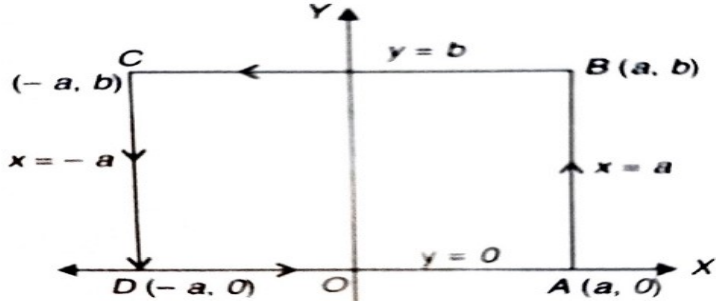
B.Tech. Semester I (2024-25)

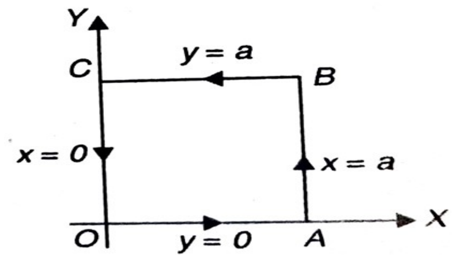
ENGINEERING PHYSICS (I) ASB-101

Unit 2- ELECTROSTATICS

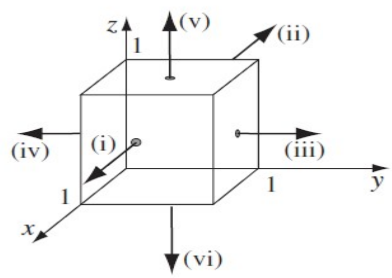
1) Convert points P (1, 3, 5) from Cartesian to cylindrical and spherical coordinates.
2) Express $f = 3y\,\hat{\imath} + x^2\,\hat{\imath} - x^2\,\hat{k}$ in terms of cylindrical polar co-ordinates.
3) Given point P (-2, 6, 3) and vector$\vec{A} = y\,\hat{x} + (x+z)\hat{y}$, express. Evaluate $\vec{A}$ at P in the Cartesian, cylindrical, and spherical systems
4) Express the following vector in Cartesian coordinate system:
$$\vec{A} = \rho z sin\,\varphi\,\hat{\rho} + 3\rho\cos\rho\,\hat{\varphi} + \rho\cos\varphi\,\hat{z}$$
5) If $\phi = 3x^2y - y^3z^2$; find grad ϕ at point$(1,-2,-1)$.
6) If $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, is the position vector of any point, calculate the gradient of $\frac{1}{r}$.
7) Given a vector $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$. Evaluate $\vec{\nabla}.\left(\frac{\vec{r}}{r^n}\right)$
8) If $\vec{v} = \frac{\boldsymbol{x\hat{\imath}+y\hat{\jmath}+z\hat{k}}}{\sqrt{\boldsymbol{x^2+y^2+z^2}}}$, find the divergence given vector.
9) Determine the constant b so that the vector field $\vec{A} = x^2\,\hat{\imath} + (y-2xy)\hat{\jmath} + (x+bz)\hat{k}$ is solenoidal.
10) Prove that $y^2 - z^2 + 3yz - 2x)\,\hat{\imath} + (3xz + 2xy)\hat{\jmath} + (3xy - 2xz + 2z)\hat{k}$ is both solenoidal and irrotational.
11) If a vector field given by $\vec{A} = y^2\hat{\imath} + 2xy\hat{\jmath} - z^2\hat{k}$, is conservative field?. If so find the scalar potential φ such that$\vec{A} = \nabla\varphi$.
12) Find the divergence and curl of $\vec{v} = (xyz)\hat{\imath} + (3x^2y)\hat{\jmath} + (xz^2 - y^2z)\hat{k}$ at (2, -1, 1).
13) Determine the constants a and b such that the vector field is irrotational
$$\vec{A} = (2xy - 3yz)\hat{\imath} + (x^2 + axz - 4z^2)\hat{\jmath} - (3xy + byz)\hat{k}.$$
14) Evaluate $\oint \vec{\boldsymbol{F}}.\overrightarrow{\boldsymbol{dr}}$ by Stoke`s theorem, where $\vec{\boldsymbol{F}} = (\boldsymbol{x^2+y^2})\hat{\boldsymbol{\imath}} - \boldsymbol{2xy}\hat{\boldsymbol{\jmath}}$ and C is the boundary of the rectangle$\boldsymbol{x = \pm a, y = 0\ and\ y = b.}$



15) Verify Stoke`s Theorem for the function $\vec{F} = x^2\hat{\imath} - xy\,\hat{\jmath}$ integrated round the square in the plane $z = 0$ and bounded by the lines $x = 0, y = 0, x = a, y = a$



16) Verify the divergence theorem, given that $\vec{F} = 4xz\,\hat{\imath} - y^2\hat{\jmath} + yz\hat{k}$ for the unit cube at origin.



17) The electric field in a cube of side 5m is $\vec{E} = x^2\hat{\imath} + 5\,\hat{\jmath} + 3z\,\hat{k}\; N/C$. Find (a) volume charge density in the cube (b) total charge inside the cube.

18) An infinitely long cylinder with a radius R has a uniform charge density per unit volume ρ. Use gauss law to determine the electric field (a) within the cylinder (b) outside the cylinder.

19) A long cylinder carries a charge density that is proportional to the distance from the axis: $\rho = ks$, for some constant k. Find the electric field inside this cylinder.

20) Using Gauss law to find the electric field due to uniformly charged sphere at a point which lies (i) inside the sphere (ii) outside the sphere.

21) Find the electric field inside a sphere that carries a charge density proportional to the distance from the origin, $\rho = kr$, for some constant k.

22) A sphere of radius R carries volume charge density $\rho(r) = \rho_o\left(1 - \frac{r}{R}\right), where\ \rho_o$ is a constant and r is the distance from the centre of the sphere. Electric flux through a large spherical surface that encloses the charged sphere completely is φ_o. Electric flux through another sphere of radius R/4 and concentric with the sphere. Find the ratio of $\frac{\varphi_o}{\varphi}$.

23) A charge distribution with spherical symmetry has density is given below. Determine electric field everywhere.

$$\rho = \begin{cases} \frac{\rho_o r}{R} & 0 \le r \le R \\ 0 & r > R \end{cases}$$

24) Using Gauss law show that the (a) electric field outside the charged spherical shell behaves as if the whole charge is concentrated at the centre. (b) discontinuity in electric field at the surface of shell.

25) A thick spherical shell carries charge density $\rho = k/r^2$(a ≤ r ≤ b). Find the electric field in the three regions: (i) r < a, (ii) a < r < b, (iii)r > b. Plot |E| as a function of r, for the case b = 2a.

26) A small conducting sphere of radius r carrying a charge +q is surrounded by a large concentric conducting shell of radius R on which the charge is +Q. Using Gauss`s law, find the electric field at a point x:

(i) between the sphere and the shell (r< x< R)

(ii) outside the spherical shell.

27) Two infinite parallel sheets carry equal but opposite uniform charge densities $\pm\sigma$. Find the field in each of the three regions: (i) to the left of both sheets, (ii) between them, (iii) to the right of both sheets.

28) Two infinite parallel sheets have uniform charge densitiesσ_1 *and* σ_2 . Determine the electric field at points (i) to the left of the sheets, (ii) between them, (iii) to the right of the sheets.

29) Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and of magnitude $17 \times 10^{-22}\ C/m^2$. What is E (a) to the left of the plate (ii) between them (iii) to the right.

30) Let there be a spherically symmetric charge distribution with charge density varying as $\rho(x) = \rho_o\left(\frac{5}{4} - \frac{r}{R}\right)$up to r = R and $\rho(r)$= 0 for r > R, where r is the distance from the origin. Find the electric field at a distance r (r<R) from the origin.