

KATHMANDU UNIVERSITY
End Semester Examination [C]
December, 2018

Marks Scored:

Level: B.E./B.Sc./B. Pharm./B. Tech.
Year : I

DEC 26 2018

Course : PHYS 102
Semester: II

Exam Roll No. :

Time: 30 mins.

F. M. : 15

Registration No.:

Date :

SECTION "A"
[15Q × 1 = 15 marks]

Choose and tick the most appropriate answer. The symbols, unless mentioned otherwise, have their usual meanings.

1. The divergence of the vector function $\vec{F} = xe^{-x}\hat{i} + y\hat{j} - xz\hat{k}$ is
 [a] $(x-1)(1+e^{-x})$ [b] $(1-x)(1+e^{-x})$ [c] $(1-x)(1-e^{-x})$ [d] $(1-x)(e^{-x}-1)$

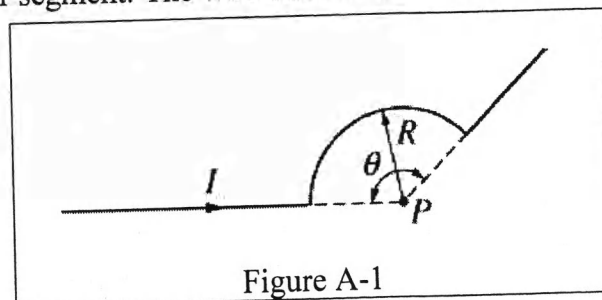
2. Which of the following equations is a consequence of the equation $\nabla \times \vec{H} = \vec{J}_f + \frac{\partial \vec{D}}{\partial t}$?
 [a] $\nabla \left(\vec{J}_f \cdot \frac{\partial \vec{D}}{\partial t} \right) = 0$ [b] $\nabla \times \left(\vec{J}_f + \frac{\partial \vec{D}}{\partial t} \right) = 0$
 [c] $\vec{J}_f + \frac{\partial \vec{D}}{\partial t} = 0$ [d] $\nabla \cdot \left(\vec{J}_f + \frac{\partial \vec{D}}{\partial t} \right) = 0$

3. A hollow metallic sphere of radius 0.1 m has 10^{-8} C of charge uniformly spread over it. The electric field intensity at point 7 cm away from the centre is
 [a] Zero [b] $\frac{90}{(0.07)^2}$ N/C [c] $\frac{90}{0.07}$ N/C [d] $\frac{90}{7^2}$ N/C

4. When a perfectly conducting sphere is placed in a uniform external electric field \vec{E}_0 , then
 [a] electric potential is zero everywhere inside the sphere.
 [b] electric potential is non-zero constant everywhere inside the sphere.
 [c] electric field is non-zero constant everywhere inside the sphere.
 [d] electric field at the centre is zero and increases as we move toward the surface.

5. The unit of atomic polarizability is
 [a] Farad per meter squared. [b] Farad per meter.
 [c] Coulomb meter squared per volt. [d] Coulomb meter squared per joule.

6. A segment of wire is bent into an arc of radius R and subtended angle θ , as shown in the Figure A-1. Point P is at the center of the circular segment. The wire carries current I . What is the magnitude of the magnetic field at P ?
 [a] $\frac{\mu_0 I \theta}{4\pi R}$ [b] $\frac{\mu_0 I \theta}{2\pi R}$
 [c] $\frac{\mu_0 I \theta}{4\pi R^2}$ [d] Zero



7. A charged particle is released from rest in a region where there is a constant electric field and a constant magnetic field. If the two fields are parallel to each other, the path of the particle is
 [a] circle [b] helix [c] cycloid [d] straight line

8. Three wire loops and an observer are positioned as shown in the Figure A-2. From the observer's point of view, a current I flows counterclockwise in the middle loop, which is moving towards the observer with a velocity v . Loops A and B are stationary. This same observer would notice that

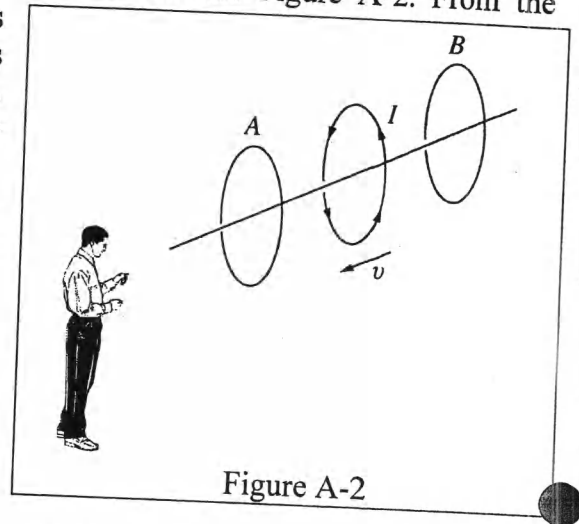


Figure A-2

- [a] clockwise currents are induced in loops A and B
 [b] counter clockwise currents are induced in loops A and B
 [c] a clockwise current is induced in loop A , but a counter clockwise current is induced in loop B
 [d] a counter clockwise current is induced in loop A , but a clockwise current is in loop B

9. Maxwell's equations can be written in the form shown below. If magnetic monopole exists, which of these equations will have to be changed?

I. $\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$

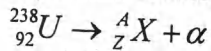
II. $\nabla \cdot \vec{B} = 0$

III. $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

IV. $\nabla \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$

- [a] I only [b] IV only [c] I and IV [d] II and III

10. What value of Z (atomic number) and A (mass number) result in the following alpha decay?



- [a] $Z = 92; A = 238$ [b] $Z = 90; A = 234$ [c] $Z = 93; A = 238$ [d] $Z = 88; A = 236$

Fill the following blanks with appropriate answers.

11. When a cube is inscribed in a sphere of radius r , the length L of a side of the cube is $L = \sqrt{\frac{4}{3}} r$. If a positive point charge Q is placed at the center of the spherical surface, the ratio of the electric flux Φ_{sphere} at the spherical surface to the flux Φ_{cube} at the surface of the cube is.....
12. Two long and straight conducting wires separated with distance d and each of carrying current I in opposite direction. The magnetic field at the point midway between the wires is
13. The dielectric constant of salt is 5.9. The ratio of bound charge and free charge in a unit volume of salt is
14. Domain formation is the necessary feature of
15. If a superconducting tin has a critical temperature of 3.7 K in zero magnetic field and a critical field of 0.0306 T at 0 K, then the critical field at 2 K is

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SECTION "B"
[5Q × 3 = 15 marks]

- Calculate the gradient and the Laplacian of the function $T = e^{-5x} \sin 4y \cos 3z$.
- How is potential difference between two points related to work? Show that electric field can be expressed as the negative gradient of electric potential.

OR

Using Gauss's law, find the electric field inside a sphere which carries the charge density proportional to the distance from the centre, $\rho = kr$, for some constant k .

- Define mutual inductance. Derive the Neumann formula for mutual inductance and hence give the statement of reciprocity theorem.

OR

Explain the term magnetic vector potential. Obtain an expression for it.

- Find the magnetic field on the axis of a tightly wound solenoid (helical coil) consisting of n turns per unit length wrapped around a cylindrical tube of radius ' a ' and carrying current I (Figure B-1) Express your answer in terms of θ_1 and θ_2 . Consider the turns to be essentially circular.

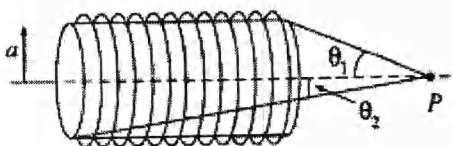


Figure B-1

- Find the energy stored in a section of length l of a long solenoid (radius R , current I , and n turns per unit length) and hence obtain the expression for energy density.

OR

Calculate the binding energy per nucleon (MeV/nucleon) for tritium, (${}^3_1\text{H}$) a radioactive isotope of hydrogen. Assume: $m_p = 1.007825$ u, $m_n = 1.008665$ u, $m_t = 3.01605$ u, $u = 1.66 \times 10^{-27}$ kg

SECTION "C"
[5Q × 5 = 25 marks]

- An **electric dipole** consists of two equal and opposite charges ($\pm q$) separated by a distance d . Find the approximate potential at points far from the dipole. Show that the electric field of a dipole in the coordinate-free form is given by

$$\vec{E}_{\text{dip}}(\vec{r}) = \frac{1}{4\pi\epsilon_0} \frac{1}{r^3} [3(\vec{p} \cdot \hat{r}) \hat{r} - \vec{p}]$$

OR

Find the electric field at the center of a cavity sphere in a uniformly polarized medium and hence establish the relation between polarizability and dielectric constant.

7. State and prove "work-energy theorem" of electrodynamics.
8. Define magnetic dipole and magnetic dipole moment. Derive the expressions for torque and energy of a magnetic dipole in terms of its dipole moment and uniform magnetic field in which it is placed.

OR

Sketch a typical hysteresis loop and explain. Show that hysteresis loss is equal to the area enclosed by B-H hysteresis loop.

9. Explain the Raman Effect with schematic diagram of experimental setup. Give the quantum mechanical explanation of Raman spectra with energy level diagram.
10. Find the electric field a distance z above the centre of a flat circular disk of radius R as shown in Figure C-1, which carries a uniform surface charge σ . What does your formula give in the limit $R \rightarrow \infty$? Also check the case $z \gg R$.

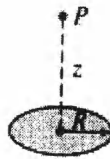


Figure C-1

OR

Three charges are situated at the corners of a square (side a), as shown in Figure C-2.

- (a) How much work does it take to bring in another charge, $+q$, from far away and place it in the fourth corner?
- (b) How much work does it take to assemble the whole configuration of four charges?

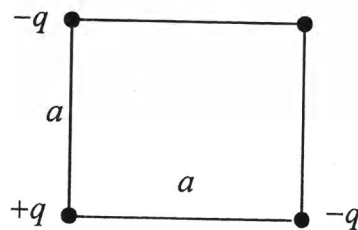


Figure C-2