

PHYSICS 110A WINTER 2003

MIDTERM I

PUT YOUR NAME ON THE EXAM RIGHT AWAY!

PROBLEM 1 [25 POINTS]

A charge of magnitude $+Q$ resides at the point $(0, a/2, 0)$ in cartesian coordinates. A charge of magnitude $-Q$ resides at the point $(0, -a/2, 0)$ in the same coordinate system. Find the magnitude and direction of the electric field \vec{E} at any point $(d, 0, 0)$ in this system, where d is any positive real number. What simplified form does your expression approach in the limit that $d \gg a$?

PROBLEM 2 [20 POINTS]

An infinitely thin cylindrical shell of radius a meters carries a charge of λ Coulombs per meter.

- a) What is the charge density function $\rho(s, \phi, z)$ of this configuration (λ is a constant, independent of the value of z)?
- b) What is the electrostatic potential at any point in space, assuming $\phi = 0$ at $s = 0$?

PROBLEM 3 [20 POINTS]

Consider the vector field

$$\vec{v}(x, y, z) = xy^2z\hat{x} + x^2yz\hat{y} + \beta x^2y^2\hat{z}.$$

- a) For what value of β will there be a scalar field $\phi(x, y, z)$ such that

$$\vec{v}(x, y, z) = \vec{\nabla}\phi(x, y, z)?$$

- b) Given this value of β , if \vec{v} represents the electric field in some region of space, what is the charge density distribution $\rho(x, y, z)$ in that region of space?

PROBLEM 4 [35 POINTS]

A sphere of radius R possesses a charge density given by

$$\rho(r, \theta, \phi) = \frac{A}{r^2}.$$

- a) Find the electrostatic potential $V(r, \theta, \phi)$ at every point in space.
- b) What is the energy required to assemble this charge distribution?