<table>
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<th>Div, Grad, and Curl</th>
<th>Coulomb and Gauss</th>
<th>Potential and Work</th>
<th>Miscellaneous</th>
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Given a general scalar field $T(r)$ and a vector field $\mathbf{v}(r)$, which second derivatives can be taken that are identically zero?
For the vector field

\[ \mathbf{v} = -xy^2 \hat{x} + zy \hat{y} - 6 \hat{z} \]

determine the line integral \( \int_{\mathcal{P}} \mathbf{v} \cdot d\mathbf{l} \) from the point \((0, 0, 0)\) to \((1, 1, 0)\) along the path \( y = x^2, \ z = 0 \).
For the vector field (in cylindrical coordinates)

\[ \mathbf{v} = s(1 + \cos \phi) \hat{s} + s(1 + \sin \phi) \hat{\phi} - sz \hat{z} \]

determine the surface integral \( \int_S \mathbf{v} \cdot d\mathbf{a} \) over the cylindrical surface defined by \( s = R \) and \( 0 < z < L \).
Given the electric field

$$\mathbf{E}(\mathbf{r}) = 2xy \hat{x} + (x^2 - 2yz) \hat{y} - y^2 \hat{z}$$

determine the charge density $\rho(\mathbf{r})$. 
Given the charge density $\rho(r) = kr$, determine the electric field $E(r)$. 
Given a half-circle of charge density $\lambda$ as shown, determine $\mathbf{E}$ at the origin.
\[ \frac{1}{2} \int_{V} \rho V \, d\tau = \frac{\epsilon_0}{2} \int_{V} E^2 \, d\tau \]

Is this a true statement? Why or why not?
Given a sphere of radius $R$ with uniform surface charge density $\sigma$, determine the potential $V$ at the point $\mathbf{r} = (R/2) \hat{z}$. 
Calculate the energy store in the following charge configuration: a sphere of radius $a$ with total charge $q$ spread uniformly on the surface, surrounded by a concentric sphere of radius $b > a$ with total charge $-q$ also uniformly spread on the surface.
Evaluate this integral:

$$\int r^2 \sin(r \cdot a) \delta^3(b - r) \, d\tau$$

where integration runs over all space.
Given the potential $V(\mathbf{r}) = xy^2z^3$, determine the charge density $\rho(\mathbf{r})$. 
A conducting spherical shell of inner radius $a$ and outer radius $b$ carries a total charge $Q$. A point charge $q$ is placed at the center. Determine the surface charge densities on the inner and outer surfaces of the conductor.