PHYS 4392 **Practice Final Exam**

Your Name ____

3 hours

Open Book (hardcopy): Griffiths Introduction to Electrodynamics 4e

Each question is worth 10 points. Point breakdown for part question is shown **[thus]**

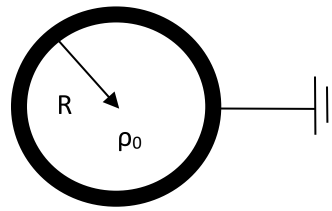
Partial Credit is given for working in case of an incorrect answer
(so write and/or draw every step clearly)

Hand in this question sheet with your solutions

1. A perfectly conducting spherical shell of radius R is filled with a uniform distribution of volume charge density:

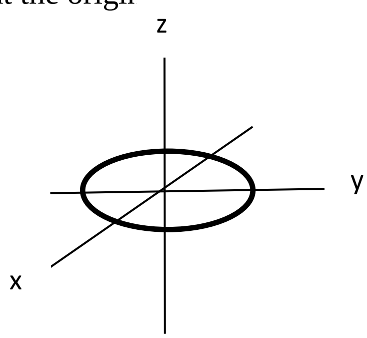
$$\rho = \rho_0 \qquad\qquad 0 < r < R$$

The conducting shell is grounded so that the scalar electric potential at radius r = R is zero, V(r = R) = 0.



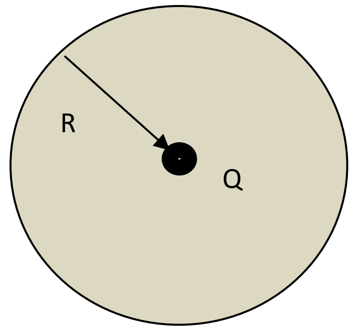
(a) What is the electric field vector **E** for $0 < r < R$? **[3]**
(b) What is the scalar electric potential V for $0 < r < R$? **[4]**
(c) What is the free surface charge density σ induced on the inside surface of the conducting shell at r = R? **[3]**

2. A ring of radius R carries uniform charge density λ per unit length and sits in the x-y plane with its center at the origin



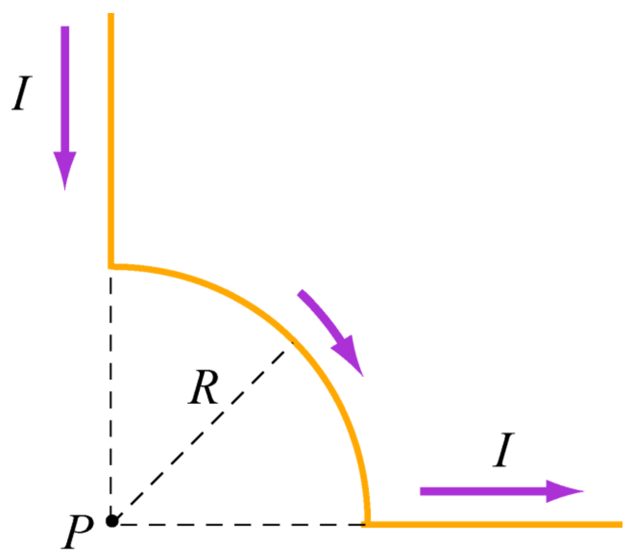
(a) In spherical polar coordinates, write the volume charge density $\rho(r,\theta,\varphi)$ in terms of delta functions. **[3]**
(b) Calculate the monopole **[2]** dipole **[2]** and quadrupole **[3]** contributions to the multipole expansion of the scalar electric potential V. [$\int_0^{2\pi} \sin^2 \varphi' \, d\varphi' = \int_0^{2\pi} \cos^2 \varphi' \, d\varphi' = \pi$]

3. A point charge Q is placed in a small hole at the center of a sphere of radius R made of linear dielectric material with permittivity ε.

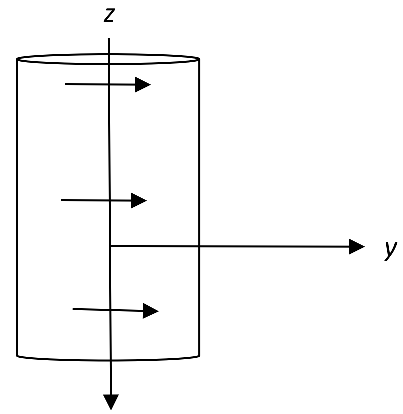


(a) Calculate the electric displacement vector $\underline{\mathbf{D}}$ inside and outside the sphere. **[2]**
(b) Calculate the electric field vector $\underline{\mathbf{E}}$ inside and outside the sphere. **[2]**
(c) Calculate the polarization vector $\underline{\mathbf{P}}$ inside the sphere. **[2]**
(d) Calculate the volume bound charge density ρ_b . **[2]**
(e) Calculate the surface bound charge density σ_b on the outer surface at radius R. **[2]**

4. Find the magnetic field $\underline{\mathbf{B}}$ at point P due to the following current I distribution in the x-y plane **[10]**



5. A solid, cylindrical permanent magnet of radius R is infinite in the z direction and is centered on the z axis. The cylinder has a uniform magnetization in the y direction: $\underline{\mathbf{M}} = M\,\underline{\hat{\mathbf{y}}}$



a) Calculate the bound volume current density $\underline{\mathbf{J}}_b$. **[3]**
b) Calculate the bound surface current density $\underline{\mathbf{K}}_b$. **[3]**
c) Calculate the magnetic field $\underline{\mathbf{B}}$ on the z-axis. **[4]**

6. A rectangular loop of wire with sides of length a and b sits in a uniform external magnetic field that is perpendicular to the plane of the loop and going into the page (see figure). The magnitude of the field is decaying linearly over time $B = B_0\,(1 - \alpha\, t)$.

   (a) If the resistance of the loop is R, find an expression for the current I induced in the loop. **[7]**
   (b) Does the current flow clockwise or anticlockwise (justify your answer)? **[2]**
   (c) Why can back-emf be neglected? **[1]**