NITDGP/BTECH/Reg/Odd/2023-24

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-term Examination, 2023-24

Course Code: PHC01 Full Marks: 25

Course Name: ENGINEERING PHYSICS Time: 90 Minutes

Question Paper No.: Date of Exam: 18/10/2023

Group A

Instructions: Answer any FIVE questions **5x2=10**

Question No.	Body of the Question	Marks	Mapped CO
1.	Two tuning forks A and B of nearly equal frequencies are employed to obtain Lissajous figures, and it is observed that the figures go through a cycle of changes in 20 seconds. On slightly loading A with wax, the figures go through cycle in 10 seconds. If the frequency of B is 100Hz, what is the frequency of A before and after loading?	2	CO1
2.	Show that the amplitude of a weakly damped oscillator reduces to half of its initial value in time $t = \tau \ln 2$, where τ is the relaxation time.	2	CO1
3.	A simple harmonic oscillator is subjected to sinusoidal driving force where frequency is altered but amplitude kept constant. It is found that the amplitude of the oscillator increases from 0.04 mm at very low frequency to 16.0 mm at a frequency of 800Hz. Obtain the value of (a) quality factor, and (b) the relaxation time.	2	CO1
4.	Explain Huygens' principle of wave propagation of light.	2	CO3
5.	What are the conditions for sustained interference?	2	CO3
6.	In Newton's rings experiment the diameter of 15^{th} ring was found to be 0.59 cm and that of the 5^{th} ring was 0.336 cm. If the radius of the plano-convex lens is 100 cm, calculate the wavelength of light used.	2	CO3

Course Outcomes

CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.

Group B

Instructions: Answer any THREE questions

3x5=15

Question No.	Body of the Question	Marks	Mapped CO
7.	(a) What are Lissajous Figures? On what factors does the shape of Lissajous figure depend? (b) Find out the Lissajous figure traced out by a particle subjected to two perpendicular SHMs of unequal amplitudes, time periods in the ratio of 2:1 and phase differing by (a) zero and (c) $\pi/2$.	1+4	CO1
8.	(a) Establish the equation of motion of a damped harmonic oscillator subjected to a resistive force proportional to the first power of velocity. If the damping is less than critical, discuss the motion of the system. How does its amplitude vary with time. (b) Show that the quality factor is a measure of sharpness of resonance in case of a forced oscillator.	4+1	CO1
9.	(a) With schematic diagram explain Young's double slit experiment. (b) Show that the formation of interference fringes is in accordance with the law of conservation of energy. (c) A light of wavelength 510 nm from a narrow slit is incident on a double slit. The overall separation of 10 fringes is given as 2 cm, observed on a screen kept at 200 cm away from the plane of double slits. Calculate the separation between the slits.	2+1+2	CO3
10.	(a) Describe and explain the formation of Newton's rings in reflected monochromatic light. Write at least two applications of Newton's ring in real life for measuring physical parameters. (b) A thin uniform soap film (μ=1.33) seen by a light of wavelength 589 nm by normal reflection appears dark. Find the minimum thickness of the film.	3+2	CO3

Course Outcomes

CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: PHC331 Full Marks: 25

Course Name: Physics of Semiconductor Devices Time: 90 Minutes

Instructions: Answer **any five** questions.
Materials to be supplied: Addition paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
1	Explain the origin of band gap in terms of electron interference within a lattice.	5	CO1
2	(a) Draw the band diagram of a one-dimensional electron in a lattice with a lattice constant 'a'. Label your axes. (b) Mark the first and second Brillouin zones in the above diagram.	3+2	CO1
3	(a) Write down ideal diode equation and draw I-V characteristic of a p-n junction diode for both forward and reverse bias. (b) A silicon p-n junction diode operated at 27^0C. If the applied forward bias is increased, the current is doubled. Calculate the increment in the bias voltage ($\eta = 2$ for Si; $K_B = 1.380649\times10^{-23}$ J·K^{-1}; assume $I \gg I_s$). (c) What is drift and diffusion current for a p-n junction? Indicate their direction of flow.	2+2+1	CO2
4	(a) Sketch the variation of Fermi level with dopant concentration (both for acceptor N_a and doner N_d concentration) in silicon for two different non-zero temperatures, T_1 and T_2 (where $T_2 > T_1$). (Qualitative hand drawing). (b) Draw a p-n junction diode and comment on mention the charge densities and charge carrier densities in depletion region, n-side and p-side.	3+2	CO2
5	(a) Describe why some typical semiconductors are highly sensitive to temperature, visible light, dopants etc. (b) Sketch the energy band diagram of a p-n junction and label E_c, E_V and E_F, where the symbols have their usual meaning (Qualitative hand drawing). What is the intrinsic carrier concentration of a semiconductor at absolute zero temperature?	2.5+2.5	CO1+CO2
6	Derive the expression for depletion layer width of an unbiased p-n junction diode in terms of the build-in potential and carrier concentrations.	5	CO2

Course Outcomes
CO1: Describe the different electronic properties of semiconductor materials.
CO2: Understand the working principal of electronic devises (PN Diode, Photodetector, Solar cell, Light-Emitting Diodes, Laser Diodes, JFET, MOSFET, Tunnel Diode, Gunn Diode, IMPATT Diode, TRAPATT Diode and semiconductor memory).
CO3: Apply the knowledge of memory expansion to design required expanded memory for specific application.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: PHC332 Full Marks: 25

Course Name: Electromagnetic Field Theory Time: 90 Minutes

Instructions: Answer any 05 questions.

Question No.	Body of the Question	Marks	Mapped CO
1	(a) What do you mean by divergence of a vector field. What does it represent when it is positive, negative or zero. (b) State and prove Stoke's theorem. What is its physical significance?	2 3	CO1
2	(a) State Gauss's law in electrostatics. Using Gauss's law, calculate the electric field intensity due to a uniformly charged sphere at an internal point. (b) Show that the function $V = 4x^2 + 8y - 4z^2$ represents the potential function in a charge free region.	3 2	CO2
3	(a) If $\vec{u}$ and $\vec{v}$ are irrotational fields, show that the field $\vec{u} \times \vec{v}$ is solenoidal. (b) Prove that $\vec{\nabla} \times [\vec{r} \times (\vec{a} \times \vec{r})] = 3\vec{r} \times \vec{a}$, where, $\vec{a}$ is a constant vector and $\vec{r}$ is the position vector. (c) Derive Poisson's equation and Laplace's equation from Gauss's law of electrostatics.	1 2 2	CO1 CO1 CO2
4	(a) What is meant by the Poynting vector? Derive an expression for it. (b) Write Maxwell's equations and explain their physical significance.	2 3	CO2
5	(a) Derive Helmholtz's wave equation in Lossy dielectric medium. (b) A plane wave propagates through a lossy dielectric medium, write the expressions for attenuation constant, phase constant and propagation constant of the medium.	2 3	CO3
6	(a) If a plane wave propagates through free space, write the expressions for phase constant, wave velocity and intrinsic impedance of the medium. (b) Write the expression for loss tangent and loss angle of lossy dielectric medium.	3 2	CO3

Course Outcomes

CO1: Able to apply fundamental knowledge of different co-ordinate systems to describe the spatial variations of the physical quantities dealt in electromagnetic field theory.

CO2: Able to explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.).

CO3: Gain an integrative overview of electromagnetic waves, its propagation in different media and different phenomena related to electromagnetic wave propagation.

CO4: Acquire basic knowledge related to wave guides and transmission line.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Alt-Mid-Term Examination, 2023-24

Course Code: PHC333 Full Marks: 25

Course Name: Physics of Engineering Materials Time: 90 Minutes

Instructions: Answer **any five** questions.
Materials to be supplied: N/A

Question No.	Body of the Question	Marks	Mapped CO
1	Why has Drude not assumed that electrons directly acquire thermal energy from external heat source? What is the assumption behind steady-state approximation in heat conduction within Drude's model? Will there be a net flow of electrons from the hot side to the cold side during thermal conduction? explain your answer.	2+1+2	CO1
2	Derive the expression for electrical conductivity of a metal within Drude's model.	5	CO1
3	What are the two mistakes that Drude made in his model that exactly cancelled each other out and gave the correct expression proving Friedmann-Weiss law? Explain in your own words how those two mistakes are fixed within the Sommerfeld model.	2+3	CO1
4	Explain why quantum mechanical calculations in the Sommerfeld model are done in k-space, instead of in real space. Draw the energy-momentum (E-K) diagram and calculate the expression of effective mass.	3 + 2	CO1 CO2
5	Write down the Vegard's law for obtaining the lattice constant the of InAs doped with Phosphorous (P, x = 0.47) at the Arsenic (As) site of the parent crystal. Assume that you know the lattice parameters of InAs and InP materials. Also calculate the bandgap of the ternary compound after P doping using crystal approximation formula. Draw a typical (model) band structure of Si and GaAs crystals and explain how the band structure of Si differs from that of GaAs.	2+3	CO2
6	Derive the expression for the mobility of semiconductor materials. Draw the temperature dependent mobility curve of the semiconductor materials and explain the three different regions. A Si P-N junction has $N_a = 10^{17}/cm^3$ on the P-side and $N_d = 10^{16}/cm^3$ on the N-side. At 300 K, calculate the fermi levels and an equilibrium band diagram if the intrinsic carrier density of Si is $9.65\times10^9\ cm^{-3}$.	3 + 2	CO2

Course Outcomes
CO1: To understand fundamental theory of metal
CO2: To comprehend theory and device applications of semiconductor materials
CO3: To be familiar with fundamental of laser and its applications.
CO4: To know about the super conductivity, dielectric and mechanical properties of material

7	Derive the expression for the Hall voltage of p-type semiconductor and list out the uses of Hall measurement techniques. A needle shaped Ge crystal with 120 mm long, 2 mm wide and 0.1 mm thick has a magnetic density of 0.5 Wbm^{-2} applied from front to back perpendicular to largest faces. When a current of 200 mA flows through the needle, the hall voltage measured across its width is found to be 20μV. What is the Hall coefficient of Ge needle? What would happen to the result if the length of the needle is doubled.	3 + 2	CO2

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NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: PHC334
Course Name: Physics II

Full Marks: 25
Time: 90 Minutes

Instructions: Answer all the questions.
Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
1	Which one is the stronger force gravitation or electromagnetic force? Justify you answer with suitable example.	2	CO3
2	Derive Gauss's law in differential form	3	CO3
3	Find the electric field at a distance z above the midpoint of a straight-line segment charge of length 2L.	3	CO3
4	One of these is an impossible electrostatic field. Identify which one? (i) $\vec{E} = K[xy\hat{\imath} + 2yz\hat{\jmath} + 3xy\hat{k}]$; (ii) $\vec{E} = K[y^2\hat{\imath} + (2xy + z^2)\hat{\jmath} + 2yz\hat{k}]$ Here K is a constant with the appropriate unit. For Possible one finds find the potential using the origin as your reference point.	4	CO3
5	Graph the vector field defined by V (x,y) = -x**i** –y**j** with at least ten points.	3	CO2
6	Find **∇.(∇XA)** and **∇X(∇∅)** with physical meaning.	3	CO1
7	Let C be the boundary of the part of the plane x+y+2z = 2 in the first octant oriented counterclockwise as viewed from above. Let F(x, y, z) = $(x + y^2, y + z^2, z + x^2)$. Use Stokes' theorem to compute $\int_C F \cdot ds$.	4	CO2
8	Evaluate $\iint F.ds$ over the surface S of a cube bounded by x = 0, x = 1, y = 0, y =1, z = 0, z= 1. Where **F** = 8xz **i** – y^2 **j** + zx **k**.	3	CO2

Course Outcomes

CO1: Able to understand the principles of classical mechanics apply to solve classical problems related to solving Lagrange's and Hamilton's equations of motion.
CO2: Able to apply fundamental knowledge of different co-ordinate systems to describe the spatial variations of the physical quantities dealt in electromagnetic field theory.
CO3: Able to explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.).
CO4: Gain an integrative overview of electromagnetic waves, its propagation in different media and different phenomena related to electromagnetic wave propagation.