first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2212 K

Summer 2019

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 1–7. 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 first Reading Day, Wednesday, April 24.

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

	a	b	c	d	e
1	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
2	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
3	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
4	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
5	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
6	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
7	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
	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 $c = 2.998\times10^{8}\,\text{m/s}$

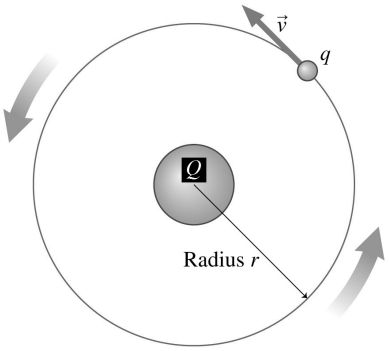
Mass of an Electron $m_{\text{e}} = 9.109\times10^{-31}\,\text{kg}$
Mass of a Proton $m_{\text{p}} = 1.673\times10^{-27}\,\text{kg}$
Vacuum Permittivity $\epsilon_0 = 8.854\times10^{-12}\,\text{C}^2/\text{N·m}^2$
Vacuum Permeability $\mu_0 = 4\pi\times10^{-7}\,\text{T·m/A}$

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

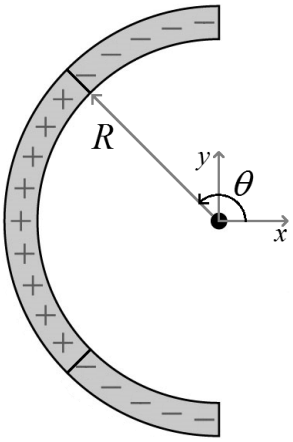
You may remove this sheet from your Quiz or Exam

Initial:

I. (16 points) A uniform sphere with charge $Q = 6.0\,\mu\text{C}$ is fixed in place. A particle with mass $m = 2.5\,\text{mg}$ and tangential speed $v = 212\,\text{m/s}$ circles the sphere in an orbit with radius $r = 1.4\,\text{m}$. What is the charge q of the particle?



1. (6 points) A plastic rod is bent into a semi-circle of radius R, as shown. It has a uniform linear charge density **magnitude** λ, but the charge density is negative from $\theta = \pi/2$ to $3\pi/4$, positive from $\theta = 3\pi/4$ to $5\pi/4$, then negative again from $\theta = 5\pi/4$ to $3\pi/2$. In what direction, if any, is the electric field at the center of the arc?



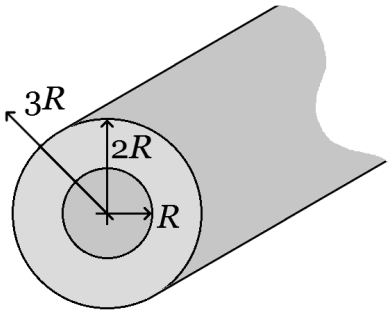
   (a) No direction, as the electric field magnitude must be zero in the center.
   (b) $+x$
   (c) $-x$
   (d) $+y$
   (e) $-y$

II. (16 points) In the problem above, find the magnitude of the electric field at the center of the arc, in terms of parameters defined in the problem and physical or mathematical constants. If the field magnitude is necessarily zero, prove it.

III. (16 points) An infinite hollow insulating cylinder has inner radius R and outer radius $2R$, as illustrated. Its volume charge density, ρ, varies with distance r from the center according to

$$\rho = \rho_0 \left(\frac{R}{r} \right)$$

where ρ_0 is a positive constant. Find the electric field magnitude at a distance $3R$ from the center in terms of parameters defined in the problem, and physical or mathematical constants.

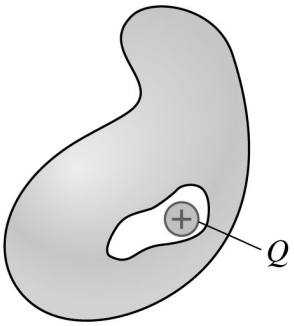


2. (6 points) In the problem above, let the magnitude of the electric field at a distance $3R$ from the center be E_0. What is the magnitude of the electric field at distance $R/3$ from the center?

   (a) $81E_0$
   (b) Zero
   (c) $E_0/9$
   (d) $E_0/3$
   (e) $9E_0$

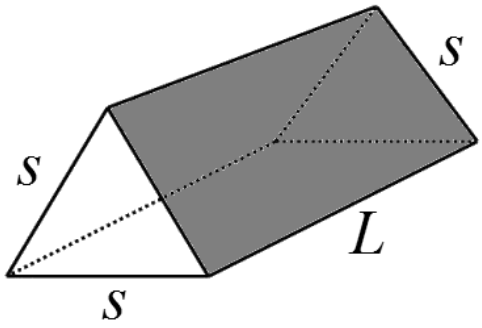
3. (8 points) A conducting object contains a hollow void. Within that void lies a particle with positive charge $+Q$, as shown. What net charge must the conducting object have if the charge on the surface of the void is twice the charge on the outer surface?

(a) $-3Q/2$
(b) $-3Q$
(c) $-Q/2$
(d) $+Q$
(e) The situation described is impossible.



4. (8 points) An equilateral prism has length L. The triangular faces have sides of length s. A uniform electric field with magnitude E_0 is directed up the page, perpendicular to the bottom face of the prism. What is the magnitude of the electric flux through the shaded face?

(a) $2E_0sL$
(b) E_0sL
(c) $E_0sL/2$
(d) $E_0sL\sqrt{2}/2$
(e) $E_0sL\sqrt{3}/2$

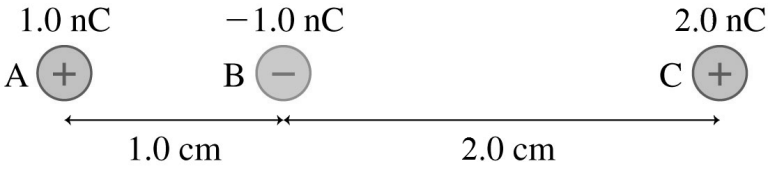


Initial:

---

5. (8 points) Three charged particles are arranged in a line, as shown. What is the magnitude of the net force on particle B?

   (a) 13.5×10^4 nN
   (b) 18.0×10^4 nN
   (c) 9.0×10^4 nN
   (d) Zero
   (e) 4.5×10^4 nN

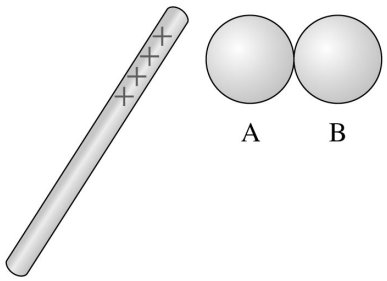


---

6. (8 points) An electric dipole is released from rest near negatively-charged particle that is fixed in place, as shown. What is the subsequent motion, if any, of the dipole?

   (a) The dipole just rotates counter-clockwise.
   (b) The dipole rotates clockwise and moves up the page.
   (c) The dipole rotates counter-clockwise and moves down the page.
   (d) The dipole remains motionless.
   (e) The dipole just rotates clockwise.

7. (8 points) Identical conducting spheres A and B are uncharged and touching. A positively-charged rod is brought near sphere A, as shown. The spheres are separated, and the rod is removed. Describe the charge on each sphere.



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