BIRZEIT UNIVERSITY
Faculty of Science كليـة العلـوم
Department of Physics دائـرة الفيـزيـاء

Phys331/Final Exam
Spring 2020/2021

1) Consider the electric field $\vec{E} = x\hat{x} + z\hat{y} + (f(x,y) + z^2)\,\hat{z}$.
   a. (5%) Determine the function $f(x,y)$.
   b. (5%) Compute the total charge contained in a cube specified by $0 \le x, y, z \le 1$.

2) Answer the following two questions with complete reasoning and using basic equations/principles.
   a. (5%) If inside some region of space there was no currents, is it possible to have a magnetic field in that region of the form
   $$\vec{B} = y\hat{x}$$
   b. (5%) If $\vec{J}_0$ is a constant vector, is it possible to realize a steady current of the form
   $$\vec{J} = \vec{J}_0 e^{-r^2}$$

3) A thick spherical shell of inner radius a and outer radius b is made of dielectric material with uniform frozen-in polarization given by
$$\vec{P}(\vec{r}) = \begin{cases} P_0\,\hat{z}, & a \le r \le b \\ 0\ ., & otherwise \end{cases}$$
   a. (5%) Calculate all bound charges σ_b and ρ_b.
   b. (10%) Find the electrostatic potential inside the spherical shell ($a \le r \le b$).
   c. (5%) Find the electric field inside the spherical shell ($a \le r \le b$).
   d. (5%) Determine the displacement vector inside the spherical shell ($a \le r \le b$).

4) An infinite conducting cylinder along the z-axis of radius R is placed in a uniform electric field $\vec{E} = E_0\hat{x}$.
   (a) (15%) Find the electrostatic potential everywhere.
   (b) (10%) Find the induced surface charge density on the conducting cylinder.

.

5) If the vector potential due to a rotating uniformly charged sphere of radius R and volume charge density ρ_0 is given by
$$\vec{A}(\vec{r}) = \begin{cases} \frac{1}{2}\mu_0\rho_0\omega\left(\frac{rR^2}{3} - \frac{r^3}{5}\right)\sin\theta\,\hat{\phi}, & r \le R \\ \frac{1}{15}\mu_0\rho_0\omega\frac{R^4}{r^2}\sin\theta\,\hat{\phi} \quad , & r > R \end{cases}$$
   a. (10%) Find the magnetic field inside and outside the sphere.
   b. (10%) Find the magnetic dipole moment.