

## 1 Gradient Practice

(2, 2, 2 pts)

Find the gradient of each of the following functions:

(a)

$$f(x, y, z) = e^{(x+y)} + x^2 y^3 \ln \frac{x}{z} \quad (1)$$

(b)

$$\sigma(\theta, \phi) = \cos \theta \sin^2 \phi \quad (2)$$

(c)

$$\rho(s, \phi, z) = (s + 3z)^2 \cos \phi \quad (3)$$

## 2 Linear Quadrupole (w/ series)

(4, 4, 2 pts)

Consider a collection of three charges arranged in a line along the  $z$ -axis: charges  $+Q$  at  $z = \pm D$  and charge  $-2Q$  at  $z = 0$ .

- (a) Find the electrostatic potential at a point  $\vec{r}$  in the  $xy$ -plane at a distance  $s$  from the center of the quadrupole. The formula for the electrostatic potential  $V$  at a point  $\vec{r}$  due to a charge  $Q$  at the point  $\vec{r}'$  is given by:

$$V(\vec{r}) = \frac{1}{4\pi\epsilon_0} \frac{Q}{|\vec{r} - \vec{r}'|}$$

- (b) Assume  $s \gg D$ . Find the first two non-zero terms of a power series expansion to the electrostatic potential you found in the first part of this problem.
- (c) A series of charges arranged in this way is called a linear quadrupole. Why?