## Physics 51 Sample Midterm Exam \#1 (23 points) by Todd Sauke

## Question \#1.

A point charge $\mathrm{Q}=-800 \mathrm{nC}$ (nanoCoulombs) and two unknown point charges, $\mathrm{q}_{1}$ and $\mathrm{q}_{2}$, are placed as shown in the figure at right. The electric field at the origin O , due to charges $\mathrm{Q}, \mathrm{q}_{1}$ and $\mathrm{q}_{2}$, is equal to zero. We want to determine the values of charges $\mathrm{q}_{1}$ and $\mathrm{q}_{2}$. The electric field vector at the origin has two components ( x and y ). Because the electric field at the origin is zero, both the x and y components are zero. We can consider the x and y components separately. Remember that the y component of the electric field at the origin due to $\mathrm{q}_{1}$ is zero, since it is on the x axis. What is the y component of the E field at the origin due to the charge Q? (Use a trigonometric function to obtain the $y$ component.)

$\qquad$ N/C
1 point (check the sign!)
What must be the y component of the E field at the origin due to $\mathrm{q}_{2}$ (in order to cancel out the E field from Q )?
$\qquad$ N/C
1 point
What must the charge $\mathrm{q}_{2}$ be to provide this field?

> |  | nC |
| :--- | ---: |
| 1 point | (note units!) |

Working similarly, what must the charge $\mathrm{q}_{1}$ be in order for the E field at the origin to be zero?


How many excess electrons are there in the charge Q ?

## Question \#2.



As shown in the figure above, a circular plate with radius 1.96 m contains 793 mC (microCoulombs) of a charge uniformly distributed. We want to find the magnitude of the electric field near the plate. First, what is the charge density, $\sigma$, of the given charge distribution?

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                        C/m
1 point
Now, write the equation from the study guide that relates the field near a sheet of charge to the charge density, \(\sigma\).
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## 1 point

What is the magnitude of the electric field near the plate?

## 1 point

## Question \#3. (2 points)

In the figure at right, charge is placed on an irregularly shaped piece of copper, a good electrical conductor. How will the charge be distributed on the object?

A) With greatest density neat point E on the flat surface.
B) With greatest density near point C on the surface.
C) With gratest density near point D in the interior.
D) Uniformly throughout the volume.
E) Uniformly over the surface.

## Question \#4.



A nonuniform electric field is directed along the $x$-axis at all points in space. The magnitude of the field varies with x , but not with respect to y or z . The axis of a cylindrical surface, 0.80 m long and 0.20 m in diameter, is aligned parallel to the $x$-axis. The electric fields $E_{1}$ and $E_{2}$, at the ends of the cylindrical surface, have magnitudes of $3000 \mathrm{~N} / \mathrm{C}$ and $7000 \mathrm{~N} / \mathrm{C}$ respectively, and are directed as shown in the figure above. What is the electric flux exiting the cylinder's circular surface at the left end?


What is the electric flux exiting the cylinder's circular surface at the right end?


What is the angle between the electric field and the side surface of the cylinder?

$$
1 / 2 \text { point }
$$

Write the equation relating the total flux exiting a closed surface to the total charge enclosed within that surface.

## 1 point

What is the charge enclosed by the cylinder?
(check your sign!)

## Question \#5.

Point charges, $\mathrm{Q}_{1}=+58 \mathrm{nC}$ and $\mathrm{Q}_{2}=-90$ nC , are placed as shown in the figure at right. An electron is released from rest at point C . (The electron will experience a force to the right, and accelerate in that direction.) We want to find the speed of the electron as it approaches infinity (far away). We could start with the force on the electron as a function of position, and integrate the
 acceleration expression from $t=0$ to infinity, but that would be rather tedious. Instead let's use the concept of potential energy, together with the Work-Energy theorum. Taking the potential energy of the electron to be zero when it is at infinity (far away), write the equation from the study guide that gives the potential energy of the electron at point C .

## 1 point

What is the potential energy of the electron at point C ?

## 1 point

What is the equation relating the potential energy and the kinetic energy of the electron at $t=0$ and at $t=\infty$ (when the electron is far away)?

1 point
What is the speed of the electron when it approaches infinity (far away)?

## 2 points (include units to get full credit)

## Question \#6. (2 points)

Two conductors are joined by a long copper wire. Thus
A) each carries the same free charge.
B) the potential on the wire is the average of the potential of each conductor.
C) the electric field at the surface of each conductor is the same.
D) no free charge can be present on either conductor.
E) each conductor must be at the same potential.

