

KATHMANDU UNIVERSITY
End Semester Examination
August, 2018

Marks scored:

Level : B.Sc.

Year : III

Exam. Roll No. :

Time: 30 mins.

Course : PHYS 313

Semester: II

F. M. : 20

Registration No.:

Date **AUG 15 2018**

SECTION "A"

[20Q. × 1 = 20 marks]

Choose and tick the most appropriate answer.

1. A point charge $2C$ is placed at a distance 2cm from the centre of grounded conducting sphere of radius 4cm . The magnitude of image charge is
 [a] $2C$ [b] $4C$ [c] $6C$ [d] $8C$
2. The value of integral $\int_0^2 (x^3 + 3x + 2) \delta(1-x) dx$ is equal to
 [a] 2 [b] 4 [c] 6 [d] 8
3. The Laplacian of magnetic vector potential $\vec{A}(\vec{r})$ is equal to
 [a] $\mu_0 \vec{J}(\vec{r})$ [b] $\frac{\vec{J}(\vec{r})}{2\mu_0}$ [c] $-\mu_0 \vec{J}(\vec{r})$ [d] $-\frac{\vec{J}(\vec{r})}{2\mu_0}$
4. According to second uniqueness theorem, if ϕ_1 and ϕ_2 are the two solutions of Laplace equation then
 [a] $\phi_1 = \phi_2$ or $\phi_1 - \phi_2 = \text{constant}$ [b] $\phi_1 \neq \phi_2$ or $\phi_1 - \phi_2 \neq \text{constant}$
 [c] $\phi_1 = \phi_2$ and $\phi_1 - \phi_2 = \text{constant}$ [d] $\phi_1 \neq \phi_2$ and $\phi_1 - \phi_2 \neq \text{constant}$
5. Four point charges $-q, -q, q$ and q are located at $(a,0), (-a,0), (0,a)$ and $(0,-a)$ respectively. The net dipole moment of this charge distribution is
 [a] 0 [b] qa [c] $2qa$ [d] $4qa$
6. The attenuation constant α_g of the guide wall is defined as the ratio of power
 [a] loss per unit length to the power transmitted through the guide
 [b] transmitted per unit length to the power loss through the guide
 [c] loss per unit length to twice the power transmitted through the guide
 [d] transmitted per unit length to twice the power loss through the guide
7. The direction of magnetic field of a long straight wire carrying a current is
 [a] in the direction opposite to the current [b] in the direction of current
 [c] along the line circling the current [d] radially outward
8. Which of the following Maxwell's equations imply that there is no magnetic monopole?
 [a] $\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$ [b] $\nabla \cdot \vec{B} = 0$
 [c] $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ [d] $\nabla \times \vec{B} = \mu_0 \left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$

9. Which of the following statement is not correct for the electromagnetic waves in free space?
- [a] They travel with the speed of light
 [b] The field vectors \vec{E} and \vec{H} are in the same phase
 [c] The direction of energy flow is perpendicular to the direction of wave propagation
 [d] The electrostatic energy density is equal to magnetic energy density
10. For a vector potential \vec{A} , $\nabla \cdot \vec{A} = \frac{\mu_0 Q}{4\pi r^2}$, where Q is some constant. The corresponding scalar potential $\Phi(r,t)$ that makes \vec{A} and Φ Lorentz gauge invariant is
- [a] $\frac{1}{4\pi\epsilon_0} \frac{Q}{r}$ [b] $\frac{1}{4\pi\epsilon_0} \frac{Qt}{r}$ [c] $\frac{1}{4\pi\epsilon_0} \frac{Qt}{r^2}$ [d] $-\frac{1}{4\pi\epsilon_0} \frac{Qt}{r^2}$
11. If the constitutive relations $\vec{D} = \epsilon\vec{E}$, $\vec{B} = \mu\vec{H}$ and $\vec{J} = \sigma\vec{E}$ hold good then the medium is
- [a] isotropic and non-linear [b] isotropic and linear
 [c] anisotropic and linear [d] anisotropic and non-linear
12. Which of the following statement is true?
- [a] Newton's third law does not hold in electrostatics
 [b] Newton's third law does not hold in magnetostatics
 [c] Newton's third law does not hold in electrodynamics
 [d] Newton's third law hold in electrodynamics
13. The potential energy of an electrical dipole in the uniform electric field is U and the magnitude of torque acting on the dipole due to the field is τ . Then
- [a] U is minimum and τ is zero when the dipole is parallel to the field
 [b] U is zero and τ is zero when the dipole is perpendicular to the field
 [c] U is minimum and τ is maximum when the dipole is perpendicular to the field
 [d] U is minimum and τ is zero when the dipole is anti-parallel to the field
14. The skin depth or penetration depth for good conductor (where symbols carry their usual meaning) is
- [a] $\delta = \sqrt{\frac{\mu\sigma}{2\omega}}$ [b] $\delta = \sqrt{\frac{\sigma}{2\mu\omega}}$ [c] $\delta = \sqrt{\frac{2\mu}{\sigma\omega}}$ [d] $\delta = \sqrt{\frac{2}{\sigma\mu\omega}}$
15. If n_1 and n_2 are the indices of refractions, then Snell's law is expressed as
- [a] $\frac{\sin i}{\sin r} = \frac{n_1}{n_2}$ [b] $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$ [c] $\frac{\tan i}{\tan r} = \frac{n_1}{n_2}$ [d] $\frac{\tan i}{\tan r} = \frac{n_2}{n_1}$

Fill in the blanks with appropriate answer:

16. The surface charge density σ for the potential function $\phi = ax^2 + by^2$ in free space is given by.....
17. The magnetic vector potential in a region is given by $\vec{A} = -y\hat{i} + 2x\hat{j}$. The associated magnetic induction \vec{B} is
18. If the dimensions of rectangular waveguide are $0.1\text{m} \times 0.05\text{m}$ and the speed of wave is $3 \times 10^8 \text{m/s}$, then the cutoff frequency propagated in TE_{01} mode is
19. The unit of the vector $\frac{1}{\mu_0}(\vec{E} \times \vec{B})$ is.....
20. A plane electromagnetic wave is incident normally on the glass air interface ($n = 1.5$ and $n' = 1.0$). The reflection and transmission coefficients are

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SECTION "B"
[5Q. × 4 = 20 marks]

1. Show that the Green's second identity $\int_v (\psi \nabla^2 \phi - \phi \nabla^2 \psi) d\tau = \int_s \left(\psi \frac{\partial \phi}{\partial n} - \phi \frac{\partial \psi}{\partial n} \right) ds$, where ϕ and ψ are scalar functions.
2. Show that the magnetic dipole potential $\vec{A}_{dip}(\vec{r}) = \frac{\mu_0}{4\pi r^2} (\vec{m} \times \hat{r})$ by the concept of multipole expansion and hence magnetic moment $\vec{m} = I \vec{a}$.

OR

Find an expression for electric potential at any point due to the conducting sphere in a uniform electric field by the method of image.

3. Determine displacement current at $t = 0$ flowing between the two plates of capacitors of capacitance 10×10^{-10} F if the voltage across the capacitor is $0.1 \sin 100\pi t$.
4. Using Maxwell's equation's in material medium, establish the relations $\nabla^2 \vec{E} - \sigma \mu \frac{\partial \vec{E}}{\partial t} - \epsilon \mu \frac{\partial^2 \vec{E}}{\partial t^2} = 0$ and $\nabla^2 \vec{H} - \sigma \mu \frac{\partial \vec{H}}{\partial t} - \epsilon \mu \frac{\partial^2 \vec{H}}{\partial t^2} = 0$ in homogeneous linear media in which charge and current densities are zero.

OR

What is transmission line theory? With well labeled block diagram distinguish between two wire transmission line and co-axial transmission line.

5. Define gauge transformation and hence show that \vec{E} and \vec{B} exhibit gauge invariance.

SECTION "C"
[5Q. × 7 = 35 marks]

6. Use the method of electrical image to show that the total charge induced on an infinite grounded conducting plane at $z = 0$ is $-q$, when a point charge $+q$ is held at a distance d above the plane.
7. What is Maxwell's stress tensor? Show that the Maxwell's stress tensor in vacuum is $T_{\alpha\beta} = \epsilon_0 (E_\alpha E_\beta - \frac{1}{2} E^2 \delta_{\alpha\beta}) + \frac{1}{\mu_0} (B_\alpha B_\beta - \frac{1}{2} B^2 \delta_{\alpha\beta})$, where symbols carry their usual meanings.

OR

Starting from the equations of electric and magnetic vectors $(\vec{E}_o + \vec{E}_o'') \times \hat{n} = \vec{E}_o' \times \hat{n}$ and $(\vec{H} + \vec{H}'') \times \hat{n} = \vec{H}' \times \hat{n}$, derive Fresnel's equation for non-conducting media when electric field vector is parallel to the plane of incidence.

8. Find the solution of Laplace equation in spherical polar coordinates by the method of separation of variables.

9. What do you mean by waveguide? Obtain the solution of an electromagnetic wave propagating in a rectangular waveguide in TE mode along z-axis. Also show that the cut-off frequency in TE mode is

$$\omega_{nm} = \pi c \sqrt{\left(\frac{n}{a}\right)^2 + \left(\frac{m}{b}\right)^2},$$

where symbol carry their usual meanings.

10.(a) Find the magnetic vector potential and magnetic induction for a long current carrying wire.

(b) Show that the magnetic vector potential for two long straight wires carrying a same current I in opposite direction is given by

$$\vec{A} = \frac{\mu_o I}{2\pi} \log\left(\frac{R_2}{R_1}\right) \hat{n}.$$

OR

A sphere of radius R centered at origin carries a charge density $\rho(r, \theta) = \frac{kR}{r^2} (R - 2r) \sin \theta$, where k is constant and r and θ are the usual spherical coordinates. Find the approximate potential for points on the z-axis far from the sphere.