North Carolina State University
Qualifying Exam
Electromagnetism

Name:

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2	______
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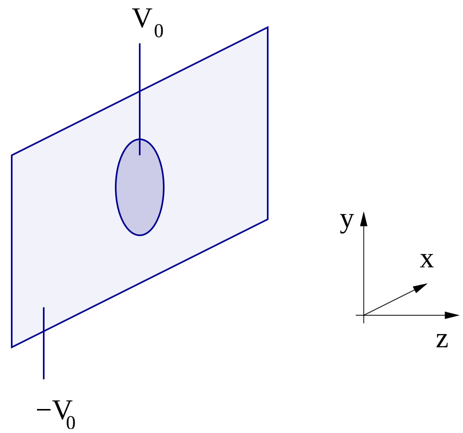
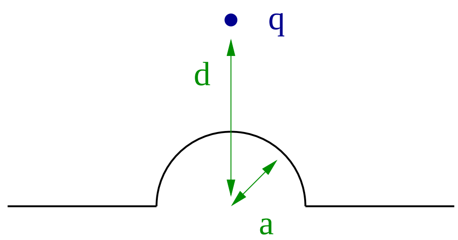
Total	______

Instructions

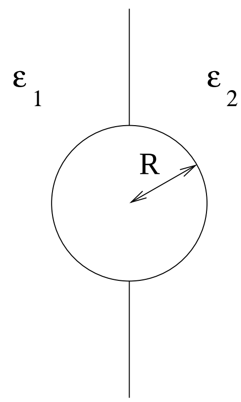
1. This is a closed book exam. You may bring an index card with formulas (as in the py785 final).
2. There are six problems. Each problem is worth 10 points. The lowest of the six scores will be dropped (the maximum total score is 50 pts).



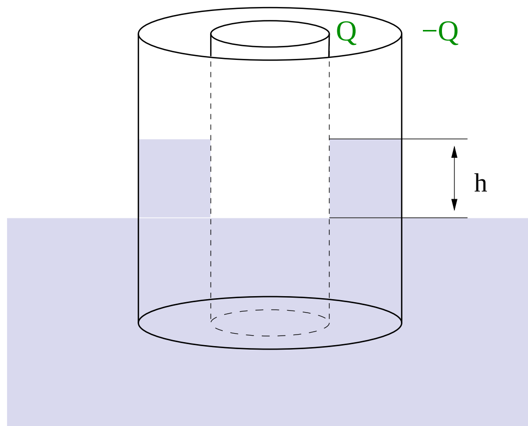
1. Consider an infinite conducting plate located at $z = 0$ in the $x - y$ plane. The disk $x^2 + y^2 < R^2$ is isolated from the rest of plane and maintained at potential V_0 while the rest of the plate is held at $-V_0$. Derive an expression for the potential $\Phi(x, y, z)$. Evaluate this expression in the case $x, y = 0$.



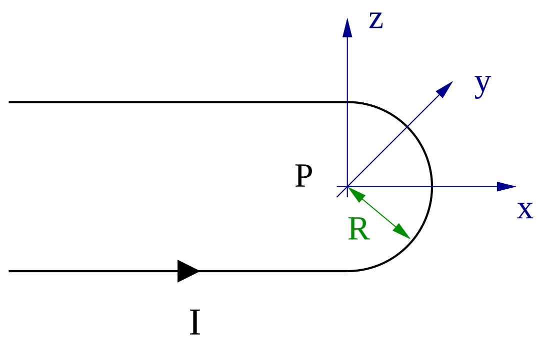
2. A conductor has the shape of an infinite conducting plane except for a spherical boss of radius a. A charge q is placed above the center of the boss at a distance d from the plane. Compute the force on the charge. (Hint: Imagine that the plate is absent, and that there is only the charge q and a conducting sphere of radius a. How does the conducting plane change the problem?)



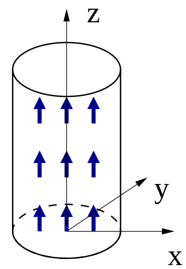
3. A hollow conducting sphere of radius R carries the total charge Q. The sphere is embedded in a dielectric consisting of two halves with dielectric constants ϵ_1 and ϵ_2 (see Figure). Determine the potential everywhere in space and the distribution of charge on the surface of the sphere.



4. Two long coaxial cylindrical conductors of radii a and and b ($a < b$) are submerged in a dielectric with dielectric constant ϵ and mass density ρ. The cylinders carry charges $+Q$ and $-Q$, respectively. Determine the height h of the fluid between the cylinders. (Hint: Minimize the energy as a function of h. In order to simplify the equation for h you may assume that $(\epsilon - \epsilon_0)/\epsilon_0 \ll 1$.)



5. A long wire is bent in a hairpin-like shape as shown in the figure. The current through the wire is I and the radius of the semi-circle is R. Compute the magnetic field $\vec{B}$ at the point P lying at the center of the semi-circle.



6. A magnetically hard material ($\vec{M}$ is independent of $\vec{B}$) is in the shape of a cylinder of length L and radius a. The cylinder has a permanent magnetization $\vec{M}_0$, uniform throughout its volume and parallel to its axis. Determine the magnetic field $\vec{H}$ and magnetic induction $\vec{B}$ at all points on the axis of the cylinder, both inside and outside.