**PHY102 Final Examination**

**Full marks : 100** **Time 180 mins**

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General Instructions: (a) Keep your answer book neat and clean. (b) Your handwriting should be clear and readable.

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**Name** ________________________________ **Roll No.** ________________

# Part A

Total marks : 60

Instruction for part A

1. There are 4 options for each question. You have to choose the correct one. You can find boxes for each option. You have to block the correct box with a **pencil**. For example:

(i) Bhopal is the capital of

(a) Uganda ☐

(b) Honolulu ☐

(c) Madhya Pradesh ■

(d) Uttar Pradesh ☐

Do it on the question paper. Do not write your option (for part one) on the answer book.

2. For part one, rough work is compulsory (if required). Do your rough work very clearly to get credit. Do your rough work on the answer book. Once you get the answer, block the corresponding option on the question paper.

3. Do not do your rough work on the question paper.

4. **Do remember to staple your question paper (Part A) with the answer book.**

5. Write your name and roll number on every page of the question paper.

6. There are total 20 questions in part A, each question carrying 3 marks.

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1. Divergence of magnetic field is always zero because,
   (a) there exists no magnetic monopole ☐
   (b) magnetic force does not work ☐
   (c) magnetic field follows inverse square law ☐
   (d) $\vec{\nabla} \times \vec{E} = 0$ ☐

2. What gives rise to diverging electric fields?
   (a) Magnetic monopoles ☐
   (b) steady current ☐
   (c) time dependent magnetic field ☐
   (d) electric charges ☐

3. If $\epsilon$ is permitivity and $\mu$ is permeability then the unit of $\frac{1}{\sqrt{\mu\epsilon}}$ in S.I. system is given by,
   (a) $\frac{s}{m}$ ☐
   (b) $\frac{Kg.m}{s^2}$ ☐
   (c) $\frac{m}{s}$ ☐
   (d) $m.s$ ☐

4. For a vector $\vec{A}$ the magnitude of $(A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k})/(A_x^2 + A_y^2 + A_z^2)^{1/2}$ is
   (a) greater than ☐
   (b) equal to ☐
   (c) less that ☐
   (d) unrelated to ☐
   $(A_r\hat{r} + A_\theta\hat{\theta} + A_\phi\hat{\phi})/(A_r^2 + A_\theta^2 + A_\phi^2)^{1/2}$.

5. Two identical metal plates are given positive charges $Q_1$ and $Q_2$ ($Q_2 < Q_1$) respectively. Now if they are brought together to form a parallel plate capacitor of capacitance $C$, the potential difference between them is
   (a) $(Q_1 + Q_2)/C$ ☐
   (b) $(Q_1 - Q_2)/2C$ ☐
   (c) $(Q_1 - Q_2)/C$ ☐
   (d) $(Q_1 + Q_2)/2C$ ☐

6. Figure 1 shows cross-section of three cylinders (black section), all having total charge $Q$. The Gaussian surfaces (shown by the dotted lines) are of equal radius $r$. The magnitude of electric field on the Gaussian surface will be

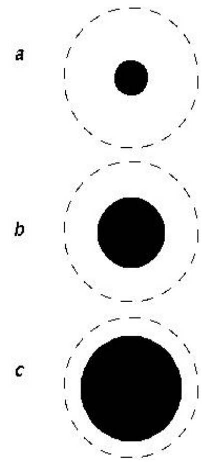


Fig. 1

(a) strongest in case c ☐
(b) strongest in case b ☐
(c) strongest in case a ☐
(d) equal in all cases ☐

7. A circular loop of radius $r$ carrying current $i_0$ in counter clockwise direction is placed in a magnetic field $\vec{B}$ pointing outwards to the plane of the conductor. The force on point P due to small length $dl$ of the coil will be
(a) radially outwards ☐
(b) radially inwards ☐
(c) tangential at P ☐
(d) parallel to $\vec{B}$ ☐

8. For which of the following parameter variation, the capacitance of the capacitor remains unaffected ?
(a) Distance between plates ☐
(b) Area of the plates ☐
(c) Nature of dielectric ☐
(d) Thickness of the plates ☐

9. In general, linear dielectric materials tend to do what to the electric fields penetrating them?
   (a) Nothing ☐
   (b) Twist them ☐
   (c) Strengthen them ☐
   (d) Weaken them ☐

10. In electrodynamics, what can give rise to a curling magnetic field $\vec{B}$?
   (a) Curling electric field ☐
   (b) Only a free current density $\vec{J}$ ☐
   (c) Both free current density $\vec{J}$ and a time-varying electric field $\vec{E}$ ☐
   (d) Stationary electric charges ☐

11. Why is the continuity equation for charges and currents not listed with Maxwell's equations?
   (a) It is not a universal law. It only holds true in certain cases ☐
   (b) It is already contained implicitly in Maxwell's equations ☐
   (c) It cannot be proven rigorously ☐
   (d) Maxwell had a personal distaste for the equation and relegated it to the appendix ☐

12. What must be used in addition to Maxwell's equation to predict the motion of a charged particle q in the presence of other electrical charges and currents?
   (a) Nothing else ☐
   (b) The Lorentz force law and Newton's law ☐
   (c) Only the Lorentz force law ☐
   (d) Only Newton's law ☐

13. A permanent bar magnet is in the shape of a long cylindrical rod and contains a constant, uniform magnetization that points along the cylinder's axis. Where is the bound (magnetization) current $\vec{J}_b$ found?
   (a) Flowing around the round sides of the cylindrical rod ☐
   (b) Flowing in little circles on the flat top and bottom ends of the cylindrical rod ☐
   (c) Flowing in little circles everywhere inside the rod ☐
   (d) There are no currents ☐

14. If an electron and a proton enter into a magnetic field perpendicularly with the same momentum.
    (a) The electron will be deflected more ☐
    (b) The proton will be deflected more ☐
    (c) Both particles will be deflected equally ☐
    (d) They will not be deflected at all ☐

15. When the north pole of bar magnet approaches the face of a closed coil the face becomes
    (a) south pole ☐
    (b) north pole ☐
    (c) no effect is observed ☐
    (d) first north and then south pole ☐

16. Four equal charges each equals to $-Q$ are placed at the four corners of square and a charge $q$ at its centre. If the system is in equilibrium the value of $q$ is
    (a) $-\frac{Q}{4}(1+2\sqrt{2})$ ☐
    (b) $\frac{Q}{4}(1+2\sqrt{2})$ ☐
    (c) $\frac{Q}{2}(1+2\sqrt{2})$ ☐
    (d) $-\frac{Q}{2}(1+2\sqrt{2})$ ☐

17. A thin spherical conducting shell of radius $R$ has charge $q$. Another charge $Q$ is placed at the centre of the shell. The electrostatic potential at a point P at a distance $R/2$ from the centre of the shell is
    (a) $\frac{2Q}{4\pi\epsilon_0 R}$ ☐
    (b) $\frac{(Q+q)^2}{4\pi\epsilon_0 R}$ ☐
    (c) $\frac{2Q}{4\pi\epsilon_0 R} - \frac{q}{4\pi\epsilon_0 R}$ ☐
    (c) $\frac{2Q}{4\pi\epsilon_0 R} + \frac{q}{4\pi\epsilon_0 R}$ ☐

18. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of the coil is B. It is then bent into a circular loop of n turns. The magnetic field at the centre of the coil will be
    (a) $nB$ ☐
    (b) $n^2B$ ☐
    (c) $2nB$ ☐
    (d) $2n^2B$ ☐

19. An elliptical cavity is carved within a perfect conductor. A positive charge $q$ is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in the figure. Then

(a) electric field near A in the cavity = electric field near B in the cavity ☐
(b) charge density at A = charge density at B ☐
(c) potential at A = potential at B ☐
(d) total electric flux through the surface of the cavity is zero ☐

20. A uniform but time varying magnetic field $B(t)$ exists in a circular region of radius $a$ and directed into the plane of the paper as shown in the figure. The magnitude of the electric field at a distance $r$ from the centre of the circular region

(a) is zero ☐
(b) decreases as $\frac{1}{r}$ ☐
(c) increases as $r$ ☐
(d) independent of $r$ ☐

# Part B

Total marks : 40

General Instructions: (a) Attempt all the questions. (b) Keep your answer book neat and clean. (c) Your handwriting should be clear and readable.

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1. A polygone of $n$ sides, each side having length $L$, carrying a uniform anti clockwise current $I$. Find the magnetic field $\vec{B}$ at the centre of the polygone. What happens when you take $L \to 0$, $n \to \infty$ keeping $nL = 2\pi R$, where $R$ is finite. **[20 points]**

2. A thick spherical shell (inner radius $a$ and outer radius $b$) is made of dielectric material of susceptibility $\chi_e$ with a "frozen-in" polarization

$$\vec{P}(\vec{r}) = -\frac{k}{r^2}\hat{r}$$

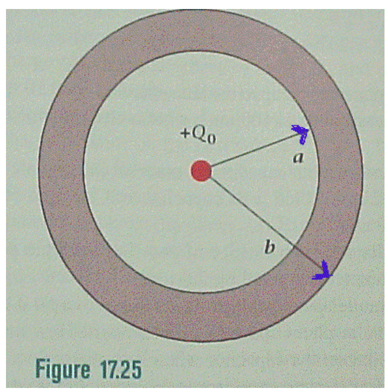


Fig. 3

where $k$ is the constant and $r$ is the distance from the center. There is a charge $Q_0$ at the centre of the shell. Find electric field in all three regions. **[20 points]**