

Name _____

Which recitation section?, Wed. _____, Thur. _____

Work directly on these pages and show your work clearly. Properly labeled figures are important and will figure into the grading.

You do not need to evaluate any of the integrals, but do show the limits of integration and reduce a vector problem so that there are no vectors within the integral itself.

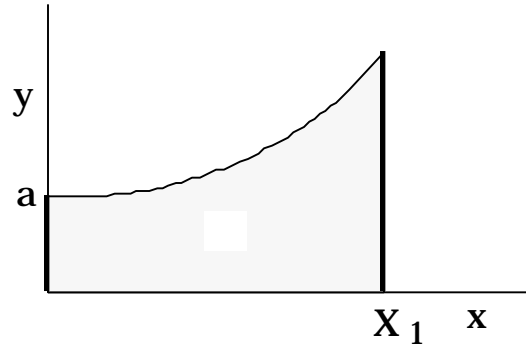
1. [5 pts] The radius vector used in the equation for the electric field of a positive point charge q points
 - (a) from the test point to the point charge
 - (b) from the point charge to the test point
 - (c) tangential to a circle centered on the point charge
 - (d) along the x axis

2. [5 pts] Gauss's law says that the field in the empty space inside a thin conducting spherical shell holding charge Q
 - (a) is zero
 - (b) is the same as having Q/ϵ_0 at the center
 - (c) is the same as having Q at the center

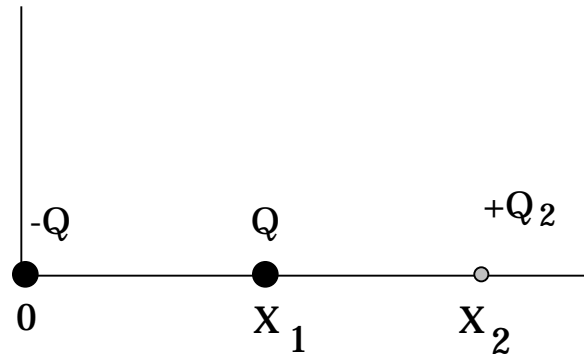
3. [5 pts] The element of area $d\mathbf{A}$ in Gauss's law *always* points
 - (a) in the direction of the electric field
 - (b) along a radius \mathbf{r} that points away from the positive charge
 - (c) perpendicular to the surface of integration
 - (d) all of the above

4. [5 pts] In the equation $V = - \int_a^b \mathbf{E} \cdot d\mathbf{r}$, the vector $d\mathbf{r}$ always points
 - (a) in the direction of the electric field \mathbf{E}
 - (b) along a radius pointing away from a plus charge
 - (c) along a path from \mathbf{a} to \mathbf{b}
 - (d) from the origin to a point on the path from \mathbf{a} to \mathbf{b}

5. [15 pts] A thin slab of material of thickness t is cut into the shape shown in the figure. The equation for the curved top edge is $y = a + bx^2$. If the material has a constant resistivity ρ , find an expression for the resistance between the left and right ends of the shape shown.



6. [15 pts] If the potential due to a point charge is given by $V = \frac{kq}{r}$, and the charges $-Q$ and $+Q$ are fixed in the positions shown, determine an expression for the energy required to bring the charge Q_2 in from infinity to the point X_2 shown in the figure. Your answer should be in terms of k and the symbols shown in the figure.



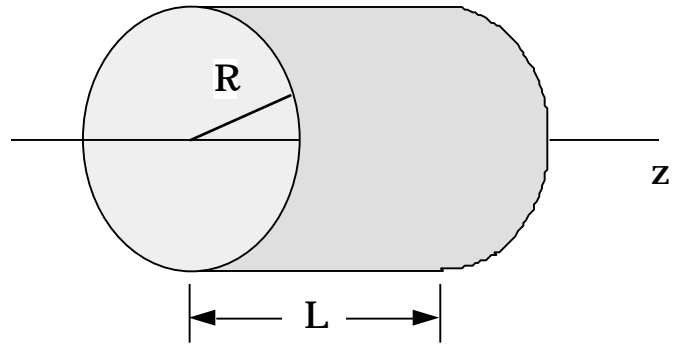
7. [20 pts] A solid dielectric cylinder of radius R and length $L \gg R$ is uniformly charged with a constant charge per unit volume ρ . Use Gauss's law,

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0},$$

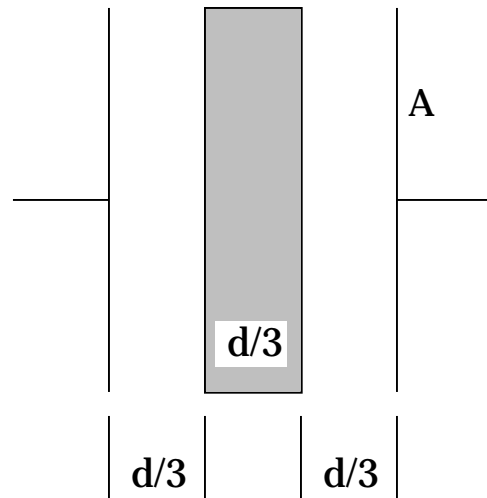
to find an expression for the electric field at points **inside** the cylinder.

Note: A substantial part of the grade for this question will be based on how effectively you convince me that you understand the meaning of

Gauss's law, particularly the symbols \oint and $d\vec{A}$. I suggest you draw some additional pictures.



8. [15 pts] A parallel plate capacitor with plates of area A separated by a distance d has capacitance $C = \frac{A}{\epsilon_0 d}$. If a block of conducting material with the same area A and thickness $d/3$ is placed midway between the plates, derive an expression for the new capacitance in terms of the original capacitance C . Depending on where you start, you might need the formulas $C = Q/V$ and $|\mathbf{E}| = \sigma / \epsilon_0$.



9. [15 pts] There are three different paths that connect point A with point B. In terms of the three currents shown, write three equations (one for each path) for the voltage difference $V_A - V_B$.

