City College

Internal Examination 2020

Physics (Hons.) [1+ 1+ 1 System] Part 2

Paper: 3

Time: 2 Hours 30 Minutes; Full Marks: 50

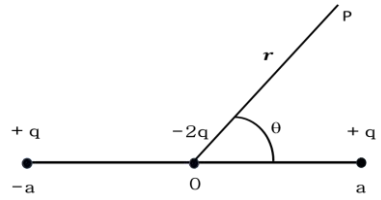
Answer any ten questions from the following: [5 × 10 = 50]

1. (a) Write the differential form of Gauss's law. Apply this law to calculate the electric field for a charge infinite plane.
   (b) Suppose the electric field in some region is found to be $\vec{E}(r) = k\, r^3\, \hat{r}$ in spherical coordinates (k is constants). Find the charge density.

   3+ 2

2. (a) What is an electric dipole?
   (b) Consider the charge distrubution along the x-axis as shown in figure. Show that the potential $[V(r, \theta)]$ due to charge distribution is 2+ 3

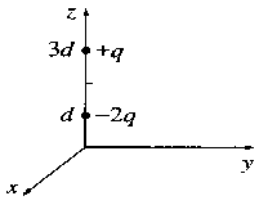
   $V(r, \theta) = \frac{qa^2}{4\pi\varepsilon_0 r^3}\left[3\cos^2\theta - 1\right]$



3. (a) State the boundary conditions prevailing at the interfaces of two dielectric in presence of charge density on the interfaces.
   (b) Assume that $z = 0$ plane is the interface between two linear and homogeneous dielectrics. The relative permittivities are $\varepsilon_r = 5$ for $z > 0$ and $\varepsilon_r = 4$ for $z < 0$. The electric field in the region $z > 0$ is $\bar{E} = (3\hat{\imath} - 5\hat{\jmath} + 4\hat{k})$. If there are no free charges on the interface, Find the electric field in the region $z < 0$.

   3+ 2

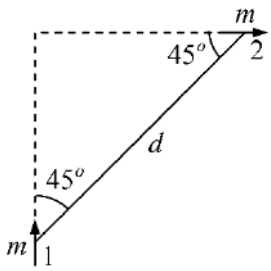
4. (a) Two identical point charges are separated by a distance $2d$ in air. An insulated uncharged conducting sphere of radius a is positioned midway between them. If $a << d$ prove that the introduction of the sphere reduces the force experienced by either point charge to $\left[1 - \left(24\frac{a^5}{d^5}\right)\right]$ its original value.
   (b) Find the force on the charge $+q$ in Figure. (The xy plane is a grounded conductor.) 3+ 2



5. State the Biot-Savart law. Obtain an expression for the magnetic field at a distance x alog the axis of a flat circular coil of radius a, carrying current I. What is the magnetic field at the centre of the coil?

   2+ 3

6. (a) Magnetic vector potential in some region is $\vec{A} = e^{-x}\sin y\ \hat{\imath} - (1+\cos y)e^{-x}\ \hat{\jmath}$. Find the magnetic induction.
(b) Two magnetic dipoles of magnitude m each are placed in a plane as shown in figure. Find the energy of interaction.



2+ 3

7. What is self-induction and mutual induction? Show that the equivalent induction of two coils of self-induction L_1, L_2 and mutual induction M connected in parallel is

$$L_{eq} = \frac{L_1L_2 - M^2}{L_1 + L_2 \pm 2M}$$

2+ 3

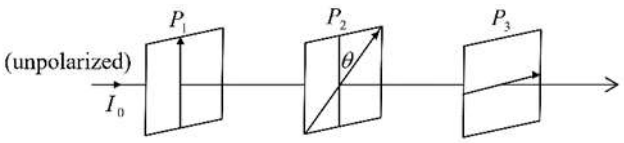
8. (a) Explain temporal and spatial coherence.
(b) In an interference pattern formed by two coherent sources, the maximum and minimum intensities are $9I_0$ and I_0 respectively. Find the intensities of the individual wave.

3+ 2

9. What is zone plate? Show that the radius of a particular zone is proportional to the square of the number of zone.

1+ 4

10. (a) Explain the phenomenon of double refraction in a uniaxial crystal by applying Huygens's theory.
(b) Consider three polarizers P_1, P_2 and P_3 placed along an axis as shown in the figure. The pass axis of P_1 and P_3 are at right angles to each other while the pass axis of P_2 makes an angle θ with that of P_1. A beam of unpolarized light of intensity I_0 is incident on P_1 as shown. Find the intensity of the light emerging from P_3. 3+ 2



11. (a) An amplifier with mid gain |A|= 400 has negative feedback |β|=0.02. If the upper cut off frequency without feedback was at 50kHz, then calculate its value with feedback.
(b) Derive an expression for frequency of the square wave generator by an OPAMP relaxation oscillator.

2+ 3

12. Deduce an expression for the voltage gain and phase difference for a lead lag network. How this network is used to design a Wein-bridge oscillator?

3+ 2

Answer scripts must be emailed to part2hcityphysics@gmail.com within 15 minutes of the end of the examination.