CLASS TEST 2019

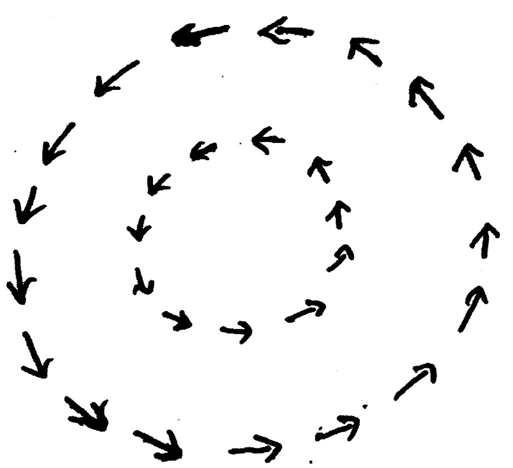
SOLUTIONS

Class Test Questions

1. If $\vec{r}_1 = 2\vec{e}_x - \vec{e}_y + 3\vec{e}_z$ and $\vec{r}_2 = \vec{e}_x + \vec{e}_y + \vec{e}_z$, then $|\vec{r}_2 - \vec{r}_1|$ is equal to:
   A. $\vec{e}_x - 2\vec{e}_y + 2\vec{e}_z$
   (B.) $\sqrt{9}$
   C. 9
   D. -4

2. Consider the vector field $\vec{A}(\vec{r}) = (x^2 - y)\,\vec{e}_x + (y^3 + z)\,\vec{e}_y + (x - y - z)\,\vec{e}_z$. Then $\vec{\nabla} \cdot \vec{A}(\vec{r})$ is equal to:
   A. $2x\,\vec{e}_x + 3y^2\,\vec{e}_y - \vec{e}_z$
   B. $-6xy^2$
   C. $-2\,\vec{e}_x - \vec{e}_y + \vec{e}_z$
   (D.) $2x + 3y^2 - 1$

3. Consider the vector field $\vec{A}(\vec{r})$ depicted below:



   Which of the following statements is CORRECT:
   A. $\vec{\nabla} \cdot \vec{A}(\vec{r}) = 0$ and $\vec{\nabla} \times \vec{A}(\vec{r}) = 0$
   B. $\vec{\nabla} \cdot \vec{A}(\vec{r}) \neq 0$ and $\vec{\nabla} \times \vec{A}(\vec{r}) = 0$
   (C.) $\vec{\nabla} \cdot \vec{A}(\vec{r}) = 0$ and $\vec{\nabla} \times \vec{A}(\vec{r}) \neq 0$
   D. $\vec{\nabla} \cdot \vec{A}(\vec{r}) \neq 0$ and $\vec{\nabla} \times \vec{A}(\vec{r}) \neq 0$

4. Which of the following statements is CORRECT:

A. The potential energy of a point charge does not change when it is moved in the direction of an electric field line.

B. The potential energy of a point charge does not change when it is moved in a direction perpendicular to an electric field line.

C. Work is done in moving a point charge in a direction perpendicular to an electric field line.

D. Work is done in moving a point charge along an equipotential surface.

5. A charge $+2q$ is located at the origin, and a charge $-q$ is located at the point with Cartesian coordinates $(0, 0, 1)$ i.e. at the point on the z axis with $z = 1$. The electric potential at the point on the z axis with Cartesian coordinates $(0, 0, 2)$ is:

A. 0

B. $\frac{2q}{4\pi\epsilon_0}$

C. $\frac{-q}{8\pi\epsilon_0}$

D. $\frac{q}{2\pi\epsilon_0}$

6. A charge $+2q$ is located at the origin, and a charge $-q$ is located at the point with Cartesian coordinates $(0, 0, 1)$ i.e. at the point on the z axis with $z = 1$. The electric field at the point on the z axis with Cartesian coordinates $(0, 0, 2)$ is:

A. $-\frac{q}{8\pi\epsilon_0}$

B. $\frac{3q}{8\pi\epsilon_0}\vec{e}_z$

C. $-\frac{q}{8\pi\epsilon_0}\vec{e}_z$

D. $+\frac{q}{8\pi\epsilon_0}\vec{e}_z$

7. Electrostatics is described by the Maxwell equations $\vec{\nabla} \times \vec{E}(\vec{r}) = 0$, $\vec{\nabla} \cdot \vec{E}(\vec{r}) = \frac{\rho(\vec{r})}{\epsilon_0}$, where $\rho(\vec{r})$ is the charge density. Which of the following statements is NOT CORRECT:

A. The flux of the electric field through a closed surface is determined by the charge density in the interior of the closed surface.

B. The electric field has no circulation around any closed curve.

C. The divergence of the electric field $\vec{\nabla} \cdot \vec{E}(\vec{r})$ is related to the flux of the electric field through a closed surface.

D. The electric field vanishes at points $\vec{r}$ at which the charge density $\rho(\vec{r})$ vanishes.

8. An electric dipole consists of a pair of point charges, with charges $+q$ and $-q$, separated by a distance d. Consider a closed surface S that contains the electric dipole. The flux of the electric field through the surface S is:

A. $\frac{qd}{4\pi\epsilon_0 r^2}$

B. $\frac{qd}{\epsilon_0 r}$

C. 0

D. $\frac{qd}{\epsilon_0}\vec{e}_r$

9. Consider a capacitor consisting of two parallel plates, with charges per unit area $+\sigma$ and $-\sigma$. The electric field between the plates points from the positively charged plate to the negatively charged plate and has a constant magnitude $|\vec{E}| = \frac{\sigma}{\epsilon_0}$. If the plates are separated by a distance d, the work done in moving a point charge q from the negatively charged plate to the positively charged plate is:

A. $\frac{qd}{\epsilon_0}$
B. $\frac{q\sigma d}{\epsilon_0}$
C. $\frac{\sigma}{\epsilon_0}$
D. 0

10. Consider a spherical metal surface (hollow inside) of radius R which is electrically charged with a uniform charge per unit area of σ. Due to the symmetry of the charge distribution, the electric field outside of the sphere (if it is nonzero) can only point in the radial direction (either inwards or outwards), and the magnitude of the electric field can only depend on the distance r from the centre of the sphere. Choose an appropriate Gaussian surface to determine the magnitude of the electric field $E(r)$ by applying Gauss's law:
(flux of the electric field through the surface) $= \frac{1}{\epsilon_0} \times$ (charge enclosed by the surface).
The magnitude $E(r)$ of the electric field for $r > R$ is:

A. $\frac{\sigma}{\epsilon_0}\frac{R^2}{r^2}$
B. $\frac{\sigma}{\epsilon_0}$
C. 0
D. $\frac{\sigma}{\epsilon_0}\frac{\frac{4}{3}\pi R^3}{r^2}$