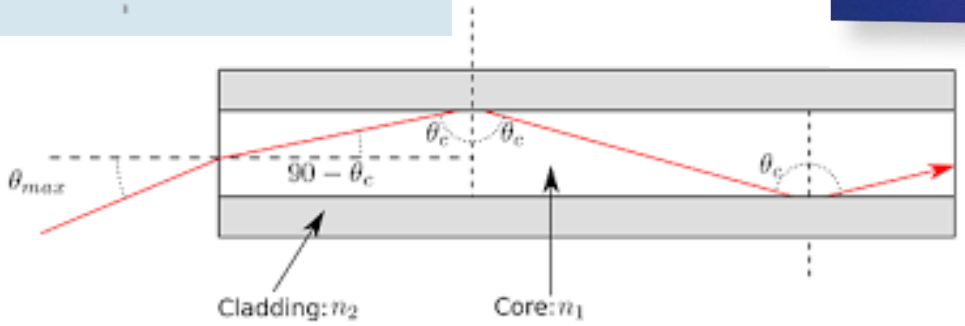


Refraction→TIR



Total internal reflection

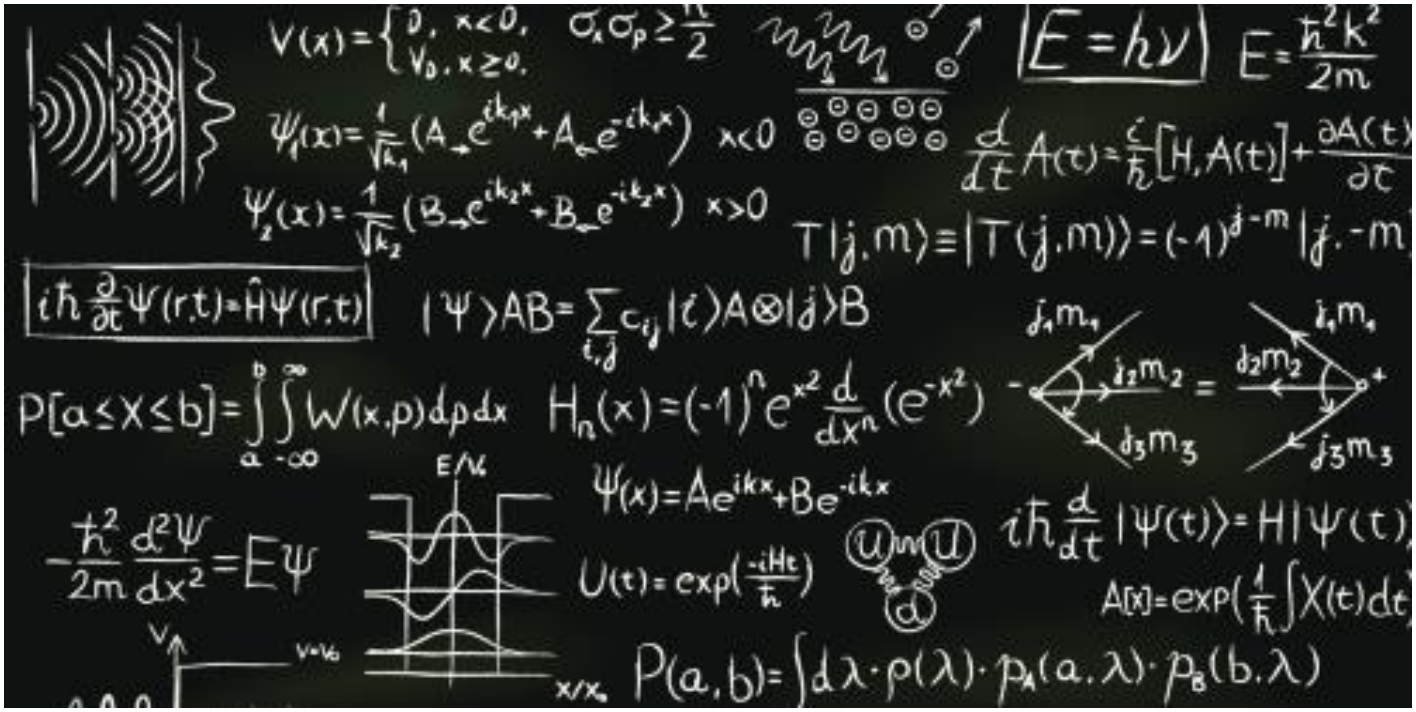




High speed data transfer

CO3: discover the concepts of physics in understanding fiber optics

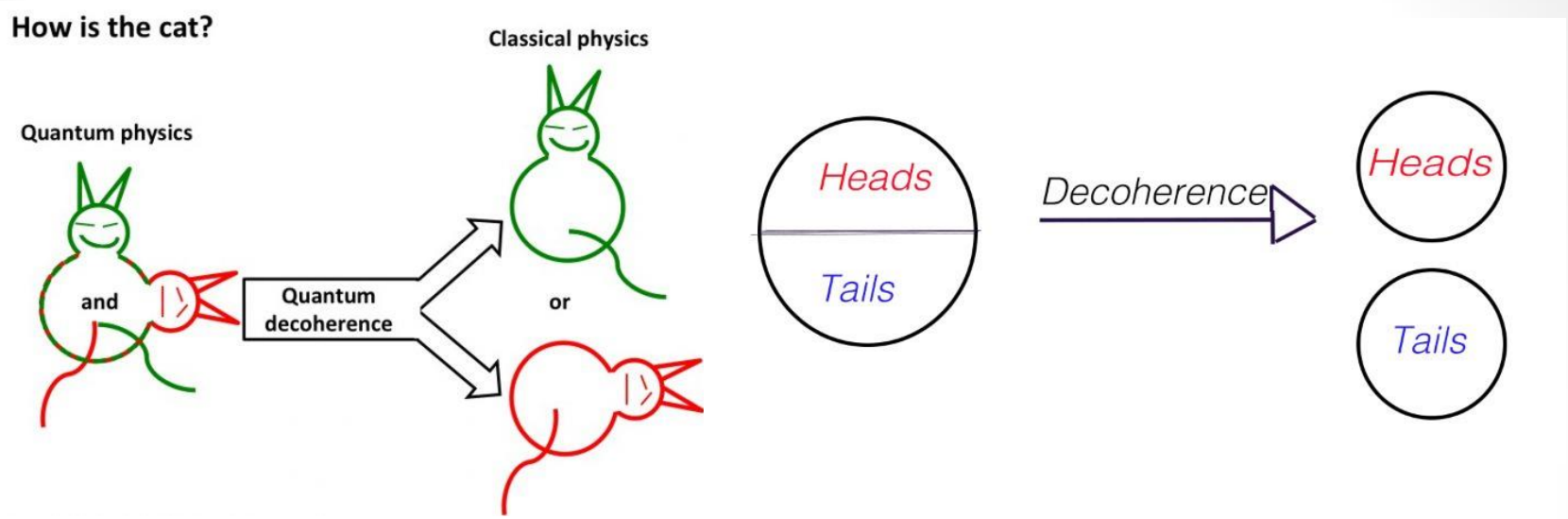
Unit-4: Quantum mechanics



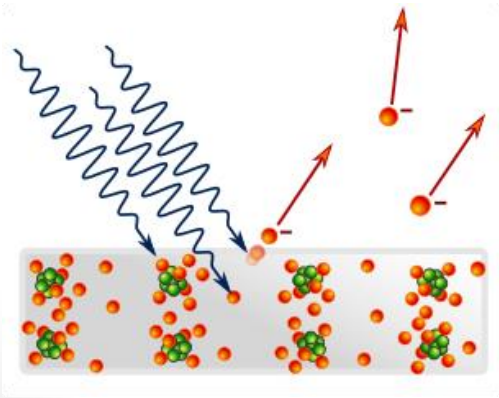
Unit-4: Quantum mechanics

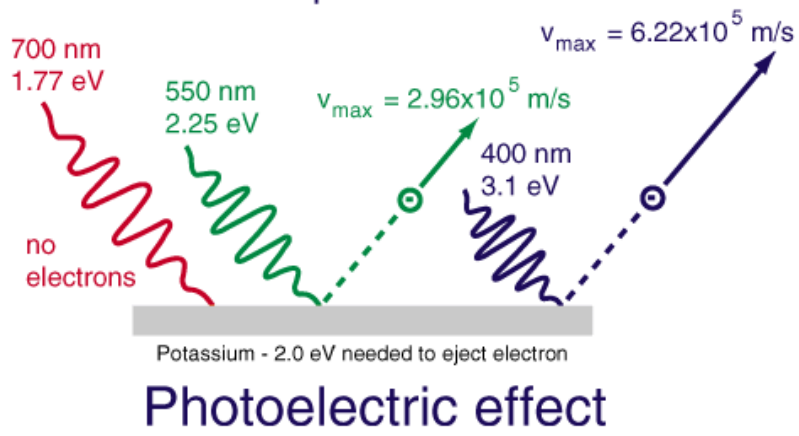
- Need of quantum mechanics
- Photoelectric effect
- Concept of de Broglie matter waves
- Heisenberg uncertainty principle
- Concept of phase velocity and group velocity (qualitative), wave function and its significance,
- Schrodinger time dependent and independent equation
- Particle in a box

Quantum decoherence (QM vs Classical mechanics)

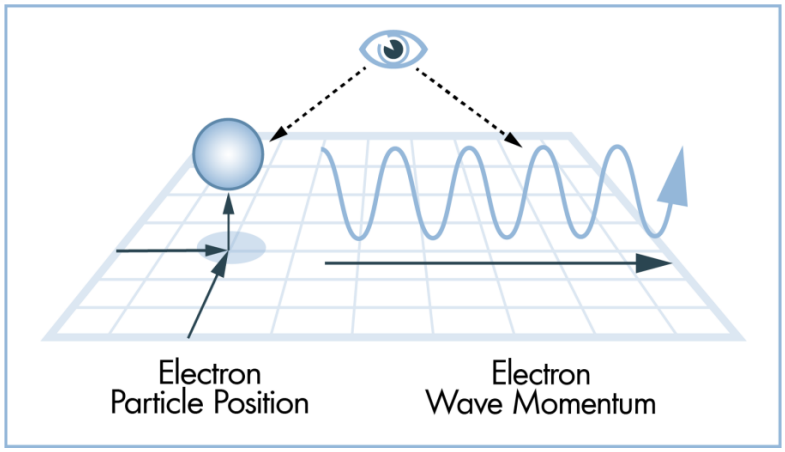


Photoelectric effect





Heisenberg uncertainty principle



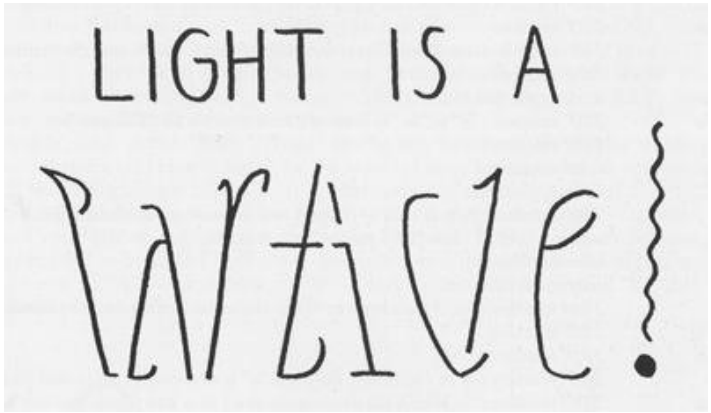
$$\Delta x \, \Delta p \geq \frac{h}{4\pi}$$

Uncertainty in position

Uncertainty in momentum

A really small number

Dual nature of light



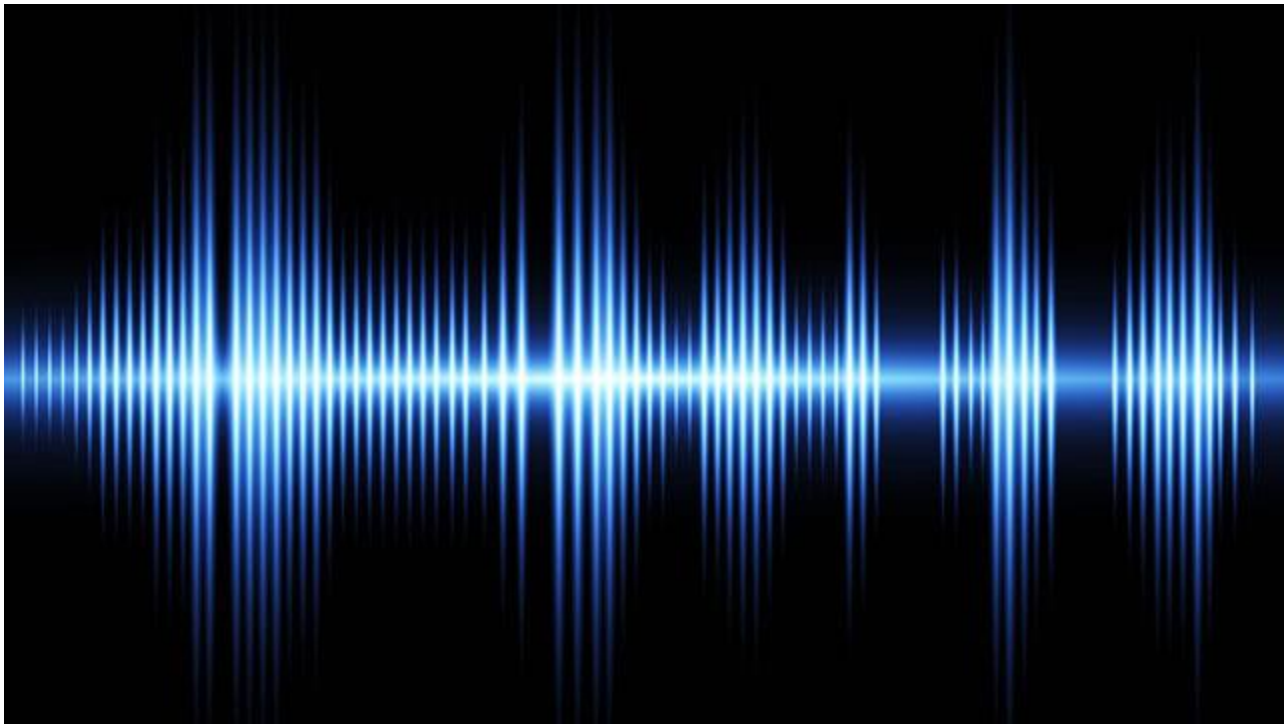
Photoelectric effect

Compton effect

Raman effect

CO4: analyze the importance of quantum physics and its application

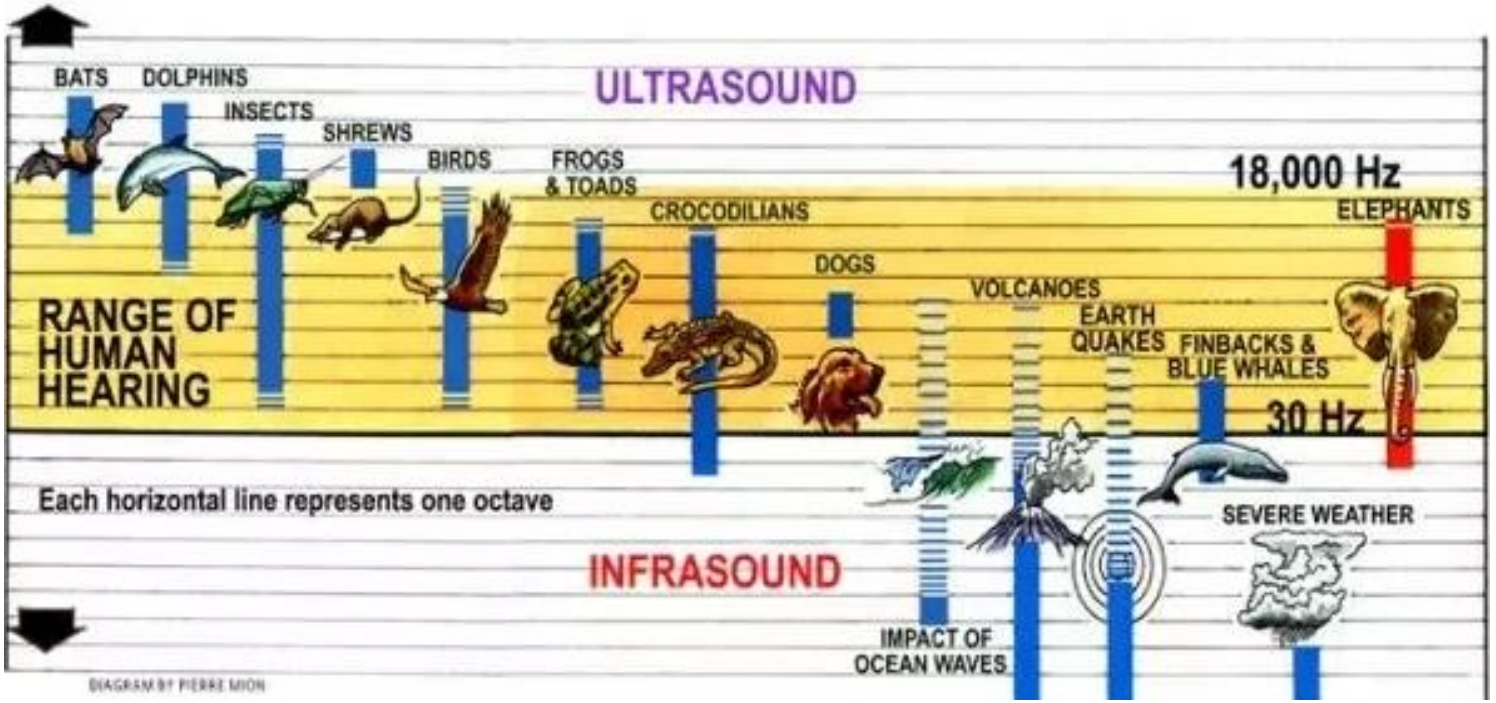
Unit-5: Waves



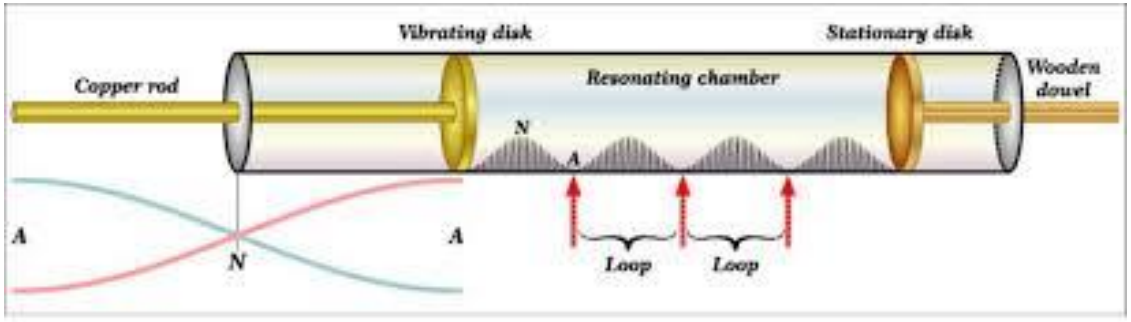
Unit-5: Waves

- Interference, resonance
- Audible, ultrasonic and infrasonic waves
- Production of ultrasonic waves (magnetostriction/piezoelectric method)
- Detection of ultrasonic waves (Kundt's tube method, sensitive flame method and piezoelectric detectors)
- Ultrasonic transducers
- Applications of ultrasonic waves

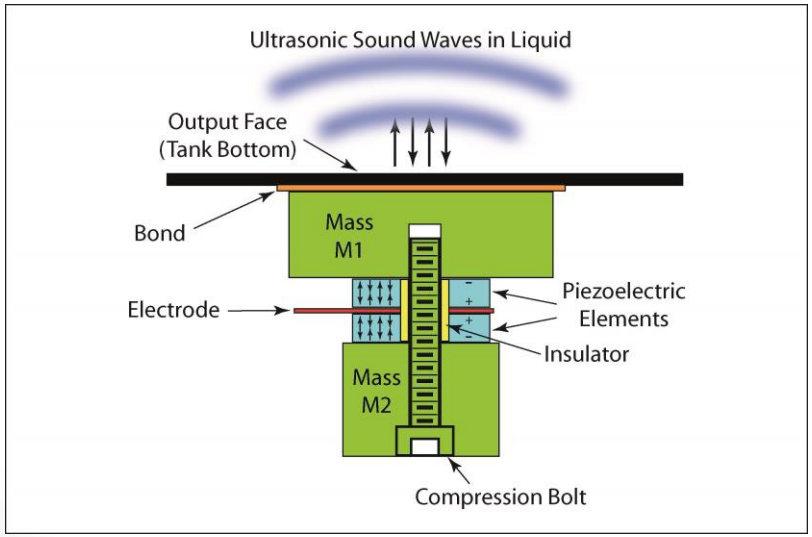
Sound waves


BATS
DOLPHINS
INSECTS
SHREWS
BIRDS
FROGS & TOADS
CROCODILIANS
DOGS
ULTRASOUND
18,000 Hz
ELEPHANTS
RANGE OF HUMAN HEARING
VOLCANOES
EARTH QUAKES
FINBACKS & BLUE WHALES
30 Hz
Each horizontal line represents one octave
SEVERE WEATHER
INFRASOUND
IMPACT OF OCEAN WAVES

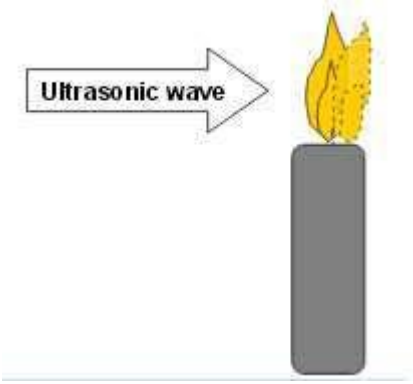
Kundt's tube method



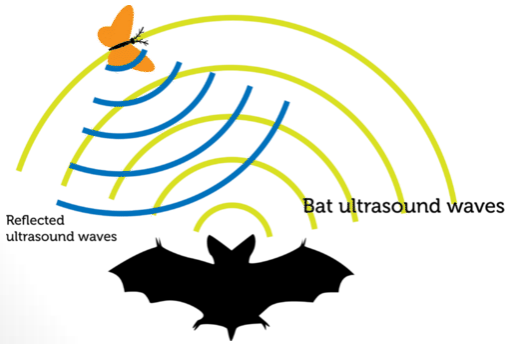
Piezoelectric transducer

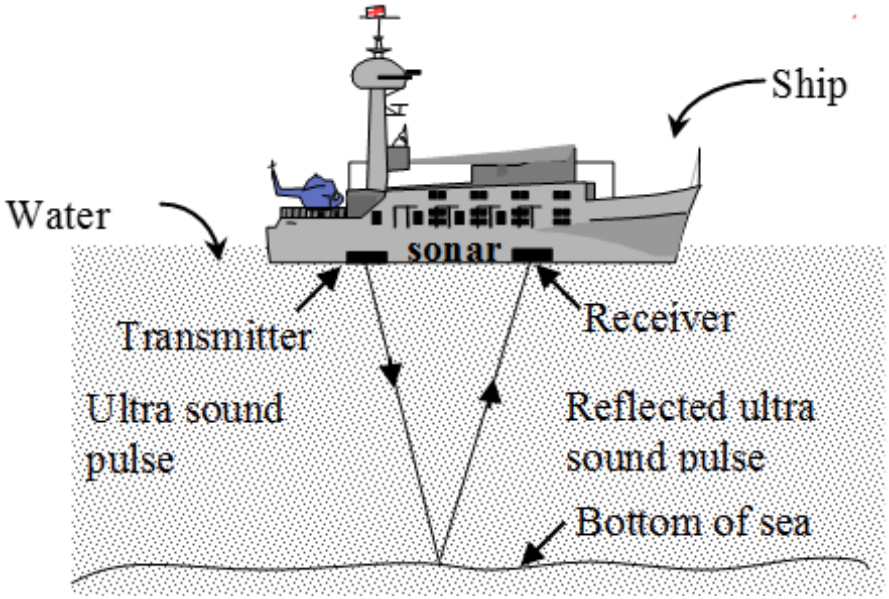


Sensitive flame method



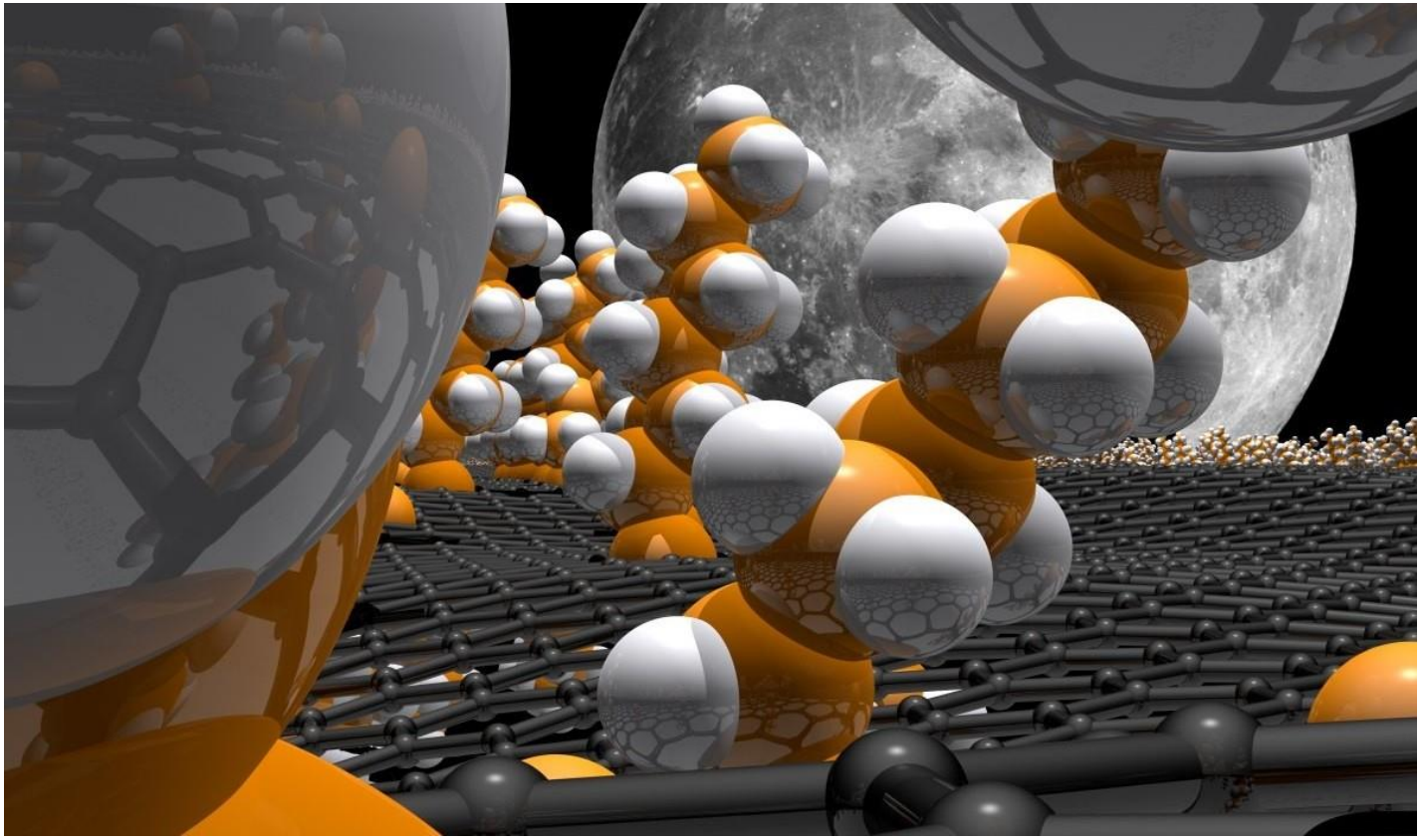
Applications of ultrasonic waves





CO5: evaluate the need of ultrasonic waves and its generation mechanism

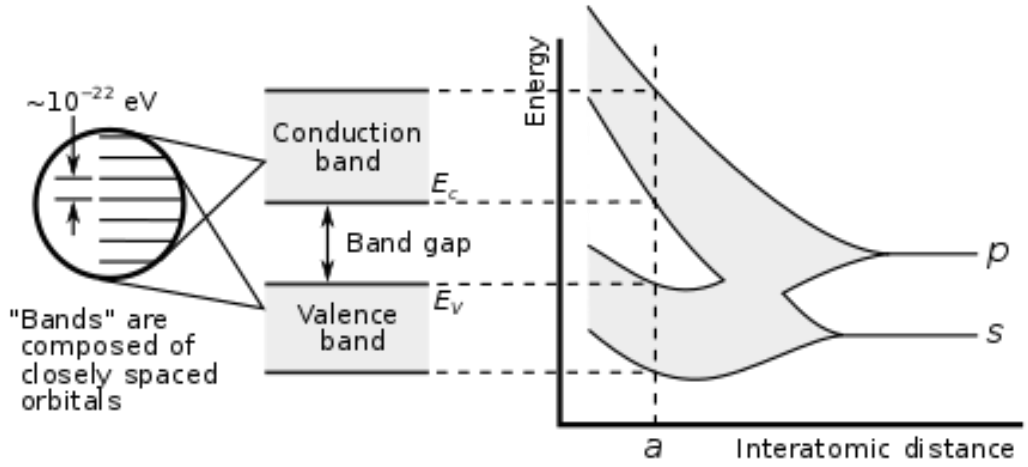
Unit-6: Solid state physics



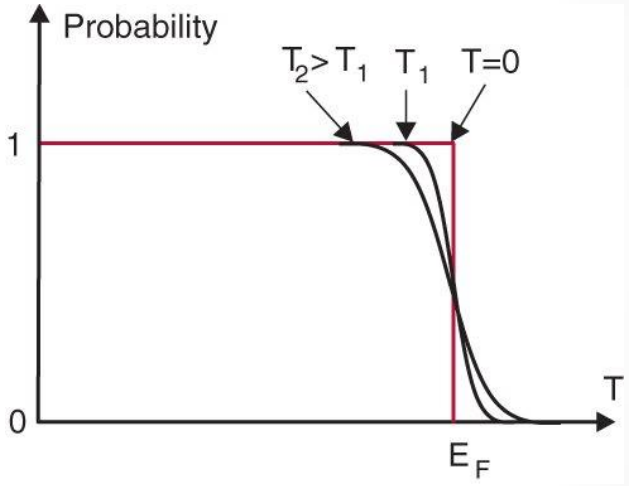
Unit-6: Solid state physics

- Free electron theory (Introduction)
- Diffusion and drift current (qualitative).,
- Fermi energy
- Fermi-dirac distribution function
- Band theory of solids (formation of allowed and forbidden energy bands)
- Concept of effective mass - electrons and holes
- Hall effect
- Semiconductors and insulators
- Fermi level for intrinsic and extrinsic semiconductors
- Direct and indirect band gap semiconductors

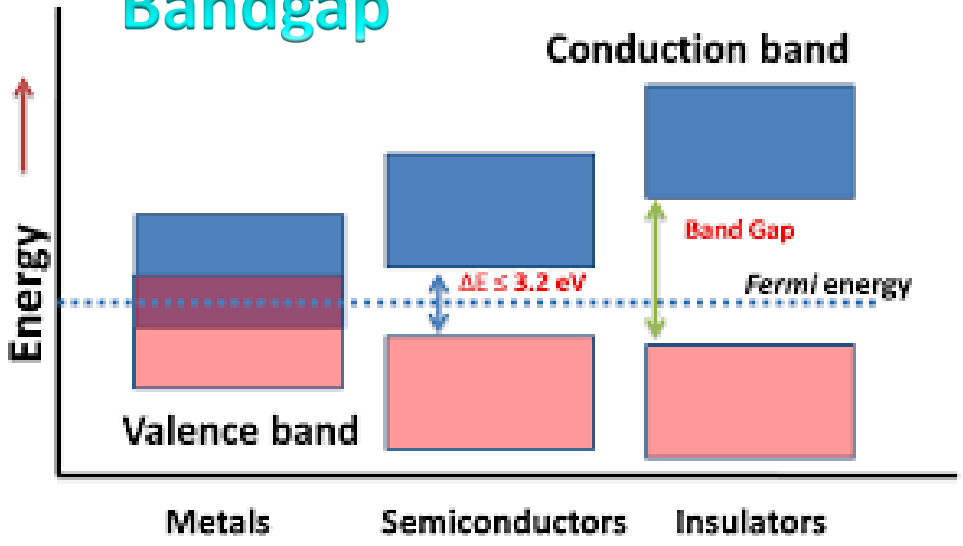
Band theory



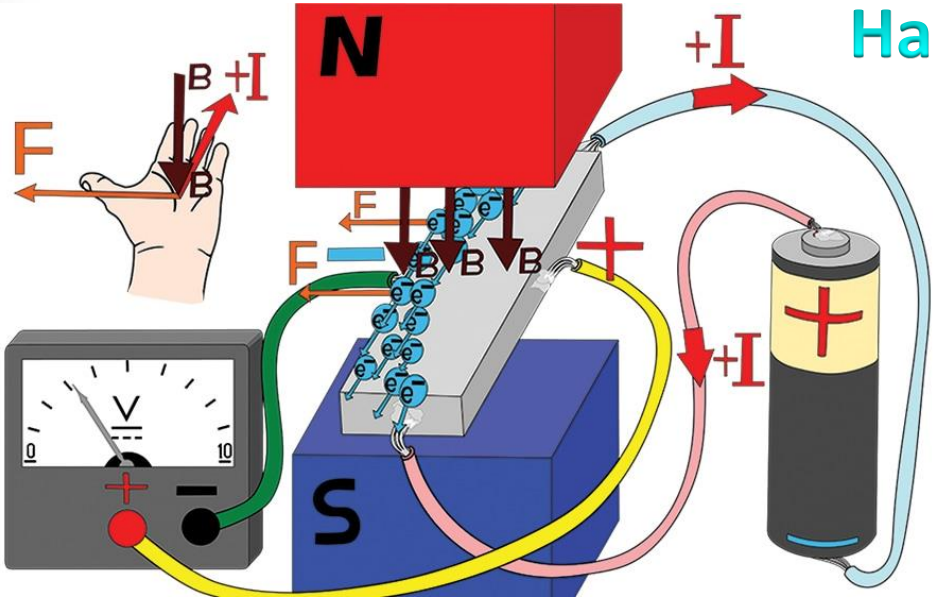
Fermi energy



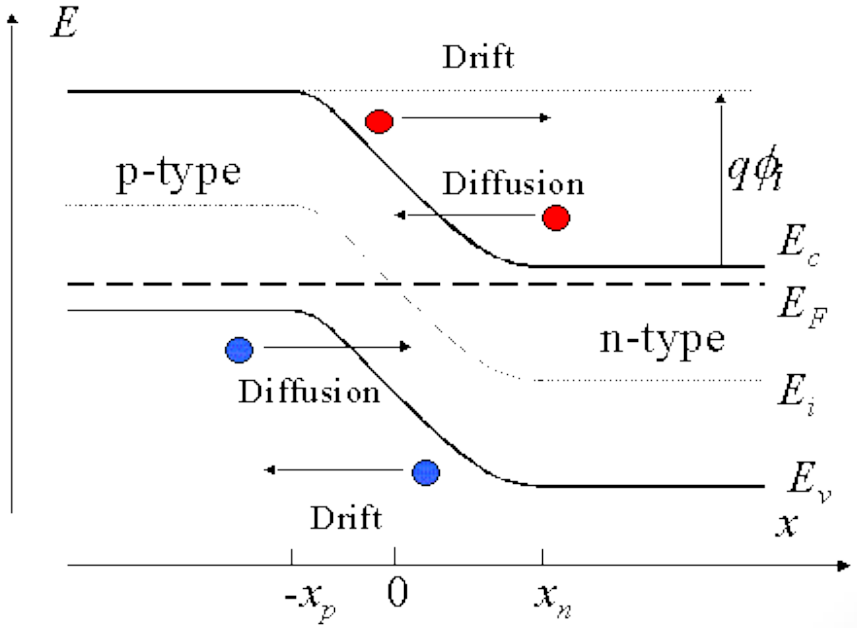
Bandgap



Hall effect



Drift current & diffusion current



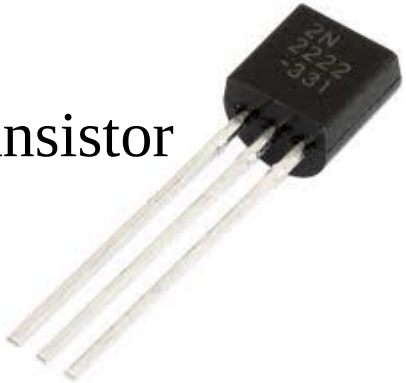
Solid state devices…

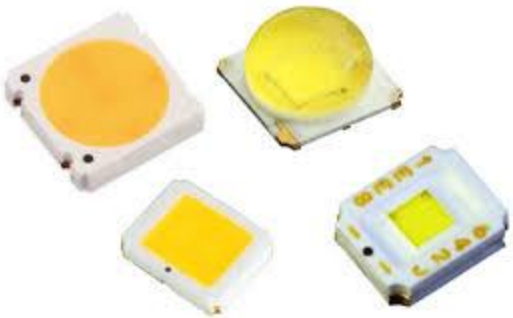
Diode

Solar Cell

Photodiode

Transistor





LEDs

Amplifier

CO6: understand physics of various solid state operating/functional devices


Good luck