1. An uncharged metal sphere of radius *R* is placed in an otherwise uniform electric field $\mathbf{E} = E_0 \hat{\mathbf{z}}$, as shown in Figure 1. Please derive the electric field inside and outside the metal sphere. (25%)
[**Information you may or may not need:** Legendre polynomials $P_0(x) = 1$, $P_1(x) = x$, $P_2(x) = (3x^2-1)/2$]

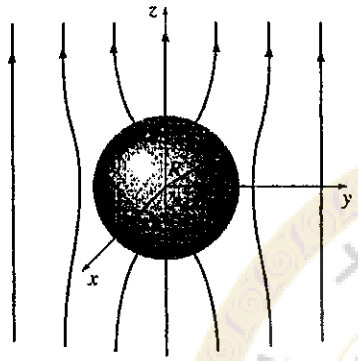

Figure 1

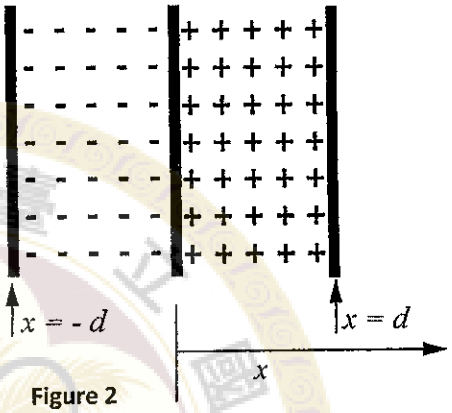

Figure 2

2. Consider the following space charge distribution, as shown in Figure 2 in which

$\rho = -n_0 \quad for\ -d < x < 0$

$\rho = +n_0 \quad for\ 0 < x < d$

Please calculate the electric field as a function of *x*. Your answer needs to cover the region of all x. **(25%)**

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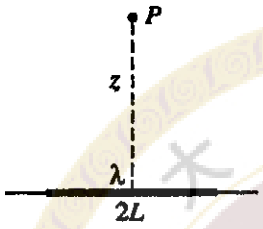
3. (25%)

A straight line segment of length $2L$ carries a uniform line charge density λ, as shown in the figure.

(a) Find the electric potential V at a distance z above the midpoint of the segment. (20%)

(b) Based on (a), find the approximate electric potential V as $L \gg z$. (5%)

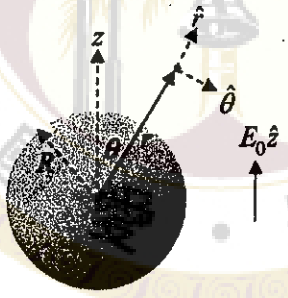


4. (25%)

An uncharged metal sphere of radius R is placed in an otherwise uniform electric field $E_0\hat{z}$.

(a) Find the electric field $\mathbf{E}(r,\theta)$ *outside* the sphere. (15%)

(b) Find the surface charge $\sigma(\theta)$ induced on the sphere surface. (10%)



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