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Internal Assessment Test 1 – October 2023

Sub:	Physics for CSE stream				Sub Code:	BPHYS102	Branch:	ISE/AIDS/AIML/CSE-AIML
Date:	31/10/2023	Duration:	90 mins	Max Marks: 50	Sem/Sec:	I Sem / A, B, C, D, E, F, G, H		OBE

Answer any FIVE FULL Questions

Given: $c = 3 \times 10^{8}$ m/s; $h = 6.625 \times 10^{-34}$Js; $k = 1.38 \times 10^{-23}$ J/K; $m_e = 9.1 \times 10^{-31}$kg; $e = 1.6 \times 10^{-19}$C

MARKS

1. Explain how transmission of light takes place in optical fibers.
2. Explain the principle of optical fiber.
3. Describe the principle on which optical fiber works
4. Explain the mechanism of light propagation in an optical fiber.
5. What are different types of optical fibers? Explain.
6. Define the following in optical fibers
   a) Critical angle of propagation
   b) Half angle of acceptance
   c) Numerical aperture
7. With neat diagrams explain (i) acceptance angle, and (ii) numerical aperture
8. What is numerical aperture? Obtain an expression for numerical aperture in terms of refractive indices of core and cladding, and then arrive at the condition for propagation.
9. Obtain an expression for numerical aperture and arrive at the condition for propagation of signal in an optical fiber.
10. Describe the different types of optical fiber along with the typical core and cladding diameter, refractive index profile, and mode propagation sketches.
11. With neat diagrams explain the different types of optical fibers.
12. What is attenuation in an optical fiber? Explain the attenuation mechanisms.
13. Obtain the expression for attenuation coefficient.
14. Why Rayleigh scattering occurs?
15. Mention the factors contributing to the fiber losses.
16. Discuss the various loss factors in optical fiber communications.
17. Derive the condition for propagation of light through an optical fiber.
18. What are the advantages of optical communications over other conventional types of communication?
19. Explain fiber-optic communication. Describe point to point communication system using fibers with the help of a block diagram.
20. Discuss point to point communication system and mention its advantages over the conventional systems.

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21. Discuss the advantages and disadvantages of an optical communication system over conventional communication system.
22. Explain the construction of an optical fiber and the principle on which it works.
23. Explain optical fiber sensors- Intensity-based displacement sensor and Temperature sensor based on phase modulation in detail with suitable diagram.
24. Obtain an expression for energy density of radiation under thermal equilibrium in terms of Einstein's coefficients.
25. Mention the conditions required for Laser action.
26. Discuss the requisites of a Laser system.
27. Briefly give a general account of displacement sensors.
28. Explain the construction and working of CO_2 laser, with the help of suitable diagrams
29. Mention the characteristics of laser beam.
30. Mention four applications of lasers.
31. Define a) stimulated emission b) spontaneous emission c) population inversion
32. Explain the applications of lasers in defence.
33. Explain the working of laser printer.
34. What is Intensity sensor? Explain in detail.

NUMERICAL:

35. Calculate the numerical aperture, relative refractive index difference, V-number and number of modes is an optical fiber of core diameter 50µm, core and cladding refreactive indices 1.41 and 1.40, at wavelength 820nm.
36. Calculate the numerical aperture of the given optical fiber if the refractive indices of the core and cladding are 1.623 and 1.522 respectively.
37. An optical fiber has clad of refractive index 1.50 and numerical aperture 0.39. Find the refractive index of the core and the acceptance angle. **(GATE Question)**
38. The numerical aperture of an optical fiber is 0.2 when surrounded by air. Determine the refractive index of its core given the refractive index of cladding as 1.59. Also find the acceptance angle when it is in a medium of refractive index1.33.
39. The refractive indices of the core and cladding of a step-index optical fiber are 1.45 and 1.40 respectively and its core diameter is 45µm. Calculate its fractional refractive index change and numerical aperture.
40. Calculate the numerical aperture and angle of acceptance of a given optical fiber if the refractive indices of the core and cladding are 1.563 and 1.498 respectively.
41. A step index fiber in air has NA of 0.12, a core refractive index of 1.42 and a core of

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diameter of 20 cm. Determine the normalized frequency for the fiber when light at a wavelength 0.8 μm is transmitted.		
42. An optic glass fiber of refractive index 1.450 is to be clad with another glass to ensure total internal reflection that will contain light travelling within 5° of the fiber axis. What maximum index of refraction is allowed for the cladding?	CO1	L2
43. An optical fiber has a NA of 0.32. The refractive index of cladding is 1.48. Calculate the refractive index of the core, the acceptance angle of the fiber and the fraction index change. **(GATE Question)**	CO1	L3
44. Calculate the number of modes that can propagate inside an optical fiber, Given n_{core}=1.53, n_{clad}=1.50, core radius 50μ m, $\lambda = 1\mu m$	CO1	L2
45. The attenuation of light is an optical-fiber is estimated at 2.2dB/km. What fractional initial intensity remains after 2 km & 6 km?	CO1	L2
46. A fiber 500m long has an input power of 8.6mW and output power 7.5mW. What is the loss specification in cable?	CO1	L2
47. The average power of a laser beam of wavelength 6328 A^0 is 5mW. Find the number of photons emitted per second by the laser source.	CO1	L2
48. The attenuation in an optical-fiber is 3.6dB/km. What fractional of its initial intensity remains after3 km?	CO1	L2
49. The attenuation in an optical-fiber is 2dB/km. What fractional of its initial intensity remains after (i) 2 km, (ii) 5 km?	CO1	L2
50. An optical fiber has lost 85% its power after traversing 500m of fiber. What is the loss in dB/km of this fiber?	CO1	L2
51. Find the attenuation in an optical fiber of length 500 m, when a light signal of power 100 mW emerges out of the fiber with a power of 90 mW.	CO1	L3
52. The angle of acceptance of an optical fiber is 300 when kept in air. Find the angle of acceptance when it is in a medium of refractive index 1.33.	CO1	L3
53. Calculate the number of modes that can propagate inside an optical fiber, given n_{core}=1.43, n_{clad}=1.40, core radius= 40 μm, λ=1 μm. **(GATE Question)**	CO1	L3
54. Calculate the value of NA, V-number and number of modes in an optical fiber of core diameter 50 μm, core and cladding refractive indices are 1.41 and 1.44 respectively at wavelength 820 nm.	CO1	L3
55. An optic glass fiber of refractive index 1.50 is to be clad with another glass to ensure total internal reflection that will contain light travelling within 5^0 of the fiber axis. What maximum index of refraction is allowed for the cladding?	CO1	L2
56. A glass clad fiber is made with core glass of refractive index 1.5 and cladding is doped to	CO1	L3

give a fractional index difference of 0.0005. Determine the cladding index and the numerical aperture of the fiber.		
57. Calculate on the basis of Einstein’s theory, the number of photons emitted per second by a He-Ne Laser source emitting light of wavelength 6328Å with an optical power of 10 mW.	CO1	L2
58. A pulse from laser with power 1mW lasts for 10 ns. If the number of photons emitted per second is 3.491 X 10^{7}, calculate the wavelength of laser.	CO1	L2
59. A ruby laser emits pulses of 20 ns duration with average power/pulse being 0.1mw. If the number of photons in each pulse is 6.981 X 10^{15}, calculate the wavelength of the photons.	CO1	L2
60. Find the ratio of population of the two energy levels in a medium in thermal equilibrium if the transition between them produces light of wavelength 694.3 nm. Assume the ambient temperature as 27°C.	CO1	L2
61. For a light of frequency 1.5 x 10^{15} Hz used as an excitation source at a temperature of 5000K, find out the ratio of spontaneous and stimulated emission.	CO1	L2
62. The transition to the ground state from the upper and lower energy states in a Ruby laser results in emission of photons of wavelengths, 6928 Å and 6943 Å respectively. Estimate the energy values of the two energy levels is eV.	CO1	L3
63. The ratio of population of two energy levels is 1.059 x 10^{-30}. Find the wavelength of light emitted at 330K.	CO1	L2
64. Find the ratio of population of two energy levels in a medium in thermal equilibrium, if the wavelength of light emitted at 330 K is 632.8 nm.	CO1	L2
65. Find the ratio of population of the two energy states of a medium in thermal equilibrium the transition between which results in the spontaneous emission of photons of wavelength 694.3 nm. Assume the ambient temperature as 27°C.	CO1	L3
66. Find the ratio of population of the two energy levels out of which one corresponds to metastable state, if the wavelength of light emitted at 330K is 632.8 nm. **(GATE Question)**	CO1	L3
67. A He-Ne laser is generating laser beam of power 4 mW. Calculate the number of photons emitted by the laser. Given the wavelength of the emitted radiation is 680nm.	CO1	L2
MODULE-1		
QUANTUM MECHANICS		
68. Define group velocity and phase velocity.	CO1	L2
69. Explain the duality of matter waves.	CO1	L3
70. Explain the energy distribution in the spectrum of blackbody. Give an account to explain the various laws to explain the spectrum.	CO1	L2

71. Explain the theoretical considerations which led de Broglie to the concept of matter waves.	CO1	L2
72. What are the matter waves? Mention their properties.	CO1	L2
73. Explain characteristics of matter waves.	CO1	L3
74. State Heisenberg's uncertainty principle and discuss its physical significance.	CO1	L2
75. What is principle of complementarity.	CO1	L3
76. Using Heisenberg's uncertainty principle, prove that electrons cannot exist in a nucleus.	CO1	L2
77. State and explain Heisenberg uncertainty principle. Discuss the significance of the principle.Prove that, using uncertainty principle, the electron emitted during β-decay is not the pre-existed electron in the nucleus	CO1	L3
78. Show that, a free electron cannot exist within the nucleus of an atom using the concept of beta decay process.	CO1	L3
79. Derive the expression for time independent Schrodinger's equation in one dimensional.	CO1	L2
80. What is the wave function? Give its physical significance and properties.	CO1	L2
81. Define expectation value.	CO1	L3
82. What is physical interpretation of wave function? Explain nature of eigen values and eigen functions.	CO1	L2
83. Define probability density, normalization of a wave function for particle by Max Born's approximation.	CO1	L2
84. Explain wave functions and probability densities for a particle in an infinite potential well for the first two states.	CO1	L3
85. Set up the time independent wave equation for a free particle in one dimension.	CO1	L2
86. Set up the time independent wave equation in one dimension.	CO1	L3
87. Obtain the solution of Schrödinger's time independent wave equation when applied to a potential box of infinite height.	CO1	L2
88. Explain the significance of zero point energy.	CO1	L2
89. Describe Zero potential energy. Solve the Schrödinger wave equation for the allowed energy levels in the case of particle in one dimensional potential well of infinite height.	CO1	L3
90. Find the eigen function and energy eigen values for a particle in a one dimensional potential well of infinite height.	CO1	L3

NUMERICAL:

91. Calculate the de Broglie wavelength associated with 0.5kg cricket ball at a speed of 120 km/hr.	CO1	L2
92. Calculate the wavelength associated with electrons whose speed is 0.01 part of the speed of light.	CO1	L3
93. Calculate the de Broglie wavelength of an electron moving with one tenth part of the velocity of light.	CO1	L2
94. Calculate the wavelength associated with an electron of energy 1.5 eV.	CO1	L3

95.	Calculate the wavelength associated with an electron raised through a potential difference of 2kV.	CO1	L2
96.	Calculate the de Broglie wavelength of a neutron moving with kinetic energy 54eV, given the mass of Neutron =1.675×10^{-27}kg.	CO1	L3
97.	Calculate the de Broglie wavelength associated with neutron of mass 1.675×10^{-27}kg with one tenth part of the velocity of light.		
98.	An electron has a wavelength of 1.66×10^{-10}m. Find the kinetic energy, Phase velocity, and group velocity of the de Broglie wave.	CO1	L3
99.	Calculate de Broglie wavelength of proton whose kinetic energy is equal to the rest mass energy of the electron. Mass of proton is 1836 times that of electron. **(GATE Question)**		
100.	Calculate the wavelength associated with an electron having K.E. 100 eV.	CO1	L2
101.	If an electron has a de Broglie wavelength of 2 nanometer, find its kinetic energy and group velocity, given that it has rest mass energy of 511 keV.	CO1	L3
102.	Green light has a wavelength of about 550 nm. Through what potential difference must an electron be accelerated to have this wavelength?	CO1	L3
103.	Compare the energy of a photon with that of an electron when both are associated with a wavelength 0.2nm.		
104.	A particle of mass 0.65 MeV/c^2 has free energy 120 eV. Find its de Broglie wavelength, c is the velocity of light.	CO1	L3
105.	A particle of mass 940 MeV/c^2 has kinetic energy 0.5keV. Find its de Broglie wavelength, c is the velocity of light. **(Gate Question)**	CO1	L2
106.	A pulsed laser emits photons of wavelength 820 nm with 22 mW average power/ pulse. Calculate the number of photons contained in each pulse, if the duration of the pulse is 12 ns.	CO1	L2
107.	A fast moving neutron is found to have an associated de Broglie wavelength of 2 x 10-12m. Find its kinetic energy and the phase and group velocities of the de Broglie waves ignoring the relativistic change in mass. (Given: mass of neutron =1.675×10^{-27} kg)	CO1	L2
108.	An electron has a speed of 4.8×10^5 m/s accurate to 0.012%. With what accuracy can be located the position of electron.		
109.	The natural uncertainty in the measurement of speed of an electron in an atom is estimated to be 2.2×10^4 m/s conceding ideal set-up and error-free measurement. Estimate the minimum width about which the electron stays confined in the atom.	CO1	L3
110.	A spectral line of wavelength 4000Å has a width of 8×10^{-5}Å. Evaluate the minimum time spent by the electrons in the upper energy state between the excitation and de-excitation processes. **(Gate Question)**	CO1	L3
111.	The velocity of an electron was measured to be 5×10^5 m/s with an uncertainty of 1%. What is the uncertainty involved in the measurement of its position.	CO1	L2
112.	An electron is confined to a box of length 10^{-8} m. Calculate the minimum uncertainty in the velocity and comment on the result.	CO1	L2
113.	An electron is bound in one dimensional potential well of width 0.18nm. Find the energy value in eV of the second excited state.	CO1	L2
114.	The speed of electron is measured to within uncertainty of 2.2×10^4 m/s in one dimension. What is the minimum width required to by the electron to be confined in an atom.	CO1	L3
115.	The position and momentum of an electron with energy 0.5 keV are determined. What is the minimum percentage in its momentum if the uncertainty in the measurement of position is 0.5 A^0.	CO1	L3
116.	The inherent uncertainty in the measurement of time spent by Iridum-191 nuclei in the excited state is found to be 1.4×10^{-10} s. Estimate the uncertainty that results in its energy in the excited state.	CO1	L3
117.	An electron is bound in one dimensional potential well of width 0.18 nm. Find its energy value in eV in the second excited state.		
118.	Compute the first 3 permitted energy values for an electron in a box of width 4 Å.	CO1	L3

119. An electron is bound in one dimensional infinite potential well of width 0.12 nm. Find the energy values in the ground state and also the first two excited states en eV. CO1 L2

120. Calculate the zero point energy for an electron in a box width 10Å. CO1 L2

121. An electron is bound in an one dimensional potential well of with 1Å, but of infinite height. Find the energy value for the electron in the ground state.

122. The first excited state energy of an electron in an infinite well is 240 eV. What will be its ground state energy when the width of the potential well is doubled? CO1 L2

123. Compare the energy of a photon with that of a neutron when both are associated with a wavelength of 0.25nm. CO1 L2

124. An electron is confined to a potential well of infinite height and width $5A^0$. Calculate the de-Broglie wavelength when the electron is (i) in ground state and (ii) 3^{rd} excited state **(Gate Question)**

125. Find the kinetic energy of an electron whose de Broglie wavelength is the same as that of a100keV X-ray. CO1 L2

MODULE – 02

ELECTRICAL PROPERTIES OF MATERIALS

126. Describe how Cooper pairs are formed and explain the salient features of superconductivity. CO1 L2

127. Describe how BCS theory explains superconductivity. CO1 L3

128. What is Meissner effect? CO1 L2

129. What is superconductivity? Explain superconductivity on the basis of BCS theory. CO1 L3

130. Describe the experiment to prove that 'a superconductor is a perfect diamagnet'. CO1 L2

131. Explain Meissner effect and Different types of superconductors. Illustrate with an example. CO1 L3

132. Explain the following:
   i) Critical magnetic field of a superconductor as a function of temperature. CO1 L2
   ii) Meissner effect.

133. Explain Matthiessen's rule and the temperature dependence of resistivity. CO1 L3

134. Distinguish between Type I and Type II superconductors. CO1 L2

135. Explain the different types of superconductors. CO1 L3

136. Define resistivity and mobility. CO1 L2

137. What are phonons? Give a brief account of how phonons are generated. CO1 L3

138. Give a brief account of high temperature superconductors. CO1 L2

139. Give a qualitative account of high temperature superconductivity. Mention any two uses of superconductivity? CO1 L3

140. Discuss the applications of superconductivity in Quantum Computing?

141. Define DC and AC Josephson effect. CO1 L2

142. Write short notes on Josephson junction. CO1 L3

143. Discuss the working of SQUIDs in brief. Mention a few of its applications. CO1 L2

144. What are dielectric materials? Give examples. CO1 L3

145. Define dielectric constant and polarization. Give the relation between them. CO1 L2

146. Define electric dipole and dipole moment. What are polar and non- polar dielectrics? CO1 L3

147. Write a note on the different types of polarization mechanism. CO1 L2

148. Define internal field in the case of solids. Give the expression for internal field in the case of solids in one dimension as well as three dimensions. CO1 L3

149. What is Lorentz field? What is the expression for it? CO1 L3

150. Derive the Clausius - Mossotti equation for a dielectric material.

NUMERICAL:

151. Calculate the Fermi velocity and the mean free path for the conduction electrons in silver, given that its Fermi energy is 5.5 eV and the relaxation time is 3.83×10^{-14}. CO1 L2

152. Calculate the mobility and the relaxation time of electrons in copper, if resistivity of copper is 1.73×10^{-8} ohm-m, atomic wt. is 63.5, density is 8.92 g/cc. CO1 L3

153. Calculate the conductivity of copper at 300K. The collision time for electron scattering is 2×10^{-14}s at this temperature. Given: Density and atomic weight is 23 and it has one conduction electron/atom). CO1 L3

154. The Fermi level in potassium is 2.1 eV. What are the energies for which the probabilities of occupancy at 300 K are 0.99, 0.01 and 0.5(Given 1J= 6.24×10^{18} eV) CO1 L3

155. The Fermi level in silver is 5.5 eV. Find the velocity of conduction electrons in silver. CO1 L2

156. Find the probability that an energy level at 0.2ev below Fermi level being occupied at temperature 300K and 1000K. CO1 L3

157. Find the temperature at which there is 1% probability that a state with energy 0.5 eV above Fermi energy is occupied. CO1 L2

158. What is the polarization produced in sodium chloride by an electric field of 600V/mm if it has a dielectric constant of 6?

159. If a NaCl crystal is subjected to an electric field of 1000V /m and the resulting polarization is 4.3×10^{-8} C/m^2, calculate the dielectric constant of NaCl. CO1 L3

160. The dielectric constant of Helium at 0ºC is 1.000074. The density of atoms is 2.7×10^{25}/m^3. Calculate the dipole moment induced in each atom when the gas is in an electric field of 3×10^4V/m. CO1 L3

161. A parallel plate capacitor consists of 2 plates each of area 5×10^{-4}m^2. They are separated by a distance 1.5×10^{-3}m and filled with a dielectric of relative permittivity 6. Calculate the charge on the capacitor if it is connected to a 100V D.C supply. CO1 L2

162. A parallel plate capacitor of area 650mm^2 and a plate separation of 4mm has a charge of 2×10^{-10}C on it. What is the resultant voltage across the capacitor when a material of dielectric constant 3.5 is introduced between the plates? CO1 L2

163. A parallel plate capacitor has an area of 7.45×10^{-4}m^2 and its plates are separated by a distance of 2.45×10^{-3} m across which a potential of 10V is applied. If a material with dielectric constant 6 is introduced between the plates, determine the capacitance, the charge stored in each plate, the dielectric displacement D and the polarization. CO1 L2

164. The dielectric constant of He gas at NTP is 1.0000684. Calculate the electronic polarizability of He atoms if the gas contains 2.7×10^{25}atoms/m^3 and hence evaluate the radius of the Helium atoms. CO1 L2

165. Find the polarization produced in a dielectric medium of relative permittivity 15 in presence of an electric field of 500V/m.

166. The dielectric constant of sulphur is 3.4. Assuming a cubic lattice for its structure, calculate the electronic polarizability of sulphur. Given, For sulphur , denstity=2.07gm/cc, and atomic weight = 32.07. CO1 L2

167. An elemental solid dielectric material has polarizability 7×10^{-40} Fm^2. Assuming the internal field to be Lorentz field. Calculate the dielectric constant for the material if the material has 3×10^{28} atoms/m^3 CO1 L2

MODULE – 04

Maxwell's Equations & EM Waves

168. State Coulomb's law. Express it in Vector form CO1 L2

169. State Gauss Law. Prove Gauss Divergence Theorem. CO1 L3

170. Mention Stoke’s Theorem	CO1	L2
171. Explain Biot –Savart’s Law and Faradays law	CO1	L3
172. Mention Maxwell’s equations for free space. 173. Obtain the expression for continuity equation	CO1	L2
174. Discuss modified Ampere’s law. **(GATE QUESTION)**	CO1	L3
175. Discuss the difference between Conduction current density and Displacement current density.	CO1	L2
176. Derive wave equation for Electric field.	CO1	L3
177. What are uniform plane waves? Mention the relation between Electric and Magnetic field for a plane wave.	CO1	L2
178. Show that electromagnetic waves are transverse in nature.	CO1	L3
179. Briefly explain the three types of Polarization. 180. Write Maxwell’s equations in differential form.	CO1	L2
181. Derive Maxwell’s electromagnetic wave equation for a non-conducting medium.	CO1	L3
182. Show that electrostatic field is equal to the negative of potential gradient and hence show that electrostatic field is conservative.	CO1	L2
183. What is the physical significance of divergence of of a vector field?	CO1	L2
184. Show that divergence of curl of a vector always vanishes. 185. What is Poynting vector and give its significance? State and prove Poynting vector theorem.	CO1	L3
186. Write differential form of Maxwell’s equations applicable in material medium.	CO1	L2
187. What do you mean by displacement current?	CO1	L3
188. What is the physical significance of gradient of a scalar field?	CO1	L2
189. What information does the quantity Poynting vector furnish?	CO1	L3
190. Derive differential form of ampere’s circuital law for (i) steady currents and (ii) varying currents. 191. Derive Maxwell’s electromagnetic wave equation for linear, isotropic and homogeneous medium. Hence prove that these waves can travel in vacuum.	CO1	L2
192. Using Maxwell’s equations prove that $\nabla \bullet \vec{J} = -\frac{\partial \rho}{\partial t}$	CO1	L2
193. What is the origin of displacement current density? 194. State and explain Ampere’s law and express it in differential form. Further explain how Maxwell modified this law to accept this as one of the Maxwell’s equations.	CO1	L3
195. Give one example for each of a solenoidal and irrotational vector field.	CO1	L3
196. Differentiate between steady current and static current.	CO1	L2
197. State Faraday’s laws of electromagnetic induction.	CO1	L3
198. Derive Maxwell’s electromagnetic wave equation and hence find the velocity of light in vacuum. 199. What do you understand by electromagnetic spectrum?	CO1	L2
200. . Define divergence of a vector field. Write its expression in terms of Cartesian coordinates and discuss its physical significance.	CO1	L3
201. Use Maxwell’s equations to deduce wave equations in terms of $\vec{E}$ & $\vec{H}$ field vectors for free space.	CO1	L3
202. What is the significance of divergence and curl of a vector?	CO1	L2
203. Write Maxwell’s equations and discuss their significance.	CO1	L3

204. Write the physical significance of gradient of a scalar function. | CO1 | L2

205. "Maxwell's equations are reformulation of existing laws." Comment and justify your answer. | CO1 | L3

206. What is the utility of Maxwell's equations in reference to electromagnetic waves? | CO1 | L2

207. Deduce Maxwell's equation Faraday's laws of electromagnetic induction. | CO1 | L3

208. What is modified Ampere's law? Discuss its significance in terms of Maxwell's theory and obtain an expression for displacement current density. | CO1 | L2

209. Curl of a vector field represents whirling/rotational features of the field. Justify. | CO1 | L3

210. Is displacement current like conduction current a source of magnetic field? | CO1 | L2

211. Show that isolated magnetic poles do not exist.

212. If a plane electromagnetic wave satisfies the equation $\frac{\partial^2 E_x}{\partial z^2} = c^2 \frac{\partial^2 E_x}{\partial t^2}$. Find the direction in which the wave propagates. **(GATE QUESTION)** | CO1 | L3

213. Show that velocity of plane electromagnetic waves in free space is given by $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ | CO1 | L2

NUMERICAL:

214. Determine the constant c such that the vector $\vec{A} = (x + ay)\hat{a}_x + (y + bz)\hat{a}_y + (x + cz)\hat{a}_z$ is solenoidal. | CO1 | L2

215. Compute the divergence and curl of the following vector fields: | CO1 | L3

(a) $\mathbf{E}(\mathbf{r}) = \frac{\mathbf{r}}{r^3}, \quad r = \sqrt{x^2 + y^2 + z^2} > 0$ (Coulomb electric field)

(b) $\mathbf{B}(\mathbf{r}) = \frac{y}{x^2+y^2}\mathbf{i} + \frac{x}{x^2+y^2}\mathbf{j}, \quad x^2 + y^2 > 0,$ (magnetic field outside a long wire)

(c) $\mathbf{A}(\mathbf{r}) = y\mathbf{i} + x\mathbf{j}$, (vector potential for a uniform magnetic field).

216. A common but erroneous claim, which stems from the notation r→**V** for the curl of a vector field **V**, is that the curl of a vector field **V** is everywhere orthogonal to **V**. Disprove this claim by exhibiting a counter-example. | CO1 | L3

217. Show that | CO1 | L2

(a) r→ (r*f*) = 0, where *f* is a function;
(b) r · (r→**V**) = 0, where **V** is a vector field;
(c) r→ (r→**V**) = r(r·**V**) r²**V**.

Hints: Work in Cartesian coordinates. To prove equality between vectors (in (a) and (c)) it is enough to show that the identities hold for one component, *e.g.*, the *x* component.

218. We derived the continuity equation for electric charge from the inhomogeneous Maxwell equations. Show that an analogous computation with the homogeneous Maxwell equations yields no new equations. | CO1 | L2

219. We used half the Maxwell equations to derive a wave equation for the magnetic field **B**. Using the other half of the equations, perform an analogous computation to derive a wave equation for **E**. | CO1 | L2

220. Suppose that $A\sin(\mathbf{k} \cdot \mathbf{r} + \beta t) = B\sin(\mathbf{k}_0 \cdot \mathbf{r} + \beta t)$ for all **r** and *t*. Show that $A = B$, $\alpha = \beta$, and $\mathbf{k} = \mathbf{k}_0$.

221. Show that **V** = *x***i** *z* **k** has vanishing divergence. Find a vector whose curl is **V**. Show that **W** = $xy^2 \cos z\,\mathbf{i} + x^2y \cos z\,\mathbf{j}$ $\frac{1}{2}x^2y^2 \sin z\,\mathbf{k}$ has vanishing curl. Find a function whose gradient is **W**. | CO1 | L2

222. Let *S* be a closed surface and let *C* be a closed curve. Prove that (a) H*S*(r→**V**) · *d***S** = 0, (b) H*C*r*f* · *d***l** =0. | CO1 | L2

223. Let *C* be a circle of unit radius in the *x-y* plane, enclosing the unit disk *D*, and let **V** = *y***i**. Compute (i) the line integral of **V** around *C* and (ii) the flux of r→ **V** through *D*. | CO1 | L2

Hint: You should find that**V** · *d***l** = Z (r→**V**) · *d***S**.

224. Find the electric flux through the surface of a sphere containing 15 protons and 10 electrons. Does the size of the sphere matter?	CO1	L2
225. What is the flux through any closed surface surrounding a charged sphere of radius a0 with volume charge density of $\rho = \rho_0(r/a_0)$, where r is the distance from the center of the sphere?	CO1	L3
226. A circular disk with surface charge density 2 x 10^{-10} C/m^2 is surrounded by a sphere with radius of one meter. If the flux through the sphere is 5.2 x 10^{-2} V-m, what is the diameter of the disk?	CO1	L3
227. A 10 cm x 10 cm flat plate is located 5 cm from a point charge of 10.8 C. What is the electric flux through the plate due to the point charge?	CO1	L2
228. A proton rests at the center of the rim of a hemispherical bowl of radius R. What is the electric flux through the surface of the bowl?	CO1	L2
229. Find the Dot product of vectors $\vec{A} = 3\hat{x} + 2\hat{z}$ and $\vec{B} = \hat{y}$. Comment on the result.	CO1	L2
230. Find the dot product of electric field vector $\vec{E} = 2x\ \hat{x} + 5y\hat{y}$ and magnetic field vector. Discuss the conclusion.	CO1	L3
231. Find the Cross product of vectors $\vec{C} = 3y\hat{x} - 4x\hat{y}$ and $\vec{D} = \hat{x}$.	CO1	L2
232. Find the divergence of vectors $\vec{D} = 2x^2\hat{x} + 5y - 6\hat{z}$	CO1	L3
233. If the Electric flux density vector is given by $\vec{D} = 5x\ \hat{x} + \hat{y} + 6z^2\hat{z}$, find the volume charge density.	CO1	L2
234. Find the divergence of magnetic field vector $\vec{B} = 2y^2\hat{x} + 5x\hat{y}$. Discuss the conclusion.	CO1	L3
235. Find the Curl of vector electric field vector $\vec{E} = 2x\ \hat{x} + 5y\hat{y}$. Discuss the conclusion	CO1	L2
236. The magnetic field vector is given by $\vec{H} = 2y\hat{x} + 5x\hat{y}$. Find the Current density. **(GATE QUESTION)**	CO1	L3

MODULE – 05

Semiconductors & Devices

237. Explain the conductivity of semiconducting materials	CO1	L3
238. What is Fermi level? Describe the variation of Fermi level in an intrinsic and extrinsic semiconductor.	CO1	L2
239. Derive the expression for electrical conductivity of an intrinsic semiconductor.	CO1	L3
240. Give the expression of charge carriers in an intrinsic semiconductor.	CO1	L2
241. What are the expressions for concentration of electrons and holes in an intrinsic semi-conductor? Obtain the expression for electrical conductivity of intrinsic semiconductor.	CO1	L3
242. Derive the relation between Fermi level and energy gap in an intrinsic semiconductor.	CO1	L2
243. Explain Hall Effect, Hall field and Hall voltage.	CO1	L3
244. What is Hall Coefficient? Obtain expression for Hall voltage in terms of Hall coefficient.	CO1	L2
245. Discuss about photodiode & phototransistor.	CO1	L3
246. Explain the construction and working of semiconductor laser.	CO1	L2
247. Explain in detail four probe method to determine resistivity of a semiconductor.	CO1	L3

NUMERICAL:

248. The intrinsic carrier density at room temperature in Ge is 2.37x10^{19} per m^3. If the electron and hole mobility are 0.38 and 0.18 m^2 V^{-1} s^{-1}, find the conductivity of the semiconductor.	CO1	L2
249. The band gap in germanium is 0.68 eV. Assuming that the number of electron hole pair is proportional to exp (E_g/2kT), find the percentage increase in the number of the charge carriers, when the temperature is increased from 300K to 320 K.	CO1	L2

250. The resistivity of intrinsic germanium semiconductor at 27^0 C is equal to 0.47 ohm-meter. Assuming electron and hole mobilities as 0.38 and 0.18 $m^2 V^{-1} s^{-1}$ respectively, calculate the intrinsic carrier density. CO1 L2

251. The effective mass for the electron in germanium is 0.55 m_0, where $m_0$is the free electron mass. Find the electron concentration in Germanium at 300 K, assuming that the Fermi level lies exactly in the middle of the energy gap, given that the energy gap for Germanium is 0.66 eV. CO1 L2

252. For germanium the energy gap is 0.7 eV in the intrinsic state. Evaluate for the ratio between its conductivity at 600 K and that at 300 K. CO1 L2

253. The conductivity and Hall coefficient of an n-type silicon specimen are 112/Ωm and $1.25x10^{-3}$ m^3/C respectively. Calculate the charge carrier density and electron mobility. CO1 L2

254. The Hall coefficient of –3.68 x 10^{-5} m^3/C. What is type of charge carriers? Also calculate the carrier concentration. CO1 L3

255. The Hall coefficient of silicon material was found to be $-7.35x10^{-5}$ m^3/C from 100 K to 400 K. Find the nature of semiconductor. If the conductivity was found to be 200 Sm^{-1}, calculate the density and mobility of the charge carriers.

256. A current of 10 mA flows through n type Ge semiconductor of 1 mm thick and 1 mm wide in a magnetic field. If the Hall voltage produced inside the semiconductor is mV, calculate the value of magnetic field. Given R_H=10^{-3} m^3/C. CO1 L3 CO1 L3

257. A silicon slab of thickness 1 mm, breadth 5 mm and length 10 cm is placed in a magnetic field of 0.4 Wb/m^2 acting perpendicular to its thickness . If 10^{-3} A current is passed through its length, calculate the Hall voltage produced if Hall coefficient is $3.66x10^{-4}$ m^3/C. CO1 L2

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