1. **Some particles carry electrical charge. Experiments suggest that there are two kinds of charges. Suppose there were three kinds of charges in nature which we call red, blue and green. Charges of the same kind repel while charges of different kind attract. Ofcourse there are particles which neither repel nor attract other particles. You can't see the colors on the particles. You can only observe the repulsion and attraction between the particles. Treating these repulsion and attraction as relations on the set of particles how will you partition the particles and thus discover the existence of the three kinds of charges.**

2. **Let C be a closed planar curve contained by a plane $\vec{r} \cdot \hat{n} = p$. Here $\hat{n}$ is the unit normal vector to the plane and p is the distance of the plane from the origin. If a is the area of the region enclosed by the curve C then show that**

$$a\hat{n} = \frac{1}{2} \oint_C \vec{r} \times \vec{dl}$$

3. **Consider a general curvilinear coordinate system u, v, w. The cartesian co-ordinates x, y, z are given as $x(u, v, w), y(u, v, w), z(u, v, w)$.**

   (a) **Determine h_u, h_v and h_w.**

   (b) **Find $\hat{u}, \hat{v}, \hat{w}$.**

   (c) **Find an expression for $\vec{\nabla} \cdot \vec{A}$ in the u, v, w coordinate system.**

4. **In the spherical polar system:**

   (a) **Evaluate** $\frac{\partial \hat{r}}{\partial \theta}, \quad \frac{\partial \hat{\theta}}{\partial \theta}, \quad \frac{\partial \hat{\phi}}{\partial \theta}, \quad \frac{\partial \hat{r}}{\partial \phi}, \quad \frac{\partial \hat{\theta}}{\partial \phi}, \quad \frac{\partial \hat{\phi}}{\partial \phi}$

   (b) **Using the above partial derivatives evaluate $\vec{\nabla} \cdot \hat{r}$, $\vec{\nabla} \cdot \hat{\theta}$ and $\vec{\nabla} \cdot \hat{\phi}$ where** $\vec{\nabla} = \hat{r}\frac{\partial}{\partial r} + \hat{\theta}\frac{1}{r}\frac{\partial}{\partial \theta} + \hat{\phi}\frac{1}{r \sin\theta}\frac{\partial}{\partial \phi}$

5. **Cylindrical system of co-ordinate is specified by three variables** (s, ϕ, z) **given by**

$$x = s\cos\phi; \qquad y = s\sin\phi; \qquad z = z$$

Find the unit vectors $\hat{s}, \;\; \hat{\phi}, \;\; \hat{z}$ **in this co-ordinate system. Find** $h_s, \;\; h_\phi$ **and** h_z **and write down the expression for** $\vec{\nabla}F$ **for a scalar function** F **in this system.**

6. **If** $\vec{A} = s\hat{z}$ **find** $\vec{\nabla} \times \vec{A}$**.**

7. **Find the divergence of** $\vec{\mathbf{v}} = (r\cos\theta)\hat{\mathbf{r}} + (r\sin\theta)\hat{\theta} + (r\sin\theta\cos\phi)\hat{\phi}$**. Check the divergence theorem for this function, using the volume as the inverted hemispherical bowl of radius** R**, resting on the** x**-**y **plane and centred at the origin.**

8. **If** $\vec{\nabla} \cdot \vec{\mathbf{B}} = 0$ **show that there exists a vector function** $\vec{\mathbf{A}}$ **such that** $\vec{\nabla} \times \vec{\mathbf{A}} = B$
