first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2211 G

Spring 2022

Nine-digit Tech ID

Quiz

1A

- **Print** your name and nine-digit Tech ID *very neatly* in the spaces above.
- Free-response problems are numbered I–III. Show all your work clearly, including all steps and logic. Write **darkly**. Blue or black ink is recommended. Do not make any erasures in your free-response work. Cross out anything you do not want evaluated. Box your answer.
- Multiple-choice questions are numbered 1–8. For each, select the answer most nearly correct, circle it on your quiz, and fill the bubble for your answer on this front page.
- Initial the odd pages in the top margin, in case the pages of your quiz get separated.
- The standard formula sheet is on the back of this page, which may be removed from the quiz form if you wish, but it must be submitted.
- If the page for a free-response problem has insufficient space for your work, ask a proctor for an additional sheet. If you wish this work to be evaluated, put your name on the sheet and make a note on the problem page, so graders will know where to look for your work.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.
- Your score will be posted when your quiz has been graded. Quiz grades become final after the last class meeting, Monday, December 6.

Fill in bubbles for your Multiple Choice answers darkly and neatly.

	a	b	c	d	e
1	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
2	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
3	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
4	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
5	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
6	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
7	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
8	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
	a	b	c	d	e

$$k = \frac{1}{4\pi\epsilon_0}$$
$$\Delta V = -\int \vec{E}\cdot d\vec{s}$$
$$V = k\frac{q}{r}$$
$$\Delta U = q\,\Delta V$$
$$I = dq/dt$$
$$P = I\,\Delta V$$
$$R = \frac{\Delta V}{I}$$

Series :

$$\frac{1}{C_{\text{eq}}} = \sum \frac{1}{C_i}$$
$$R_{\text{eq}} = \sum R_i$$

Parallel :

$$\frac{1}{R_{\text{eq}}} = \sum \frac{1}{R_i}$$
$$C_{\text{eq}} = \sum C_i$$

$$\vec{E} = k\frac{q}{r^2}\hat{r}$$
$$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r}$$
$$\vec{F} = q\vec{E}$$
$$\vec{p} = q\vec{d}$$
$$\vec{\tau} = \vec{p}\times\vec{E}$$
$$U = -\vec{p}\cdot\vec{E}$$
$$|\vec{E}| \propto \frac{|\vec{p}|}{r^3}$$
$$\Phi_{\text{E}} = \int \vec{E}\cdot d\vec{A}$$
$$\epsilon_0 \oint \vec{E}\cdot d\vec{A} = q_{\text{enclosed}}$$
$$\oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_{\text{B}}}{dt}$$
$$C = \frac{Q}{\Delta V}$$
$$C = \epsilon_0\frac{A}{d}$$
$$U = \tfrac{1}{2}C\left[\Delta V\right]^2$$
$$R = \rho\frac{\ell}{A}$$
$$\tau_{\text{C}} = RC$$
$$u_{\text{E}} = \tfrac{1}{2}\epsilon_0 E^2$$

$$\vec{B} = \frac{\mu_0 q}{4\pi}\frac{\vec{v}\times\hat{r}}{r^2}$$
$$d\vec{B} = \frac{\mu_0 I}{4\pi}\frac{d\vec{\ell}\times\hat{r}}{r^2}$$
$$\vec{F} = q\vec{v}\times\vec{B}$$
$$\vec{F} = I\vec{\ell}\times\vec{B}$$
$$\vec{\mu} = NI\vec{A}$$
$$\vec{\tau} = \vec{\mu}\times\vec{B}$$
$$U = -\vec{\mu}\cdot\vec{B}$$
$$\Phi_{\text{B}} = \int \vec{B}\cdot d\vec{A}$$
$$\oint \vec{B}\cdot d\vec{A} = 0$$
$$\oint \vec{B}\cdot d\vec{\ell} = \mu_0(I_{\text{c}} + I_{\text{d}})$$
$$L = \frac{\Phi_{\text{B}}}{I}$$
$$L = \mu_0 N^2\frac{A}{\ell}$$
$$U = \tfrac{1}{2}LI^2$$
$$B = \mu_0 nI$$
$$\tau_{\text{L}} = L/R$$
$$u_{\text{B}} = \frac{1}{2\mu_0}B^2$$

$$q = q_{\max}\left(1 - e^{-t/\tau_{\text{C}}}\right)$$
$$q = q_0 e^{-t/\tau_{\text{C}}}$$
$$I = I_{\max}\left(1 - e^{-t/\tau_{\text{L}}}\right)$$
$$I = I_0 e^{-t/\tau_{\text{L}}}$$
$$I = \int \vec{J}\cdot d\vec{A}$$
$$\vec{J} = \sigma\vec{E}$$
$$\mathcal{E} = -N\frac{d\Phi_{\text{B}}}{dt}$$
$$I_d = \epsilon_0\frac{d\Phi_{\text{E}}}{dt}$$
$$\mathcal{E} = -L\frac{dI}{dt}$$
$$c = f\lambda = \frac{|\vec{E}|}{|\vec{B}|}$$
$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$$

Fundamental Charge $e = 1.602\times10^{-19}\,\text{C}$
Earth's gravitational field $g = 9.81\,\text{N/kg}$
Coulomb constant $K = 8.988\times10^{9}\,\text{N·m}^2/\text{C}^2$
Speed of Light $c = 2.998\times10^{8}\,\text{m/s}$

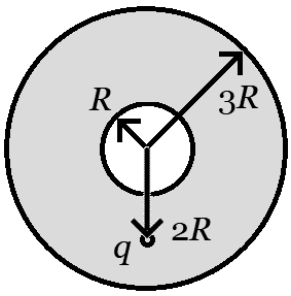
Mass of an Electron $m_{\text{e}} = 9.109\times10^{-31}\,\text{kg}$
Mass of a Proton $m_{\text{p}} = 1.673\times10^{-27}\,\text{kg}$
Vacuum Permittivity $\epsilon_0 = 8.854\times10^{-12}\,\text{C}^2/\text{N·m}^2$
Vacuum Permeability $\mu_0 = 4\pi\times10^{-7}\,\text{T·m/A}$

Unless otherwise directed, friction, drag, and gravity should be neglected, all batteries and wires are ideal, and all derivatives and integrals in free-response problems must be evaluated.

You may remove this sheet from your Quiz or Exam

Initial:

I. (16 points) A hollow sphere with inner radius R and outer radius $3R$ has uniform volume charge density ρ. A particle with charge q is embedded in the sphere, a distance $2R$ from the center. What is the magnitude of the electric force, if any, exerted by the particle on the sphere? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.



II. (16 points) Three charged particles lie on the y axis. Particles with negative charge $-2q$ lie at $\pm d$. A particle with positive charge $+q$ lies on the origin. Find an expression for the electric field $\vec{E}$ as a function of position, x, on the x axis. Express your answer in terms of parameters defined in the problem and physical or mathematical constants.

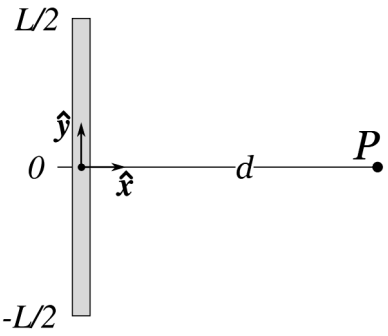
1. (6 points) In the problem above, what is the direction, if any, of the electric field on the $+x$ axis?

   (a) In the $+x$ direction.
   (b) In the $-x$ direction.
   (c) No direction, as the electric field magnitude is zero on the $+x$ axis.
   (d) The direction depends on the particular value of x.

2. (6 points) A straight, insulating rod is placed on the y-axis, spanning from $y = -L/2$ to $y = +L/2$. The rod carries a nonuniform charge density,

$$\lambda = \lambda_0 \left(\frac{y}{L}\right)$$

where λ_0 is a positive constant. What is the direction of the electric field vector at point P, located on the x-axis at distance d from the rod?



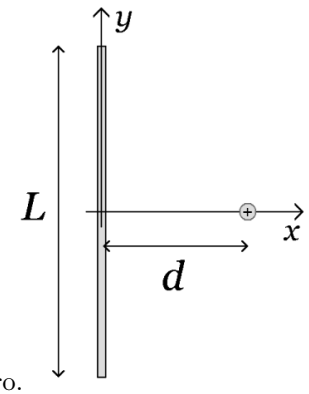
(a) $+\hat{x}$
(b) $-\hat{y}$
(c) No direction, as the electric field magnitude must be zero.
(d) $+\hat{y}$
(e) $-\hat{x}$

III. (16 points) What is the electric field magnitude at point P? If it is non-zero, express the field magnitude in terms of λ_0, y, L, d, and physical or mathematical constants, and **leave it as a definite integral; do not evaluate it!** If the field is zero, prove it.

3. (6 points) A non-uniform line segment of charge with length L is centered on the y axis. Its linear charge density, λ, depends on position, y, according to

$$\lambda = \lambda_0 y^4$$

where λ_0 is a positive constant.



A proton is placed at a position $+d$ on the x axis. What is the direction of the electric field due to the line segment of charge at the location of the proton?

(a) The electric field at the proton is in the $+x$ or $+\hat{\imath}$ direction.
(b) The electric field at the proton is in the $-x$ or $-\hat{\imath}$ direction.
(c) The electric field at the proton is in the $-y$ or $-\hat{\jmath}$ direction.
(d) The electric field at the proton has no direction, because its magnitude is zero.
(e) The electric field at the proton is in the $+y$ or $+\hat{\jmath}$ direction.

4. (6 points) In the question above, an electron is placed at a position $+d$ on the x axis, instead of a proton. What is the direction of the electric field due to the line segment of charge at the location of the electron?

(a) The electric field at the electron is in the $+y$ or $+\hat{\jmath}$ direction.
(b) The electric field at the electron has no direction, because its magnitude is zero.
(c) The electric field at the electron is in the $+x$ or $+\hat{\imath}$ direction.
(d) The electric field at the electron is in the $-y$ or $-\hat{\jmath}$ direction.
(e) The electric field at the electron is in the $-x$ or $-\hat{\imath}$ direction.

Initial:

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5. (7 points) A positive point charge q is released near a positive fixed charge Q. As q moves further away from Q, it will move with:

(a) increasing velocity and increasing acceleration.
(b) None of the others is correct.
(c) increasing velocity and decreasing acceleration.
(d) decreasing velocity and increasing acceleration.
(e) decreasing velocity and decreasing acceleration.

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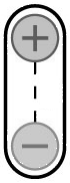
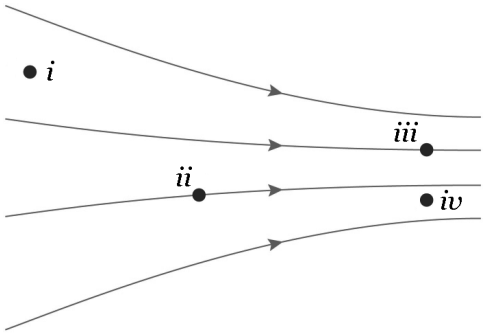
6. (7 points) An electric dipole is released from rest in the orientation shown. It is observed to rotate 90° clockwise, then move to the right. If this motion is due to an electron, where is that electron located?



(a) Up the page from the dipole.
(b) To the left of the dipole.
(c) Above the page from the dipole (that is, near you).
(d) To the right of the dipole.
(e) Down the page from the dipole.

7. (7 points) The figure shows electric field lines in a region of space. Rank in order, from greatest to least, the electric field magnitudes at points i through iv.

(a) $iv = iii > ii > i$
(b) $ii = iii > i = iv$
(c) $iii = iv > ii > i$
(d) $i > ii > iv = iii$
(e) $iii = ii > i > iv$



8. (7 points) Two neutral conducting spheres, A and B, are in contact (*Step i*). A positively charged rod is brought near, but not touching, sphere A (*Step ii*). The spheres are separated (*Step iii*), and then the rod is removed (*Step iv*). Describe the charge of each sphere after *Step iv*.

(a) A is negative, B is neutral.
(b) A is positive, B is neutral.
(c) A is negative, B is positive.
(d) A is positive, B is negative.
(e) A is neutral, B is neutral.