INSTITUTE OF AERONAUTICALENGINEERING

(Autonomous)
Dundigal, Hyderabad-500043

FRESHMAN ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**SEMICONDUCTOR PHYSICS (Common for CSE /IT)**			
Course Code	**AHSB13**			
Program	**B.Tech**			
Semester	**I**			
Course Type	**Core**			
Regulation	**IARE - R18**			
Course Structure	**Lectures**	**Tutorials**	**Practical**	**Credits**
	3	**1**	**-**	**4**
Course Coordinator	**Ms. S Charvani, Associate Professor**			
Course Faculty	**Dr. P Koteshwar Rao, Assistant Professor** **Mr. K Sai Baba, Assistant Professor**			

I. COURSE OBJECTIVES (CO's):

The course should enable the students to:

I	Enrich knowledge in principals of quantum mechanics and semiconductors.
II	Develop strong fundamentals of electronic and optoelectronic materials.
III	Enrich knowledge about measuring resistivity, conductivity and other parameters.
IV	Correlate principles and applications of lasers and fiber optics.

II. COURSE LEARNING OUTCOMES (CLO's):

Students, who complete the course, will have demonstrated the ability to do the following:

AHSB13.01	Recall the basic principles of physics and apply these concepts of physics in solving the real-time problems.
AHSB13.02	Acquire knowledge about fundamentals in quantum mechanics.
AHSB13.03	Interpretation of dual nature of matter wave concept using Davisson & Germer's experiment.
AHSB13.04	Estimate the energy of the particles using Schrödinger's wave equation and apply it to particle in potential box.
AHSB13.05	Understand the band structure of a solid and Classify materials as metals, insulators, or semiconductors, and sketch a schematic band diagram for each one.
AHSB13.06	Recollect the conductivity mechanism involved in semiconductors and calculate carrier concentrations.
AHSB13.07	Acquire knowledge about fundamentals in semiconducting devices
AHSB13.08	Understand the basics of a p-n junction and construction of optoelectronic devices like LED, photo diode , solar cell.
AHSB13.09	Recollect the concept of electric polarization and classify dielectric materials.
AHSB13.10	Recollect the concept of magnetization and classify magnetic materials.
AHSB13.11	Apply different laws of radiation to understand the phenomenon behind production of light.

AHSB13.12	Understand the basic principles involved in the production of Laser light and also real-time applications of lasers.
AHSB13.13	Recollect basic principle, construction, types and attenuation of optical fibers.
AHSB13.14	Understand the importance of optical fibers in real-time communication system.

TUTORIAL QUESTION BANK

MODULE – I			
QUANTUM MECHANICS			
Part - A(Short Answer Questions)			
S No	**QUESTION**	**Blooms Taxonomy Level**	**Course Learning Outcomes (CLOs)**
1	Discuss the de-Broglie's hypothesis of duality of material particles and arrive at the concept of matter waves.	Understand	AHSB13.01 AHSB13.03
2	Write an expression for de-Broglie wave length in terms of momentum and kinetic energy.	Understand	AHSB13.01 AHSB13.03
3	Light radiation exhibits both particle and wave nature. Explain this conception of light.	Understand	AHSB13.01 AHSB13.03
4	Explain the concept of Black body radiation.	Remember	AHSB13.01 AHSB13.02
5	Explain the concept of Photoelectric effect.	Remember	AHSB13.01 AHSB13.02
6	Explain the concept of Compton effect.	Understand	AHSB13.01 AHSB13.02
7	Explain the physical significance of wave function which connects the particle nature and wave nature of matter wave.	Understand	AHSB13.04
8	Describe behavior of matter waves by giving any two of its properties.	Understand	AHSB13.04
9	Write expressions for wave function and energy of a particle in three dimensional square well box of infinite potential.	Understand	AHSB13.04
10	Write expressions for eigen function and eigen values for a particle in one dimensional square well box of infinite potential.	Understand	AHSB13.04
Part - B (Long Answer Questions)			
1	Explain the concept of Black body radiation, Photoelectric effect and Compton effect.	Understand	AHSB13.01 AHSB13.02
2	Matter waves are not electromagnetic waves but a new kind of waves. Justify this concept by discussing different properties of matter waves.	Understand	AHSB13.01 AHSB13.03
3	Using Planck's and Einstein's theory of radiation, Show that the wavelength associated with an electron of mass *'m'* and kinetic energy *'E'* is given by $h / \sqrt{2mE}$.	Understand	AHSB13.01 AHSB13.03
4	Describe Davisson Germer experiment with a neat diagram and explain how it established the proof for wave nature of electrons.	Understand	AHSB13.01 AHSB13.03
5	Considering dual nature of electron, Derive Schrodinger's time independent wave equation for the motion of an electron.	Understand	AHSB13.01 AHSB13.03
6	Assuming that a particle of mass m is confined in a field free region between impenetrable walls in infinite height at $x = 0$ and $x = a$, show that the permitted energy levels of a particle are given by $n^2 h^2 / 8 m a^2$.	Understand	AHSB13.01 AHSB13.03
7	Discuss the results from the eigen values, eigen functions and probability density for a particle in a one dimensional potential box of infinite height. Also sketch the figures.	Understand	AHSB13.01 AHSB13.03
Part - C (Analytical Questions)			
1	Calculate the velocity and kinetic energy of an electron having wavelength of 0.21nm.	Understand	AHSB13.03

2	Calculate the de Broglie wavelength associated with a proton moving with a velocity of 1/10 of velocity of light. (mass of proton = 1.674×10^{-27} kg).	Understand	AHSB13.03
3	Calculate the wavelength of an electron raised to a potential 15kV.	Understand	AHSB13.03
4	Calculate de-Broglie wavelength of neutron. (Given kinetic energy of the neutron is 0.025eV mass of neutron =1.674×10^{-27} kg).	Understand	AHSB13.03
5	Calculate the wavelength of an electron, if the kinetic energy of the neutron is 0.025 eV.	Understand	AHSB13.03
6	Find the wavelength associated with an electron rose to a potential 1600V.	Understand	AHSB13.03
7	Calculate the energies that can be possessed by a particle of mass 8.50×10^{-31}kg which is placed in an infinite potential box of width 10^{-9}m.	Understand	AHSB13.03
8	Find the lowest energy of an electron confined in a square box of side 0.1nm.	Understand	AHSB13.03
MODULE – II			
ELECTRONIC MATERIALS AND SEMICONDUCTORS			
Part – A (Short Answer Questions)			
1	Define Bloch theorem.	Understand	AHSB13.05
2	Define a metallic solid and draw its band diagram to explain its electronic behavior.	Understand	AHSB13.05
3	On the basis of band theory how the crystalline solids are classified into conductors, semiconductors and insulators.	Understand	AHSB13.05
4	Define a semiconductor and draw its band diagram to explain its electronic behavior.	Understand	AHSB13.05
5	Define an insulator and draw its band diagram to explain its electronic behavior.	Remember	AHSB13.05
6	Write the classification of semiconductors based on variation of conductivity in terms of temperature and doping.	Understand	AHSB13.07
7	What do you understand by an intrinsic semiconductor? Give an example.	Remember	AHSB13.07
8	Write the expressions for carrier concentration of electrons and holes in intrinsic semiconductors.	Remember	AHSB13.07
9	Write an expression for carrier concentration of electrons in p-type semiconductor.	Understand	AHSB13.07
10	What is an expression for carrier concentration of holes in n-type semiconductor ?	Understand	AHSB13.07
11	Give the statement of Hall effect using a proper diagram representing current, magnetic field and Hall voltage.	Understand	AHSB13.07
Part - B (Long Answer Questions)			
1	What is Bloch's theorem? Explain in detail the motion of electron in a periodic potential.	Understand	AHSB13.06
2	Using Kronig-Penny model show that the energy spectrum of an electron contains a number of allowed energy bands separated by forbidden bands.	Understand	AHSB13.05
3	Explain the origin of energy band formation in solids and classify the solids into conductors semiconductors and insulators.	Understand	AHSB13.05
4	Distinguish between intrinsic and extrinsic semiconductors. Indicate on an energy level diagram, the conduction and valence bands, donor and acceptor levels for intrinsic and extrinsic semiconductors.	Understand	AHSB13.07
5	Deduce the mathematical expression for intrinsic carrier concentration and hence show that the Fermi level lies at the middle for an intrinsic semiconductor.	Remember	AHSB13.07
6	Obtain an expression for carrier concentration of n- type semiconductor.	Understand	AHSB13.07
7	Obtain an expression for carrier concentration of p- type semiconductor.	Understand	AHSB13.07
8	Explain the dependence of Fermi level on temperature for an intrinsic semiconductor, n type and p type semiconductors.	Understand	AHSB13.07
9	Discuss in detail Hall effect and obtain an expression for Hall coefficient. Mention the uses of Hall effect.	Understand	AHSB13.07
Part - C (Analytical Questions)			
1	Find carrier concentration of an intrinsic semiconductor of band gap 0.78eV at 300K. [Given that the effective mass of electron = effective mass of hole	Understand	AHSB13.07

	= rest mass of electron].		
2	What temperature would the E_F be shifted by 15% from middle of forbidden gap (E_g)? Given E_g =1.2ev, effective mass of holes is 5 times that of electrons.	Understand	AHSB13.07
3	Calculate intrinsic carrier concentration for Ge at 27^0C. Given Eg in Germanium is 0.7eV.	Understand	AHSB13.07
4	Calculate Hall voltage developed across the width of the slab of a metallic slab carrying a current of 30A is subjected to a magnetic field of 1.75T. The magnetic field is perpendicular to the plane of the slab and to the current. The thickness of the slab is 0.35cm. The concentration of free electrons in the metal is 6.55×10^{28}electrons/m^3.	Understand	AHSB13.07
5	Find carrier concentration, if the R_H of a specimen is 3.66×10^{-4} m^3c^{-1}.	Understand	AHSB13.07
6	Calculate the density of charge carriers of semiconductor, given the Hall coefficient is -6.85×10^{-5} m^3/Coulomb.	Understand	AHSB13.07
MODULE -III			
LIGHT-SEMICONDUCTOR INTERACTION			
Part - A (Short Answer Questions)			
1	Define diffusion and drift with respect to a semiconducting material.	Understand	AHSB13.08
2	Explain the terms Carrier generation and recombination.	Understand	AHSB13.08
3	Give the differences between Direct and indirect band gaps in semiconducting materials.	Remember	AHSB13.08
4	Explain biasing of a semiconductor material. Show how they are connected in forward and reverse biasing.	Understand	AHSB13.08
5	Draw the plot of V-I characteristics of a PN junction diode.	Understand	AHSB13.08
6	Draw the circuit of a forward biased PN junction diode.	Understand	AHSB13.08
7	Define the concept of Photo voltaic effect	Understand	AHSB13.08
8	Explain the principle behind LED.	Remember	AHSB13.08
9	Draw the circuit of a reverse biased PN junction diode	Remember	AHSB13.08
10	Explain the principle behind a photo diode.	Understand	AHSB13.08
Part – B (Long Answer Questions)			
1	Explain the terms drift and diffusion. Give the differences between Direct and indirect band gap semiconductors.	Understand	AHSB13.08
2	What is forward biasing of a PN junction diode ? Draw the circuit diagram and explain.	Understand	AHSB13.08
3	Explain the V-I characteristics of a PN junction diode under forward and reverse biasing.	Understand	AHSB13.08
4	Discuss about formation of a PN junction diode and explain biasing of the diode	Understand	AHSB13.08
5	What is reverse biasing of a PN junction diode ? Draw the circuit diagram and explain.	Understand	AHSB13.08
6	Define the terms generation and recombination relevant to a semiconductor material.		
6	Discuss the Construction of a Avalanche photo diode with a neat diagram .Explain the working principle of it with the help of band diagram.	Understand	AHSB13.08
7	Explain the Construction of a LED with a neat diagram, also discuss the working principle of it with the help of band diagram.	Understand	AHSB13.08
8	Describe photo voltaic effect. Explain how a solar cell works in response to incident light.	Understand	AHSB13.08
9	Explain the Construction of a photo diode with a neat diagram, and discuss the working principle of it with the help of band diagram.		
10	Discuss the Construction of a PIN photo diode with a neat diagram, and explain the working principle of it with the help of band diagram.		
Part - C (Analytical Questions)			
1	**Calculate** the wavelength of emitted radiation from a	Understand	AHSB13.08

	diode, which has a band gap of 1.44eV.		
2	A semiconductor diode has a wavelength of 1.55μm. **Find** its band gap in eV.	Understand	AHSB13.08
3	**Calculate** the wavelength of emitted radiation from a doide made up of GaAs with a band gap of 1.43eV.	Understand	AHSB13.08
4	**Calculate** the wavelength of emitted radiation from a LED made up of GaAs with a band gap of 1.52eV.	Understand	AHSB13.08
5	A semiconductor diode laser has a wavelength of 1.65μm. **Find** its band gap in eV	Understand	AHSB13.08
6	Calculate the density of charge carriers of semiconductor, given the Hall coefficient is -7.85×10^{-5} m^3/Coulomb	Understand	AHSB13.08
7	Calculate intrinsic carrier concentration for Ge at 37^0C. Given Eg in Germanium is 0.6eV.	Understand	AHSB13.08
MODULE -IV			
ENGINEERED ELECTRIC AND MAGNETIC MATERIALS			
Part – A (Short Answer Questions)			
1	**What** do you understand by dielectric constant and electric polarization related to a dielectric material?	Understand	AHSB13.09
2	**Explain** the terms: i. Displacement vector ii. Electric susceptibility	Remember	AHSB13.09
3	**Describe** polarization vector and polarizability of a dielectric material when placed in external electric field.	Understand	AHSB13.09
4	**Write** notes on electric dipole and electric dipole moment associated with dielectric materials.	Remember	AHSB13.09
5	**Mention** different types of polarizations that occur in dielectric materials in the presence of external electric field.	Understand	AHSB13.09
6	When an electric field is applied, **how** does the phenomenon of polarization takes place?	Understand	AHSB13.09
7	**Explain** the terms: i. Magnetic field intensity ii. Permeability	Understand	AHSB13.10
8	**Write** notes on relative permeability and magnetic moment related to magnetic material.	Remember	AHSB13.10
9	**Mention** the types of magnetic materials based on electron spins.	Understand	AHSB13.10
10	**Sketch** neatly hysteresis loop observed in ferromagnetic materials.	Remember	AHSB13.10
Part – B (Long Answer Questions)			
1	On application of external electric field, various polarization processes takes place in dielectric material. **Explain** briefly all these polarization processes.	Understand	AHSB13.09
2	**What** is electronic polarization? Derive an expression for electronic polarizability in terms of the radius of the atom.	Understand	AHSB13.09
3	**Show** that the ionic polarizability occurring in ionic solids is inversely proportional to square of angular frequency (ω_0).	Understand	AHSB13.09
4	**Obtain** an expression for the internal field experienced by an atom inside a dielectric material subjected to an external field by using Lorentz method.	Understand	AHSB13.09
5	**Describe** the origin of magnetic moment and find the magnetic dipole moments due to orbital and spin motions of an electron.	Understand	AHSB13.10
6	**How** would you differentiate dia, para and ferromagnetic substances based on their magnetic behaviour?	Understand	AHSB13.10
7	**Discuss** the magnetization of ferromagnetic material by domain wall movement and rotation of domains based on domain theory of ferromagnetism.	Understand	AHSB13.10
8	**Draw** the hysteresis loop for a ferromagnetic material and explain the loop based on remanent magnetization and coercive field.	Remember	AHSB13.10
Part - C (Analytical Questions)			

1	**Find** the electric susceptibility of a dielectric gas having dielectric constant of 1.000041.	Understand	AHSB13.09
2	A parallel capacitor has an area of 100cm^2, a plate separation of 1 cm and is charged to a potential of 100 Volts. **Calculate** the capacitance of the capacitor and the change on the plates.	Understand	AHSB13.09
3	The dielectric constant of He gas is 1.0000684. **Find** the electronic Polarizability of He atoms if the gas contains 2.7 x 10^{25} atoms per m^3.	Understand	AHSB13.09
4	A solid dielectric with density 3 x 10^{28} atoms / m^3 shows an electronic polarizability of 10^{-40} farad -m^{-2}. Assuming the internal electric field to be a Lorentz field, **calculate** the dielectric constant of the material.	Understand	AHSB13.09
5	A parallel capacitor of area 650 mm^2 and a plate separation of 4 mm has a charge of 2x10^{-10} C on it. When a material of dielectric constant 3.5 is introduced between the plates, **what** is the resultant voltage across the capacitors?	Understand	AHSB13.09
6	**Calculate** magnetization and magnetic flux density if magnetic field intensity 250amp/m and relative permeability is 15.	Understand	AHSB13.10
7	**Find** relative permeability, if H=220amp/m and M=3300 amp/m.	Understand	AHSB13.10
8	The magnetic susceptibility of aluminium is 2.3 x 10^{-5}. **Find** its permeability and relative permeability.	Understand	AHSB13.10
9	If a magnetic field of strength 300 amp/meter produces a magnetization of 4200 A/m in a ferromagnetic material, **find** the relative permeability of the material.	Understand	AHSB13.10
10	A paramagnetic material has a magnetic field intensity of 10^4 A/m. If the susceptibility of the material at room temperature is 3.7 x 10^{-3}, **calculate** the magnetization and magnetic flux density in the material.	Understand	AHSB13.10
MODULE-V			
LASERS AND FIBER OPTICS			
Part – A (Short Answer Questions)			
1	Define spontaneous and stimulated emission processes involved during de-excitation of atoms.	Understand	AHSB13.11
2	Explain the phenomenon of lasing action required for the production of laser light.	Understand	AHSB13.11
3	Explain the different characteristics of laser?	Remember	AHSB13.12
4	What are the different types of lasers?	Understand	AHSB13.12
5	Mention any three applications of laser beams in different fields.	Understand	AHSB13.12
6	Write the expression for Acceptance angle and Numerical aperture of an optical fiber.	Understand	AHSB13.13
7	Draw a neat sketch of refractive index profile of step index optical fiber.	Remember	AHSB13.13
8	What is the principle behind propagation of light signal through an optical fiber?	Remember	AHSB13.13
9	Write the expressions for Snell's law and critical angle associated with an optical fiber.	Understand	AHSB13.13
10	Discuss different types of attenuation in optical fibers that occur during propagation of light signals.	Understand	AHSB13.13
Part - B (Long Answer Questions)			
1	What are the characteristics of lasers, and explain the phenomenon of lasing action required for the production of laser light.	Understand	AHSB13.11
2	What do you understand by absorption and pumping mechanism related to excitation of atoms from lower to higher energy states?	Understand	AHSB13.11
3	Explain the construction of a Ruby laser in detail, with the help of a neat suitable diagram.	Understand	AHSB13.12
4	Describe the construction of He-Ne gaseous laser in detail, with the help of a neat diagram.	Understand	AHSB13.12
5	Discuss the importance of lasers in various fields like industry, medicine, science, etc., by giving their applications.	Understand	AHSB13.12
6	What is an optical fiber? Explain its construction and principle with a neat diagram.	Understand	AHSB13.13
7	Derive an expression for angle of acceptance of an optical fiber in terms of	Understand	AHSB13.13

	refractive indices of core and cladding		
8	Define Numerical aperture. Derive an expression for numerical aperture of an optical fiber.	Understand	AHSB13.13
9	Explain in detail, different types of optical fibers based on refractive index profile of core medium.	Understand	AHSB13.13
10	Draw the block diagram of fiber optic communication system and explain the functions of each block in the system.	Understand	AHSB13.14
	Part - C (Analytical Questions)		
1	Calculate the wavelength of emitted radiation from a semiconductor diode laser, which has a band gap of 1.44eV.	Understand	AHSB13.12
2	A semiconductor diode laser has a wavelength of 1.55μm. Find its band gap in eV.	Understand	AHSB13.12
3	Calculate the wavelength of emitted radiation from a semiconductor diode laser, which has a band gap of 1.68eV.	Understand	AHSB13.12
4	A semiconductor diode laser has a wavelength of 1.42μm. Find its band gap in eV.	Understand	AHSB13.12
5	Calculate the refractive indices of core &cladding of an optical fiber with a numerical aperture of 0.33 and their fractional differences of refractive indices being 0.02.	Understand	AHSB13.13
6	A step index fiber has a numerical aperture of 0.16 and core refractive index of 1.45.Calculate the acceptance angle of the fiber and refractive index of the cladding.	Understand	AHSB13.13
7	The refractive indices of core and cladding materials of a step index fiber are 1.48 and 1.45 respectively. Calculate i) Numerical aperture ii) Acceptance angle.	Understand	AHSB13.13
8	An optical fiber has a numerical aperture of 0.02 and a cladding refractive index of 1.59. Find the acceptance angle for the fiber in water which has a refractive index of 1.33.	Understand	AHSB13.13
9	Calculate the fractional index change for a given optical fiber if the refractive indices of the core and the cladding are 1.563 and 1.498 respectively.	Understand	AHSB13.13
10	Calculate the numerical aperture and acceptance angle for an optical fiber with core and cladding refractive indices being 1.48 and 1.45 respectively.	Understand	AHSB13.13

Prepared By:

Ms. S Charvani, Associate Professor

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