B. Sc. PHYSICS
SECOND SEMESTER
ELECTRICITY & MAGNETISM
BSP – 201 [REPEAT]

(Use Separate Answer Scripts for Objective & Descriptive)

Duration : 3 hrs. **Full Marks : 70**

[PART-A: Objective]

Time: 20 min. **Marks: 20**

Choose the correct answer from the following: ***1X20=20***

1. The potential for a point charge goes as (in spherical polar coordinates)
   a. $V \sim \frac{1}{r}$ b. $V \sim \frac{1}{r^2}$
   c. $V \sim \frac{1}{r^3}$ d. $V \sim \frac{1}{r^4}$

2. The flux of an electric field $\vec{E}$ through a surface S is given by
   a. $\Phi_E = \int_S \vec{E} \cdot d\vec{a}$ b. $\Phi_E = \int_S \vec{\nabla} \times \vec{E} \cdot d\vec{a}$
   c. $\Phi_E = \int_S (\vec{\nabla}\vec{E}) \cdot d\vec{a}$ d. None of these

3. For symmetrical objects, it is easier to find the electric field using the
   a. Coulomb's law b. Gauss's law
   c. Ohm's law d. Lenz's law

4. $\int_{-\infty}^{\infty} \delta(x)dx =$
   a. 1 b. 2
   c. 3 d. 4

5. For conductors, the charges located
   a. Inside the conductors b. On the surface
   c. Outside the conductors d. Nowhere

6. The energy per unit volume stored in the field is
   a. $\frac{\epsilon_0}{2}E^2$ b. $\epsilon_0 E^2$
   c. $3\frac{\epsilon_0}{2}E^2$ d. $2\epsilon_0 E^2$

7. The potential of a polarized object is the same as that produced by
   a. A volume charge density ρ_b plus a surface charge density σ_b. b. Only a volume charge density ρ_b
   c. Only a surface charge density σ_b. d. None of these

8. Laplace's equation reads as
   a. $\nabla^2 V = -\rho/\epsilon_0$ b. $\nabla^2 V = \rho/\epsilon_0$
   c. $\nabla V = 0$ d. $\nabla^2 V = 0$

9. For parallel LCR circuit, the current is
   a. Maximum at resonance
   b. Minimum at resonance
   c. Finite and constant throughout the frequency range
   d. Zero always

10. For a capacitor
   a. The current leads the voltage by $\frac{\pi}{2}$
   b. The current lags the voltage by $\frac{\pi}{2}$
   c. The current and voltage are in phase
   d. The current leads the voltage by π

11. The value of $\nabla \times B$ at a point outside the current loop is
   a. $\mu_0 J$
   b. $\frac{\mu_0 J}{2}$
   c. Zero
   d. Infinity

12. The magnetic vector potential is zero
   a. Never
   b. Always
   c. In free space
   d. In current carrying space

13. No force is exerted by a magnetic field on a charge
   a. Moving with constant velocity
   b. Moving in a circle
   c. At rest
   d. Moving along a curved path

14. An atom is paramagnetic if it has
   a. An electric dipole moment
   b. Zero electric dipole moment
   c. Zero magnetic moment
   d. A permanent magnetic moment

15. S.I. unit of magnetic susceptibility are
   a. A/m
   b. A/m^2
   c. Unit less
   d. Am^2

16. The equation $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ represents
   a. Gauss's law
   b. Coulomb's law
   c. Faraday's law
   d. Ampere's law

17. Mark the statement which is correct in all circumstances
   a. $\vec{\nabla} . \vec{B} = 0$
   b. $\vec{\nabla} \times \vec{B} = 0$
   c. $\vec{\nabla} . \vec{E} = 0$
   d. $\vec{\nabla} \times \vec{E} = 0$

18. The direction of induced e.m.f. in a circuit is given by
   a. Faraday's law
   b. Fleming left hand rule
   c. Lenz's law
   d. None of these

19. An electromagnetic field satisfies
   a. Gauss's law
   b. Faraday's law
   c. Ampere's law
   d. All of them

20. The displacement current is due to
   a. Variation of magnetic field
   b. Flow of steady current
   c. Variation of electric field
   d. Magnetic flux linked with the circuit

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PART-B : Descriptive

Time : 2 hrs. 40 min. **Marks : 50**

[Answer question no.1 & any four (4) from the rest]

1. a.Evaluate the following integrals: (i) $\int_0^5 \cos x\, \delta(x-\pi)dx$, (ii) $\int_\infty^a \delta(x-b)\, dx$. **2+3+5 =10**

   b. Deduce Faraday's law of electromagnetic induction in differential form.

2. a.Find the electric field (magnitude and direction) a distance z above the midpoint between two equal charges, q, a distance d apart. Check that your result is consistent with what you'd expect when $z \gg d$. **5+5=10**

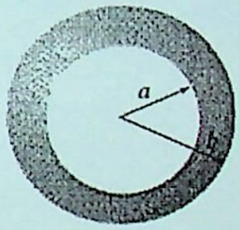
   b. Calculate the co-efficient of mutual induction between two coplanar concentric rings of radius R_1 and R_2 when current flows through the ring of R_1 and $R_1 \geq R_2$.

3. a.A hollow spherical shell carries charge density **2+3+2+3 =10**

$$\rho = \frac{k}{r^2}$$

   In the region $a \leq r \leq b$. Find the electric field in the three regions: (i) $r < a$, (ii) $a < r < b$, (iii) $r > b$.

   b. Plot $|E|$ as a function of r.



4. a. Find the energy of a uniformly charged spherical shell of total charge q and radius R. **5+5=10**

   b. If the electric field in some region is given (in spherical coordinates) by the expression

$$\vec{E} = \frac{A\hat{r} + B\sin\theta\cos\phi}{r},$$

   Where A and B are constants, what is the charge density?

$$\left[\text{Given: } \nabla\cdot\vec{V} \equiv \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 V_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\, V_\theta) + \frac{1}{r\sin\theta}\frac{\partial V_\phi}{\partial\phi}\right]$$

5. a. Draw a series LCR circuit. What is the impedance of the circuit? 4+6=10

b. A sphere of radius R carries a polarization

$$\boldsymbol{P}(\boldsymbol{r}) = k\boldsymbol{r}$$

Where k is a constant and $\boldsymbol{r}$ is the vector from the center.
Calculate the bound charges σ_b and ρ_b.

6. State and prove the reciprocity theorem. 2+8=10

7. Define magnetic susceptibility and permeability. Show that $\mu_r = 1 + \chi_m$. A sample of iron develops a magnetic moment of 8000 Am^2. If the area of cross-section of the sample of 16 sq. cm and its length is 5 cm. calculate 1+1+3+2 +1+1+1 =10

(i) Intensity of magnetization
(ii) Magnetic induction
(iii) Permeability and

Susceptibility of the sample when the magnetizing field intensity is $2\times10^7 Am^{-1}$

8. i. Find the magnetic field at the centre of a square carrying a current I in the clock-wise direction. 4+3+3 =10

ii. A wire shaped to regular hexagon of side $2cm$ carries a current of $2\ amp$. Find the magnetic induction at the centre of the hexagon.

ii. Two parallel straight wires are placed at $2cm$ an $6cm$ mark at right angles to the metre scale. The currents in them are $1A$ and $3A$ respectively. Find the mark at which they will produce zero magnetic field.

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