1. Suppose the potential $V_0(\theta)$ at the surface of a sphere is specified, and there is no charge inside or outside the sphere. Show that the charge density on the sphere is given by

$$\sigma(\theta) = \frac{\varepsilon_0}{2R} \sum_{l=0}^{\infty} (2l + 1)^2 C_l P_l(\cos \theta)$$

where $C_l = \int_0^\pi V_0(\theta) P_l(\cos \theta) \sin \theta d\theta$.

2. The potential at the surface of a sphere (radius $R$) is given by $V_0 = k \cos 3\theta$, where $k$ is a constant. Find the potential inside and outside the sphere, as well as the surface charge density $\sigma(\theta)$ on the sphere. (Assume there is no charge inside or outside the sphere.)

3. A circular ring of negligible cross-section placed on the $xy$-plane carries a linear charge distribution $\lambda = \lambda_0 (1 - \cos \phi)$. Calculate the monopole, dipole, quadrupole moment of the charge distribution.