PHY 322: Electromagnetic Fields - Spring 2004

Midterm I

February 27, 2004

Please print your name here:

For the grader:

Problem 1	
Problem 2	
Problem 3	
Total	

Problem 1:

A spherical charge distribution has a volume charge density which is a function only of r, the distance from the center of the distribution. In other words, $\rho = \rho(r)$. If

$$\rho(r) = \begin{cases} A/r & 0 \leq r \leq R \\ 0 & r > R \end{cases}$$

where A is a constant.

(a) Calculate the electric field $\vec{E}$ everywhere. *(3 points)*

(b) Calculate the potential V everywhere (choose $V(\infty) = 0$). *(3 points)*

(c) Calculate the energy stored in the system. *(3 points)*

Problem 2:

Suppose the electric field in the plane $z = 0$ is given by

$$E_x = \frac{3xy}{(x^2+y^2)^{5/2}} \ , \qquad E_y = \frac{2y^2 - x^2}{(x^2+y^2)^{5/2}} \ , \qquad E_z = 0$$

(a) Choose infinity as the reference point and calculate the potential V at $(R, 0, 0)$ and $(0, R, 0)$. *(4 points)*

(b) Calculate the potential difference between $(R, 0, 0)$ and $(0, R, 0)$ by:

(i) subtracting the results in (a); *(1 point)*

(ii) integrating along the arc $(R\cos\theta, R\sin\theta, 0)$. *(3 points)*

Problem 3:

Consider an infinite one-dimensional ionic crystal, i.e., a row of equally spaced charges of magnitude e and alternating sign.

Calculate:

(a) The potential energy between nearest neighbors; (*3 points*)

(b) The potential energy between next nearest neighbors; (*2 points*)

(c) The potential energy *per ion* for the one-dimensional crystal. (*3 points*)
(Hint: $\ln(1+x) = x - x^2/2 + x^3/3 - x^4/4 + \ldots$).