

KATHMANDU UNIVERSITY  
End Semester Examination  
March/ April, 2017

Marks Scored:

Level : B.Sc.  
Year : I

Course : PHYS 102  
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 15

Registration No.:

Date : MAR 29 2017

SECTION "A"

[15Q × 1 = 15 marks]

Choose and tick the most appropriate answer.

- Which one of the following statements is NOT CORRECT?  
[a] The gradient  $\nabla T$  is a scalar.  
[b] The divergence  $\nabla \cdot \vec{v}$  is a scalar.  
[c] The curl  $\nabla \times \vec{v}$  is a vector.  
[d] The Laplacian of a vector  $\nabla^2 \vec{v}$  is a vector.
- In two vectors  $\vec{E} = -\nabla V$  and  $\vec{B} = \nabla \times \vec{A}$ ,  
[a] both  $\vec{E}$  and  $\vec{B}$  are solenoidal. [b] both  $\vec{E}$  and  $\vec{B}$  are irrotational.  
[c]  $\vec{E}$  is solenoidal and  $\vec{B}$  is irrotational. [d]  $\vec{E}$  is irrotational and  $\vec{B}$  is solenoidal.
- A charge of uniform volume density ( $40 \text{ nC/m}^3$ ) fills a cube with 8.0-cm edges. What is the total electric flux through the surface of this cube? [ $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 / \text{N} \cdot \text{m}^2$ ]  
[a]  $2.9 \text{ N} \cdot \text{m}^2/\text{C}$ . [b]  $2.0 \text{ N} \cdot \text{m}^2/\text{C}$ . [c]  $2.3 \text{ N} \cdot \text{m}^2/\text{C}$ . [d]  $1.8 \text{ N} \cdot \text{m}^2/\text{C}$ .
- Equipotentials are lines along which  
[a] the electric field is constant in magnitude and direction.  
[b] the electric charge is constant in magnitude and direction.  
[c] maximum work against electrical forces is required to move a charge at constant speed.  
[d] a charge may be moved at constant speed without work against electrical forces.
- The unit of atomic polarizability is  
[a] Farad meter squared. [b] Farad per meter squared.  
[c] Farad per meter. [d] Farad meter cubed.
- An electric dipole placed in a uniform electric field experiences;  
[a] both, a torque and a net force. [b] only a force but no torque.  
[c] only a torque but no net force. [d] no torque and no net force.
- The relative permittivity of ethylene glycol at room temperature is 37. The ratio of bound charge and free charge in a unit volume of ethylene glycol is  
[a]  $\frac{37}{38}$ . [b]  $\frac{36}{37}$ . [c]  $\frac{37}{36}$ . [d]  $\frac{36}{35}$ .
- A charged particle is circling in a magnetic field with cyclotron frequency  $f_0$ . If the speed of charge particle is doubled, the new cyclotron frequency will be  
[a]  $f_0$ . [b]  $2f_0$ . [c]  $4f_0$ . [d]  $\sqrt{2}f_0$ .

9. Figure A-1 shows two adjacent chunks of magnetized material, with a larger arrow on the one to the right suggesting greater magnetization at that point. On the surface where they join there is a net current in the x-direction, given by

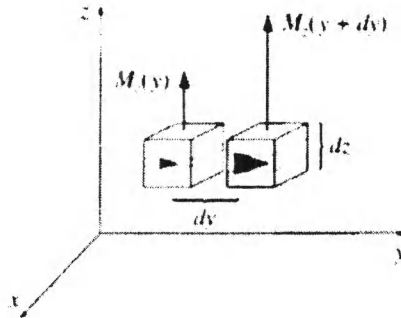


Figure A-1

- [a]  $I_x = \frac{\partial M_z}{\partial y} dy dz$     [b]  $I_x = \frac{\partial M_z}{\partial y}$     [c]  $I_x = \frac{\partial M_y}{\partial z} dy dz$     [d]  $I_x = \frac{\partial M_y}{\partial z}$
10. On the average, in a ferromagnetic domain permanent atomic magnetic moments are aligned \_\_\_\_\_ to one another.  
 [a] antiparallel.    [b] parallel.    [c] perpendicular.    [d] randomly relative.
11. The direction of induced emf is given by  
 [a] Fleming's left hand rule.    [b] Fleming's right hand rule.  
 [c] Lenz's law.    [d] Biot-Savart law.
12. A short solenoid (length  $l$  and radius  $a$ , with  $n_1$  turns per unit length) lies on the axis of a very long solenoid (radius  $b$ ,  $n_2$  turns per unit length) as shown in (Figure A-2). Current  $I$  flows in the short solenoid. What is the flux through the long solenoid?

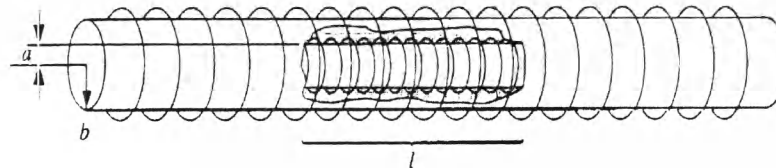


Figure A-2

- [a]  $\mu_0 \pi a^2 n_2 I$     [b]  $\mu_0 \pi b^2 n_1 n_2 I$     [c]  $\mu_0 \pi a^2 n_1 n_2 I$     [d]  $\mu_0 \pi a^2 n_1 n_2 l$
13. The speed of light is given by the value of  
 [a]  $\sqrt{\epsilon_0 \mu_0}$     [b]  $\epsilon_0 \mu_0$     [c]  $\frac{1}{\epsilon_0 \mu_0}$     [d]  $\frac{1}{\sqrt{\epsilon_0 \mu_0}}$
14. Find the unknown atomic number and mass number respectively, for the following reaction
- $$n + {}^{235}_{92}\text{U} \rightarrow {}^A_Z\text{X} + {}^{94}_{38}\text{Sr} + 2n$$
- [a] 140,54    [b] 54,140    [c] 141,53    [d] 54,141
15. Release of energy from sun is due to  
 [a] nuclear fission.    [b] nuclear fusion.    [c] burning of gases.    [d] chemical reaction.

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SECTION "B"  
[5Q × 3 = 15 marks]

- Calculate the gradient and Laplacian of the function  $T = e^{-5x} \sin 4y \cos 3z$ .
- Find the field outside a uniformly charged solid sphere of radius  $R$  and total charge  $q$ .  
OR  
Derive an expression for the curl of a vector field in Cartesian co-ordinates.
- Show that when a magnetic field is applied on a diamagnetic substance, the change in the dipole moment of an orbiting electron is given by  $\Delta \vec{m} = -\frac{e^2 r^2}{4m_e} \vec{B}$ , where the symbols have their usual meanings.
- Explain the term magnetic vector potential. Obtain an expression for it.  
OR  
What do you mean by the term 'Motional emf'? Obtain the flux rule for motional emf.
- Find the electric field (magnitude and direction) a distance  $z$  above the midpoint between two equal charges,  $q$ , a distance  $d$  apart (Figure B-1). Check that your result is consistent with what you'd expect when  $z \gg d$ .

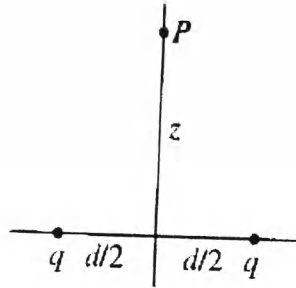


Figure B-1

OR

Find the potential inside the spherical shell of radius  $R$  (Figure B-2), which carries a uniform surface charge  $\sigma$ .

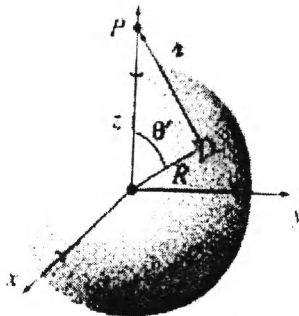


Figure B-2

SECTION "C"  
[5Q × 5 = 25 marks]

6. Obtain an expression for potential energy of the configuration of three charges and generalize the result for a system of  $n$  point charges. Also, show that the energy density stored in an electrostatic field is given by  $U = \frac{\epsilon_0}{2} E^2$ .
7. A (physical) **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 (pure) dipole 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

A spherical cavity is made inside a dielectric medium of uniform polarization  $\vec{P}$ . Show that the electric field at the center of the cavity due to the bound charge on the cavity surface is  $\frac{\vec{P}}{3\epsilon_0}$  and hence establish the Clausius-Mossotti relation.

8. Define Poynting vector. Deduce theoretically Poynting's Theorem for the flow of energy in an electromagnetic field.
9. Define half-life ( $T_{1/2}$ ) of a radioactive substance and show that  $T_{1/2} = \frac{0.693}{\lambda}$ , where  $\lambda$  is the decay constant. How long does it take for 60% of a sample of radon to decay? Half-life of radon is 3.8 days.

OR

What is superconductivity? Define and explain the Meissner effect in superconductors. Also, describe the effect of magnetic field on superconductors.

10. Find the magnetic field at point  $P$  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 C-1) Express your answer in terms of  $\theta_1$  and  $\theta_2$ . What is the field on the axis of an *infinite* solenoid (infinite in both directions)?

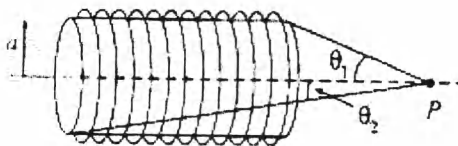


Figure C-1

OR

A long coaxial cable carries current  $I$  (the current flows down the surface of the inner cylinder, radius  $a$ , and back along the outer cylinder, radius  $b$ ) as shown in Figure C-2. Find the magnetic energy stored in a section of length  $l$ .

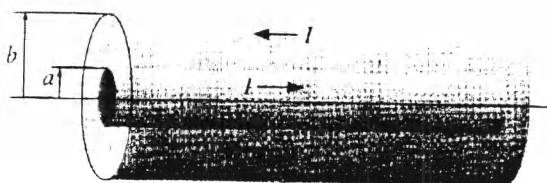


Figure C-2