Physics 301. Final Exam
Worth: 50%.
(Each problem has equal weight.)
December 9, 2009

1. A thin glass rod is bent into a semicircle of radius r. A charge $+q$ is uniformly distributed along the right half of the semicircle and a charge $-q$ is uniformly distributed along the left half of the semicircle as shown in Fig.1 Find the electric field $\vec{E}$ at the center of the semicircle.

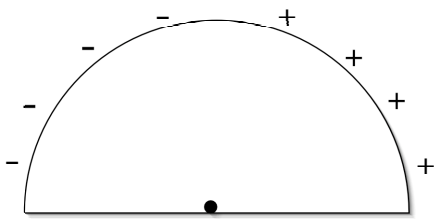
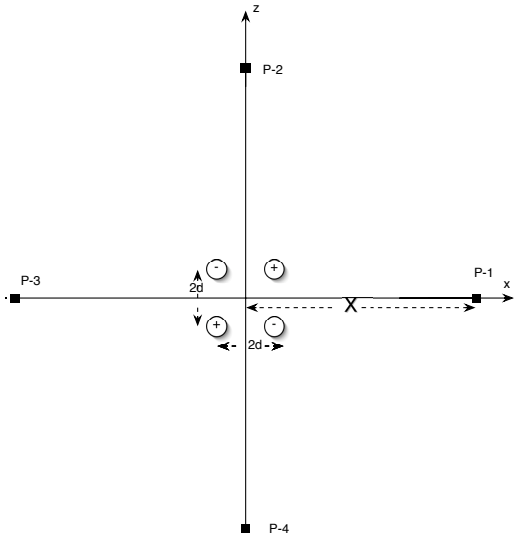


Fig 1.

2. The electric quadrupole is formed by four charges located at vertices of a square of size $2d$. Points P_1, P_2, P_3, P_4 are at distance $X \gg d$ from the center of quadrupole as shown. Compute the electric potential V and the electric field $\vec{E}$ (absolute value and direction) at points P_1, P_2, P_3, P_4.
Hint: treat the quadrupole as two dipoles



3. The potential at the surface of a sphere (radius R) is given by

$$V_0 = k\cos(2\theta),$$

where k is the constant. find the potential inside and outside the spehere, as well as the surface charge density $\sigma(theta)$ on the sphere. There are no any other charges inside, or outside the sphere.

4. Consider a system of two magnetic dipole moments $\vec{M}$ and $\vec{m}$ separated by a distance $\vec{r}$. Magnetic moment at the origin $\vec{M}$ always points along z direction. Points P_1, P_2, P_3 are in xz plane and at distance r from the origin and make angles $\theta_{P_1} = \pi/2, \theta_{P_2} = \pi/4, \theta_{P_3} = 0$ with z axis.
a) Find the force $\vec{F}$ and torgue $\vec{N}$ on magnetic dipole $\vec{m}$ at points P_1, P_2, P_3 if magnetic moment $\vec{m}$ is held fixed along z direction.
b) Find the force $\vec{F}$ and torgue $\vec{N}$ on magnetic dipole $\vec{m}$ at points P_1, P_2, P_3 if magnetic moment $\vec{m}$ is held fixed along x direction.