

## Spring 2006 Qualifying Examination – Electromagnetism

1. [20 points] A static charge distribution produces a spherically radial electric field

$$\mathbf{E} = A \frac{e^{-br}}{r} \hat{r}$$

where  $A$  and  $b > 0$  are constants.

- [15] What is the charge density? Make a sketch of the function.
- [5] What is the total charge  $Q$ ?

2. [40 points] Consider ultraviolet-rays with angular frequency  $\omega$  incident on a plane metal surface. The density of conduction electrons in the metal is  $n_e$ .

- [5] Comment on why metals are shiny (reflective to visible light), and the difference in color between silver, and gold or copper.
- [25] Determine the critical angle of incidence  $\theta_0$  beyond which the incident rays are totally reflected.
- [10] For normal incidence, what is the reflection coefficient?

3. [40 points] Two equal point charges  $+q$  oscillate along the  $z$ -axis with their positions given by  $z_1 = z_0 \sin(\omega t)$ ,  $z_2 = -z_0 \sin(\omega t)$ ,  $x_i = y_i = 0$ . The radiation field is observed at a position  $\mathbf{r}$  with respect to the origin. Assume that  $|\mathbf{r}| \gg \lambda \gg z_0$ , where  $\lambda$  is the wavelength of the emitted radiation.

- [25] Find the electric and magnetic fields, in this approximation.
- [15] Compute the power radiated per unit solid angle in the direction of  $\mathbf{r}$ .