Physics 208

Exam 1

February 17, 2009

Family Name:

First Name:

Student ID Number:

Your Section Number:

USEFUL INFORMATION

For two point particles,

\[
\vec{F} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \vec{r}
\]

\[
\int_{\vec{r}_1}^{\vec{r}_2} \vec{E} \cdot d\vec{r} = -[V(\vec{r}_2) - V(\vec{r}_1)]
\]

\[
d\vec{r} = dx \vec{i}_x + dy \vec{i}_y = dr \vec{i}_r + r d\theta \vec{i}_\theta
\]

\[
E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}
\]

DO NOT WASTE TIME ON COMPLICATED INTEGRALS.

Do not write below

<table>
<thead>
<tr>
<th>Prob. 1</th>
<th>Prob. 2</th>
<th>Prob. 3</th>
<th>Prob. 4</th>
<th>TOTAL</th>
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</thead>
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[1] (25 points) Three charges are located as shown: two positive charges, \( q_1 \) and \( q_2 \), and one negative, \( -q_3 \).

Find the total force that would be exerted by these charges on a fourth, positive charge \( q_4 \) if it were located at the point \((x = d, y = 0)\).
(25 points) You are given the electric potential function

\[ V(x, y) = \alpha x^2 + \beta y^3. \]

Here \( \alpha \) and \( \beta \) are known constants.

(a) For this electric potential function, find the electric field everywhere.

(b) What is the electric force that would be exerted on a charge \( q \) by this electric field at the arbitrary point \((x, y)\)?

(c) What work would be done by this electric force if \( q \) moved from the origin to the point \((x = a, y = b)\)?
[3] (25 points) Suppose there were an electric field given by

\[ \vec{E} = \alpha \hat{i}_x + \beta x^2 \hat{i}_y. \]

(a) What would be the electric flux through the \( L \) by \( W \) rectangle if it is the \( y-z \) plane.

(b) What would be the electric flux through the shaded quarter of a circle of radius \( R \) if the circle is in the \( x-y \) plane?

(c) What would be the electric flux through the \( L \) by \( W \) rectangle if it is in the \( x-z \) plane with one corner at \((x = a, z = c)\) as shown?
(25 points) Suppose there is a half circle of radius $R$ that has positive charge, $+Q$, uniformly spread over the top half and negative charge, $-Q$, uniformly spread over the bottom half. Find the electric field at the center of the semi-circle.