For each problem, state the system of units in which you are working.

1. In the following parts, C is a constant.

   (a) Is this a valid electrostatic field: $\vec{E}(\vec{r}) = C[(xy)\hat{i} + (2yz)\hat{j} + (3xz)\hat{k}]$?

   (b) Is this a valid electrostatic field: $\vec{E}(\vec{r}) = C[(y^2)\hat{i} + (2xy + z^2)\hat{j} + (2yz)\hat{k}]$?

   (c) The electrostatic field inside an insulating sphere of radius a is $\vec{E}(\vec{r}) = Cr^2\hat{r}$. What is the volume charge density inside the sphere?

   (d) What is the electrostatic field outside the sphere in the previous part?

   (e) Simplify as much as possible: $\vec{\nabla} \cdot \vec{r}$ (divergence of the position vector).

   (f) Simplify as much as possible: $\vec{\nabla} \times \vec{r}$ (curl of the position vector).

   (g) Simplify as much as possible: $\vec{\nabla}|\vec{r}|$ (gradient of the length of the position vector).

2. Two halves of a long hollow conducting cylinder of inner radius b are separated by small lengthwise gaps on each side, and are kept at different potentials V_1 and V_2.

   (a) Find the electrostatic potential everywhere inside.

   (b) Find the electrostatic field at the center.

3. What are the Cartesian magnetic dipole and quadrupole moment tensors of a "figure-8" current loop (loop radius a) with current flow as indicated in the diagram below? (There is no short-circuit at the cross-over point.)