Physics 1215 – Spring 2008
Exam #2
March 7, 2008

Name (Print): Key

My signature below is a statement that all work contained in this exam is my own work. I have not copied work from any other source, or used any material other than one 3 by 5 card and my calculator.

Name (Signature):______________________________

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE INSTRUCTED TO DO SO.

STOP WORKING ON THIS EXAM AS SOON AS YOU ARE INSTRUCTED TO DO SO.

You will have approximately 1 hour to do this exam

- The following exam consists of 7 multiple-choice questions and 2 worked problems.
  - Point values are assigned to each problem in the exam.
- It is a good idea to first skim through the entire test and begin with the problems that seem most familiar. If you get stuck on a problem, skip to another.
- For the computational problems, please show all problem solving steps and all your work.
  - All work must be done on the pages provided.
  - Please write neatly and put a BOX around your final answer.
  - Use significant figures in your answers.
- Calculators may be used only to do arithmetic. You cannot use your calculator for solving algebraic equations, for graphing, for vectors, etc.
- One 3 by 5 card with written notes may be used. No books or other notes are allowed.

Problem #	Max Points	Score	Problem #	Max Points	Score
1	5		6	5	
2	5		7	5	
3	5		8	30	
4	5		9	35	
5	5		Total	100	

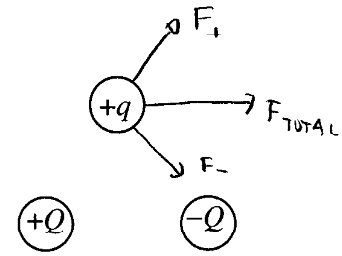
Constants

$k = 8.99 \times 10^9$ N·m^2/C^2

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N·m^2

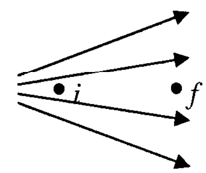
$g = 9.80$ m/s^2

1. Three charges $+q$, $+Q$, and $-Q$ are placed at the corners of an equilateral triangle as shown. The net force on charge $+q$ due to the other two charges is



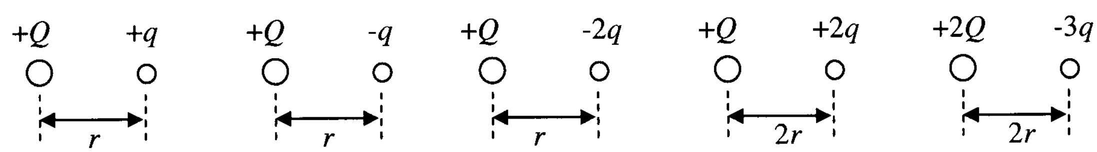
- ☐ vertically up.
- ☐ vertically down.
- ☐ horizontal to the left.
- ☒ horizontal to the right.
- ☐ zero.

2. An electric field is shown by the field lines in the figure at the right. When an electron is moved from the point marked i to the point marked f:



- ☐ the electrostatic potential increases and the electrostatic potential energy increases.
- ☐ the electrostatic potential increases and the electrostatic potential energy decreases.
- ☐ the electrostatic potential decreases and the electrostatic potential energy decreases.
- ☒ the electrostatic potential decreases and the electrostatic potential energy increases.
- ☐ the electrostatic potential and the electrostatic potential energy stay the same.

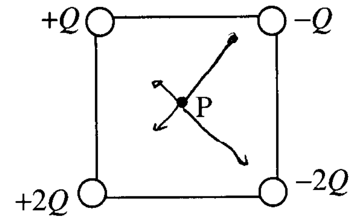
3. Two objects are separated by a distance which is either r or $2r$. In addition, one of the objects has a charge which is some multiple of Q, and the other object has a charge which is some multiple of q. In which figure below is the charge labeled with a q at the *lowest* electrostatic potential?



☐ ☐ ☐ ☒ ☐

$$V = \frac{Q}{4\pi\epsilon_0}\frac{1}{r}$$

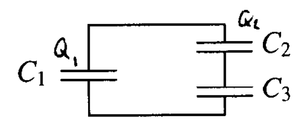
4. Objects with the charge indicated are arranged at the corners of a square as shown. When the magnitude of the electric field E, and the electric potential V, are determined at P, the center of the square, we find that



- [x] $E \neq 0$, $V = 0$
- [ ] $E = 0$, $V = 0$
- [ ] $E = 0$, $V > 0$
- [ ] $E \neq 0$, $V < 0$
- [ ] None of the above is correct

E vector
V scalar so ±2Q cancel and ±Q cancel

5. Capacitor C_1 is connected alone to a battery and charged until the magnitude of the charge on each plate is Q_0. Then it is removed from the battery and connected to two other capacitors C_2 and C_3 as shown. The final charges on the capacitors (Q_1, Q_2, and Q_3) are related by:



- [ ] $Q_0 = Q_1 + Q_2 + Q_3$
- [ ] $Q_1 + Q_2 + Q_3 = 0$
- [ ] $Q_0 = Q_1$, $Q_2 + Q_3 = 0$
- [x] $Q_0 = Q_1 + Q_2$, $Q_2 = Q_3$
- [ ] $Q_0 = Q_2 + Q_3$, $Q_1 = 0$

$Q_0 \to Q_1 + Q_2$ $\quad Q_3 = Q_2$

6. Doubling only the potential difference across a capacitor and making no other changes

- [ ] doubles its capacitance.
- [ ] halves its capacitance.
- [ ] doubles the energy of the capacitor
- [ ] halves the charge stored on the capacitor
- [x] none of the above

$U = \frac{1}{2} C V^2$

$Q = CV$

7. A parallel plate capacitor with air between the plates is charged to a potential V and then isolated. A dielectric with dielectric constant of 4 is placed between the plates of the capacitor. What happens to the energy stored in the capacitor?

- [ ] It decreases by a factor of 16
- [x] It decreases by a factor of 4
- [ ] It increases by a factor of 2
- [ ] It increases by a factor of 4
- [ ] It increases by a factor of 16

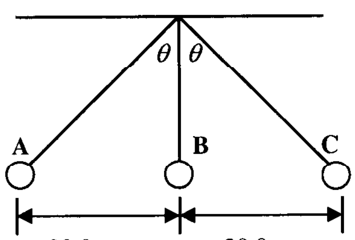
$U = \frac{1}{2} C V^2 = \frac{1}{2} \frac{Q^2}{C}$

isolated ⇒ Q stays the same

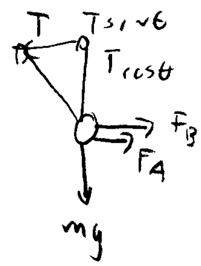
$U = \frac{1}{2} Q^2 \frac{d}{\varepsilon_0 k A}$

k goes from 1 to 4

8. Three identical spheres with mass 0.100 kg hang from insulating strings as shown in the figure on the right. Each sphere carries the same charge of $Q = +3.00\ \mu C$ and the distance between each sphere is 20.0 cm. What is the angle θ between the string holding sphere **C**, and the vertical string holding sphere **B**?



Draw FBD of C



$$F_B = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{r_B^2}$$

$$= \left(8.99\times10^9\ \frac{N\cdot m^2}{C^2}\right)\frac{(3\times10^{-6}\,C)^2}{.20m^2} = 2.02N$$

$$F_A = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{r_A^2}$$

$$= \left(8.99\times10^9\ \frac{N\cdot m^2}{C^2}\right)\frac{(3\times10^{-6}\,C)^2}{(.40m)^2} = .506\ N$$

in x: $T\sin\theta = F_B + F_A$ ①   in y: $T\cos\theta = mg$ ②

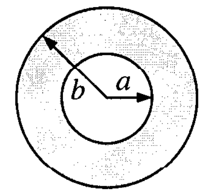
DIVIDE ① BY ②

$$\tan\theta = \frac{F_B + F_A}{mg}$$

$$\theta = \tan^{-1}\left(\frac{F_B + F_A}{mg}\right) = \tan^{-1}\frac{(2.02\ N + .506\ N)}{(.100\ kg)(9.8\ m/s^2)}$$

$$= \boxed{68.8^\circ}$$

9. A nonconducting spherical shell has an inner radius of a and an outer radius of b, as shown. The shell is filled with a uniform volume charge density of ρ.
a) Find the electric field at a radius R, for (i) $R>b$, (ii) $a<R<b$, and (iii) $R<a$.
b) Find the electric potential ~~in the same three regions~~. at point b if
(Please show all of your work on this problem to get credit.) $V=0$ at ∞



a) Use Gauss's Law

$V = \frac{4}{3}\pi r^3$

$dV = 4\pi r^2 dr$

(i) $\oint \vec{E}\cdot\vec{A} = \frac{q_{encl}}{\varepsilon_0} = \frac{1}{\varepsilon_0}\int_a^b \rho\, dV = \frac{1}{\varepsilon_0}\int_a^b \rho\, 4\pi r^2 dr$

$4\pi r^2 E = \frac{4\pi\rho}{\varepsilon_0}\frac{r^3}{3}\Big|_a^b = \frac{4}{3}\frac{\pi\rho}{\varepsilon_0}(b^3-a^3)$

$\boxed{\vec{E} = \frac{\rho}{3\varepsilon_0}\frac{(b^3-a^3)}{r^2}\hat{r}}$

(ii) $\oint \vec{E}\cdot d\vec{A} = \frac{1}{\varepsilon_0}\int_a^r \rho 4\pi r^2 dr$

$4\pi r^2 E = \frac{4\pi\rho}{3\varepsilon_0}(r^3-a^3)$

$\boxed{\vec{E} = \frac{\rho}{3\varepsilon_0}\frac{r^3-a^3}{r^2}\hat{r}}$

iii) $\oint E\cdot dA = \frac{q_{enc}}{\varepsilon_0} = 0 \Rightarrow \boxed{E=0}$

b) $\Delta V = -\int_\infty^b \frac{\rho}{3\varepsilon_0}(b^3-a^3)\frac{dr}{r^2} = \frac{\rho}{3\varepsilon_0}\frac{(b^3-a^3)}{r}\Big|_\infty^b = \boxed{\frac{\rho}{3\varepsilon_0}\frac{(b^3-a^3)}{b}}$