July 28th, 2008

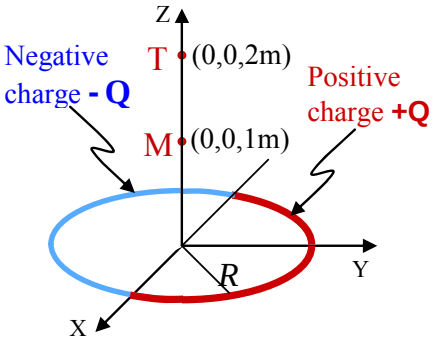
# Physics 212
# Exam #1

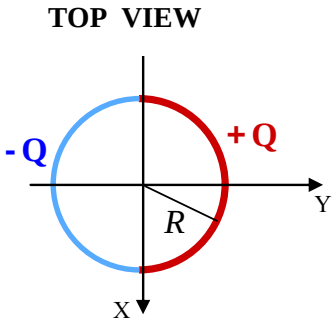
NAME _____

Please sign and write down your name also on the back of the last page of this exam

Use $1/4\pi\varepsilon_0 = 9 \times 10^9$ N.m$^2$/C$^2$ , g = 10 m/s$^2$

**1.** A ring of radius R= 1 m has charge distributed as shown in the figure. Assume that |Q| = 1 μC, and that the positive and negative charges are uniformly distributed over half of the ring, respectively.




**1A** Circle all the expression(s) that is(are) correct.

**a)** The magnitude of the electric potential at T is greater than the magnitude of the electric field at M.

**b)** The electric field at T is zero.

**c)** The electric potential at M is zero.

**d)** The magnitude of the electric field at T is greater than the magnitude of the electric field at M.

**e)** All the expressions above are incorrect.

**1B** The external work needed to take an electron from M to T is equal to:

**a)** 0 **b)** 6.36 x 10$^3$ J **c)** 5.20 x 10$^3$ J **d)** 1.16 x 10$^3$ J **e)** NA

---

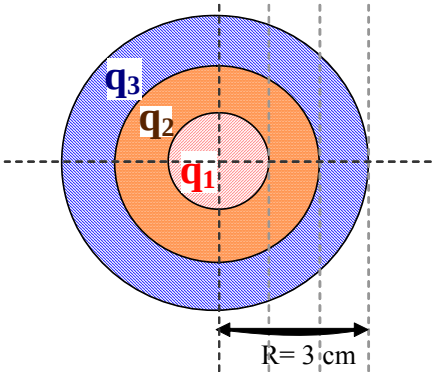
**2.** A sphere of radius R=3 cm has charge distributed as shown in the figure below.
From r =0 to r =1 cm the total charge uniformly distributed is $q_1$= 1 μC;
from r =1 cm to r =2 cm the total charge uniformly distributed is $q_2$= 2 μC;
from r =2 cm to r =3 cm the total charge uniformly distributed is $q_3$= 3 μC;.

**2A** The magnitude of the electric field at a distance 6 cm from the center of the sphere is equal to (in units of N/C):

**a)** 9 x 10$^5$ **b)** 1.83 x 10$^7$ **c)** 2.5 x 10$^5$ **d)** 1.5 x 10$^7$ **e)** NA

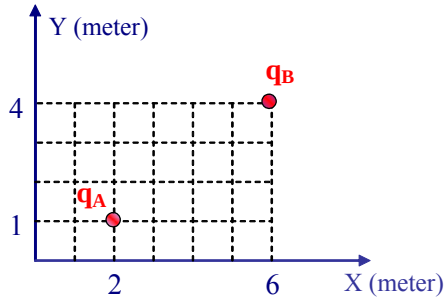
**2B** The magnitude of the electric field at a distance r =1.5 cm from the center of the sphere is equal to (in units of $10^7$ N/C):

**a)** 0.25 **b)** 6.71 **c)** 1.45 **d)** 2.7 **e)** NA




---

**3.** The figure at the right shows two positive point-charges, $q_A$ = - 10 μC and $q_B$ = +25 μC.




**3A** The <u>magnitude</u> of the electrostatic force $\mathbf{F}_{BA}$ acting on the charge $q_B$ due to $q_A$ is equal to (in units of Newton):

**a)** 0.67 **b)** 1.344 **c)** 0.09 **d)** 0.50 **e)** NA

**3B** The <u>vector</u> force $\mathbf{F}_{BA}$ acting on the charge $q_B$ due to $q_A$ is equal to (in units of Newton):

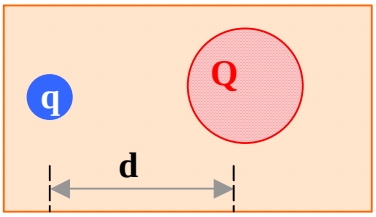
**a) (-** 0.18 **, -** 0.18 **)** **b) (-** 0.072 **, -** 0.054 **)** **c) (-** 1.67 **, -** 0.67 **)**

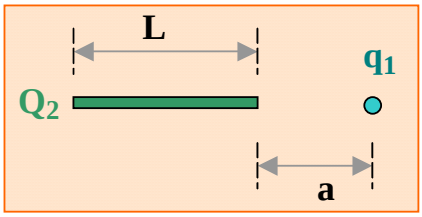
**d) (** 0.1 **,** 0.14**)** **e)** NA

---

**4.** **4A** The figures below show <u>two separate cases</u>, where all the different objects have positive charge uniformly distributed; **Q** > q and $\mathbf{Q_2} > q_1$. The figure on the left shows two solid spheres, of different radius, separated by a distance "d". The figure on the right shows a small solid sphere in front of a thin bar of length "L".

Assuming that the charges are uniformly distributed all over the volume of the corresponding object, indicate which of the following statement(s) is (are) correct:




**a)** The magnitude of the electrostatic force acting on the sphere of charge Q is greater than the magnitude of the electrostatic force acting on the sphere of charge q.

**b)** The magnitude of the electrostatic force acting on the sphere of charge Q is lower than the magnitude of the electrostatic force acting on the sphere of charge q.

**c)** The magnitude of the electrostatic force acting on the thin bar of charge $Q_2$ is:

$$\boldsymbol{F} = \frac{1}{4\pi\varepsilon_0}\frac{\boldsymbol{Q_2 q_1}}{\left(a+\frac{L}{2}\right)^2}$$

**d)** The magnitude of the electrostatic force acting on the sphere of charge $q_1$ is:

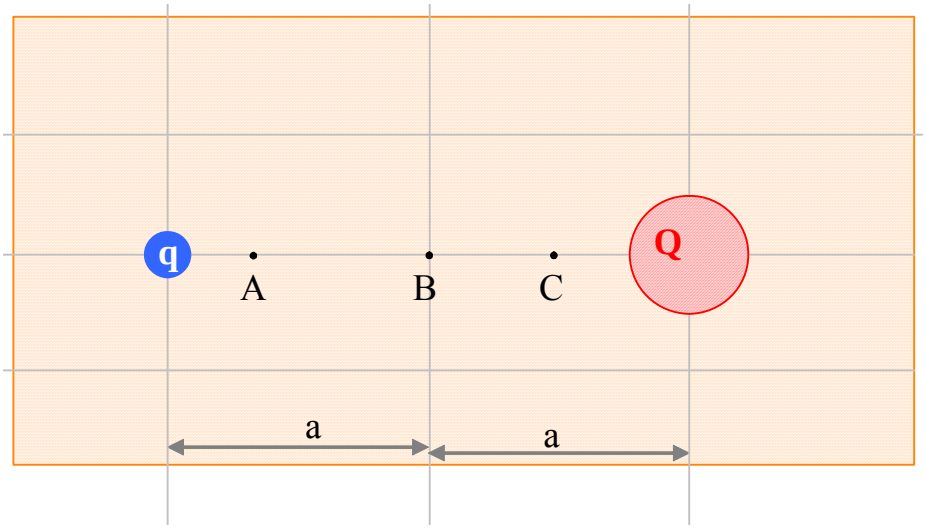
$$\boldsymbol{F} = \frac{1}{4\pi\varepsilon_0}\frac{\boldsymbol{Q_2 q_1}}{a^2}$$

**e)** All the expressions above are incorrect.

**4B** The figure below shows two spherical shells with positive charge uniformly distributed, where Q = 3 q.

***i)*** Sketch the electric field lines in the region outside the objects (draw more than 6 electric field lines spread all over the space in each case).

***ii)*** Draw three equi-potential lines passing through the s A, B, and C respectively.

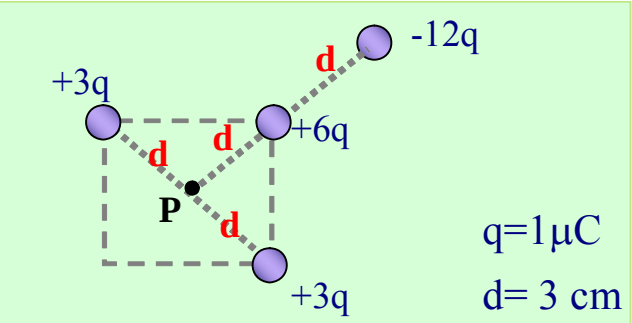


**5.** **5A** In the figure shown below, the magnitude of the electric field at point "P" due to the four point charges is equal to (in units of N/C):

**a)** 0.2 x $10^{12}$ **b)** 1.2 x $10^{12}$ **c)** 0.3 x $10^{8}$ **d)** 0 **e)** NA

**5B** In the figure shown below, what is the electric potential at point "P", if V=0 at infinity (in units of $10^{6}$ Volt)?

**a)** 0 **b)** - 1.2 **c)** 1.8 **d)** 4.3 **e)** NA




---

**6.** There exist an electric field $\vec{E} = (3\ \text{N/C} + 5x\ \text{N/mC})\,\vec{i}$ (pointing in the positive X direction all over the place.) The figure shows a Gaussian surface.

**6A** The electric flux through the Gaussian surface is (in units of $Nm^2/C$):

**a)** 40 **b)** 20 **c)** 0 **d)** - 40 **e)** NA

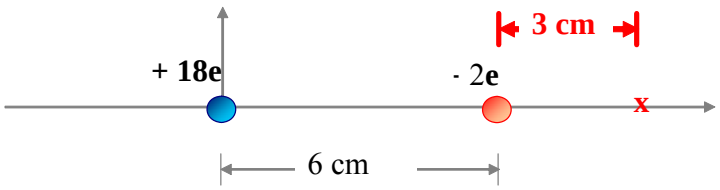
**6B** The total charge inside the Gaussian surface is (in units of $10^{-10}$C):

**a)** 22 **b)** 6.3 **c)** 12 **d)** 1.7 **e)** NA

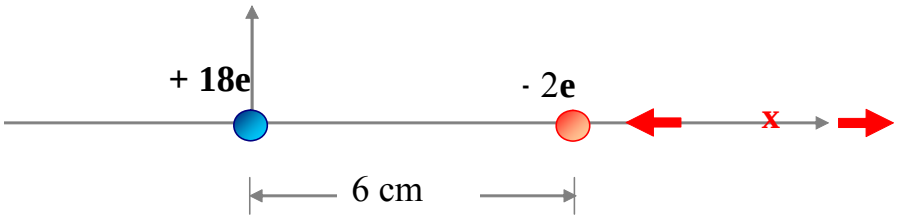
---

**7.** The figure below shows two particles fixed in place: a particle of positive charge +18e at the origin, and a particle of negative charge -2e at 6 cm far away. Here e is the magnitude of the charge of an elementary charge.

**7A** At what point along the axis that joins the charges (other than infinite far away) can a proton be placed so that it is in equilibrium? Indicate your answer with an "x" drawn in the graph provided above. Indicate explicitly also the distance between the proton and the closest charge



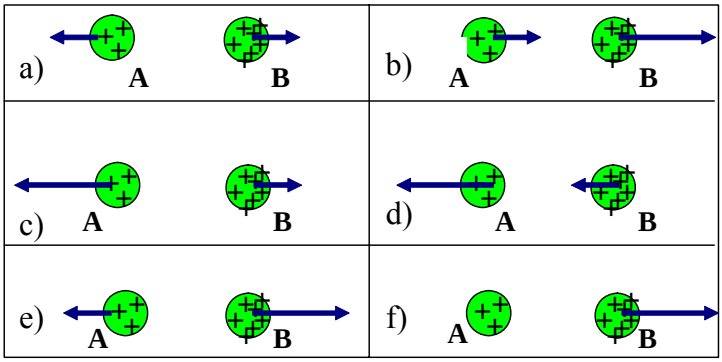
**7B** Draw the electric fields that exist *i)* at 1 cm to the left and *ii)* at 1 cm to the right of the proton's position found in part 1A above.



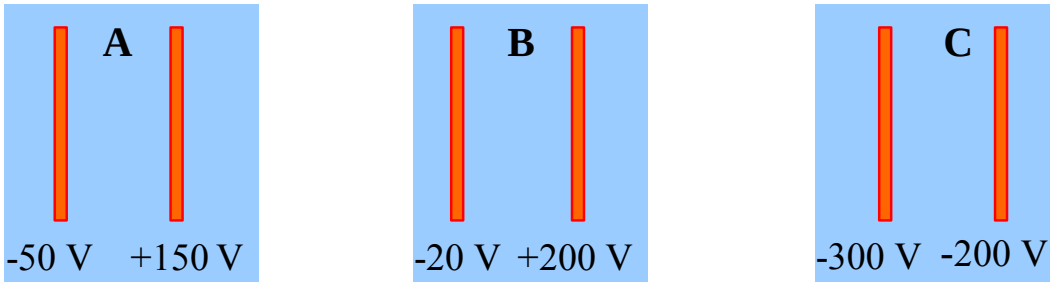

---

**8.** **8A** The figures show two uniformly charged spheres. The positive charge on sphere B is 2 times the positive charge on sphere A. Which force diagram correctly shows the magnitude and direction of the electrostatic forces acting on each sphere?

**a)** **b)** **c)** **d)** **e)** **f)**




**8B** The figure shows three pairs of parallel plates with the same separation, and the electric potential at each plate. The electric field between the plates is uniform and perpendicular to the plates. Rank the pairs according to the magnitude of the electric field between the plates, greatest first.

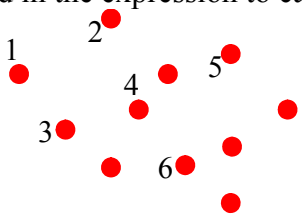



**a)** B, A, C **b)** C, B, A **c)** A, B, C **d)** A, C, B **e)** NA

---

**BONUS QUESTION**

**B.1 (5 points on the scale of 100)** A system consists of 100 point charges. To calculate the potential energy of the system, How many terms of the form $kq_iq_j/r_{ij}$ is expected to be included in the expression to calculate the total potential energy of the system?




Answer: 4950

---

**Some formulas:**

- $\mu = 10^{-6}$ nano $= 10^{-9}$
- **Coulomb's Law:** $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_2\, q_1}{r^2}\ \vec{u}$
- Electric field, along the z-axis, due to a charge Q distributed uniformly along a thin ring of radius R.: $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q\ z}{\left(z^2 + R^2\right)^{3/2}}\ \hat{k}$
- For an infinite uniformly charged sheet: $E = \sigma / 2\varepsilon_o$
- **Gauss' Law**
  $\Phi = \int_S \vec{E} \bullet d\vec{s} = q/\varepsilon_o$ , where q is the net charge inside the gaussian surface
- **Definition of Electric Potential** $V(r) = \frac{W_{ext}(\infty \xrightarrow[q_0]{} r)}{q_0}$
- Potential difference $V_B - V_A = -\int_A^B \vec{E} \cdot d\ \vec{s}$
- Electric potential due to a point charge q: $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$
- Relationship between E and V: $E_x = -\ dV/dx$
- **About capacitance**

  $Q = C\ V$

  For a parallel-plate capacitor $C = A\varepsilon_o / d$

  $U = CV^2 / 2 = Q^2 / 2\ C$

  Capacitors connected in parallel $C_{equiv} = C_1 + C_2 + C_3$

  Capacitors connected in series $1/C_{equiv} = (1/C_1) + (1/C_2) + (1/C_3)$

  **When filing a capacitor with a dielectric:** Capacitance increases by a factor of k
- $\int \sin\theta\ d\theta = -\cos\theta$ $\int Cos\theta\, d\theta = \sin\theta$