Physics 241
Fall 2008
Exam 1

October 1, 2008

Giving information to or receiving information from another person while taking this exam is cheating. To intentionally do anything that would cause the level of your knowledge of the material to be misrepresented is cheating. Anyone found to be cheating will receive an F for the course and their names will be forwarded to the Dean of Students.

Physics 241, Exam 1
Equation Sheet

$k = 9\cdot10^{9}\,\frac{Nm^2}{C^2}$ $\quad k = \frac{1}{4\pi\varepsilon_o}$ $\quad \varepsilon_o = 9\cdot10^{-12}\,\frac{C^2}{Nm^2}$ $\quad 1eV = 1.6\cdot10^{-19}J$ $\quad e = 1.6\cdot10^{-19}C$

$\vec{F} = k\frac{q_1q_2}{r^2}\hat{r}$ $\quad \vec{E} = k\frac{q_1}{r^2}\hat{r}$ $\quad \vec{E}(p) = \sum \vec{E}_{ip}$ $\quad d\vec{E} = k\frac{dq_1}{r^2}\hat{r}$ $\quad \vec{E} = \frac{\sigma}{\varepsilon_o}$ $\quad \Delta\vec{E} = \frac{\sigma}{\varepsilon_o}$

$\phi = \int_S \vec{E}\cdot\hat{n}\,dA$ $\quad \oint_S \vec{E}\cdot\hat{n}\,dA = \frac{Q}{\varepsilon_o}$ $\quad \Delta V = V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{l}$ $\quad dU = -\vec{F}\cdot d\vec{l}$ $\quad \vec{F} = q\vec{E}$

$dV = \frac{dU}{q_o} = -\vec{E}\cdot d\vec{l}$ $\quad V = \frac{kq}{r}$ $\quad V = \sum\frac{kq_i}{r_i}$ $\quad E_x = -\frac{dV}{dx}$ $\quad E_y = -\frac{dV}{dy}$ $\quad E_z = -\frac{dV}{dz}$

$\vec{E} = -\frac{\Delta V}{\Delta\vec{r}}$ $\quad V = \int\frac{k\,dq}{r}$ $\quad C = \frac{Q}{V}$ $\quad C = \frac{\varepsilon_o A}{d}$ $\quad V = \frac{Qd}{\varepsilon_o A}$ $\quad U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV = \frac{1}{2}CV^2$

$u = \frac{1}{2}\varepsilon_o E^2$ $\quad \varepsilon = \kappa\,\varepsilon_o$

$\int\cos(\theta)\,d\theta = sin(\theta)$ $\quad \int sin(\theta)d\theta = -\cos(\theta)$ $\quad \int\frac{dr}{r^2} = -\frac{1}{r}$ $\quad \int\frac{dr}{r} = \ln(r)$ $\quad \int r\,d\theta = r\theta$

$\int dr = r$ $\quad \int r\,dr = \frac{r^2}{2}$

Question 1

What is the magnitude of the electric field at point P?

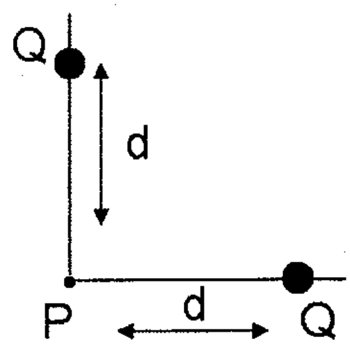
(a) $\frac{1}{4\pi\varepsilon_0}\frac{2Q^2}{d^2}$

(b) $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{d^2}$

(c) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{2}Q}{d^2}$

(d) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{2}Q}{d}$

(e) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{\sqrt{2}d}$



Question 2

What is the electric potential difference at point P?

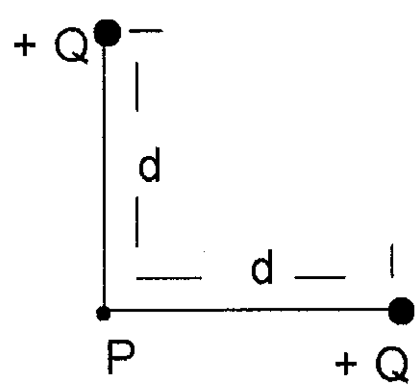
a) $\frac{1}{4\pi\varepsilon_0}\frac{2Q}{d}$

(b) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d^2}$

(c) $\frac{1}{4\pi\varepsilon_0}\frac{2Q^2}{d}$

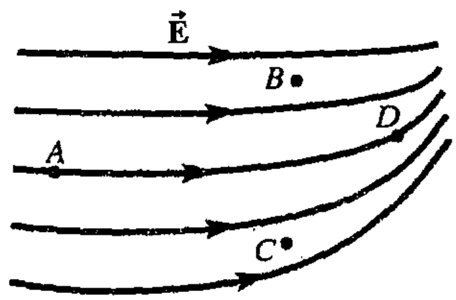
(d) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{\sqrt{2}d}$

(e) $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{d^2}$



Question 3

In the diagram, which two points are closest to being at the same potential?

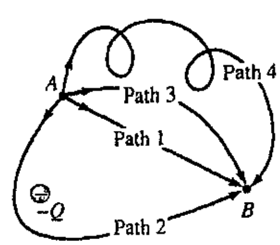


(a) A and D
(b) B and C
(c) B and D
(d) A and C
(e) Potential is not defined here

Question 4

A large negative charge –Q is located in the vicinity of points A and B. Suppose a positive charge +q is moved at constant speed from A to B by an external agent. Along which of the paths shown in the figure will the work done by the field be the greatest?

(a) path 1
(b) path 2
(c) path 3
(d) path 4
(e) work is the same along all four paths.



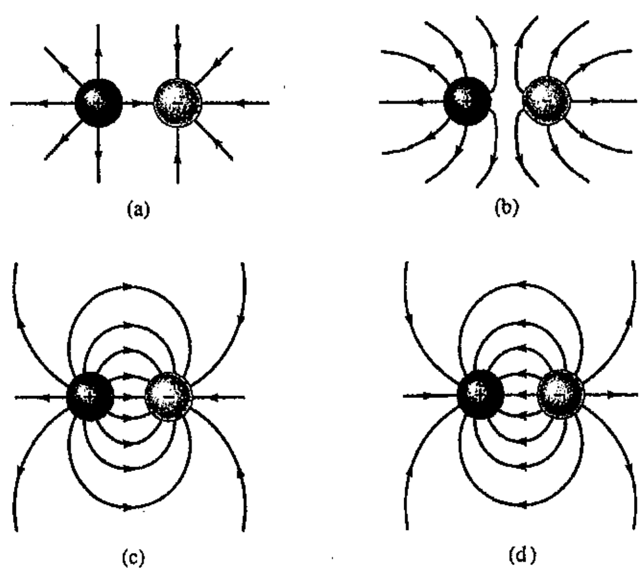
Question 5

The electric charge on a conductor is

(a) uniformly distributed throughout the volume.
(b) confined to the surface and is uniformly distributed.
(c) mostly on the outer surface, but is not uniformly distributed.
(d) entirely on the surface and is distributed according to the shape of the object.
(e) dispersed throughout the volume of the object and distributed according to the object's shape.

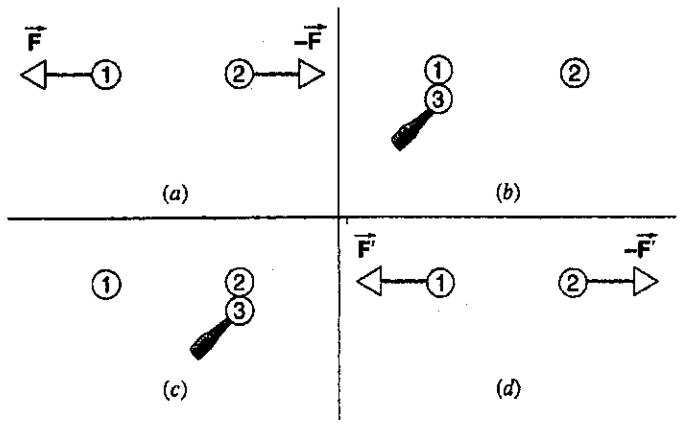
Question 6

In the figure, which best represents the field lines due to two spheres with equal and opposite charges?



Question 7

Two identical conducting spheres, 1 and 2, carry equal amounts of charge and are fixed a distance apart that is large compared with their diameters (shown in part a). The spheres repel each other with an electrical force of F. Suppose now that a third identical sphere 3, having an insulating handle and initially uncharged, is touched first to sphere 1(shown in part b), then to sphere 2 (shown in part c), and finally removed (shown in part d). Find the force between spheres 1 and 2 now.



(a) $\frac{1}{2}$ F

(b) $\frac{3}{4}$ F

(c) $\frac{3}{8}$ F

(d) $\frac{1}{16}$ F

(e) same F

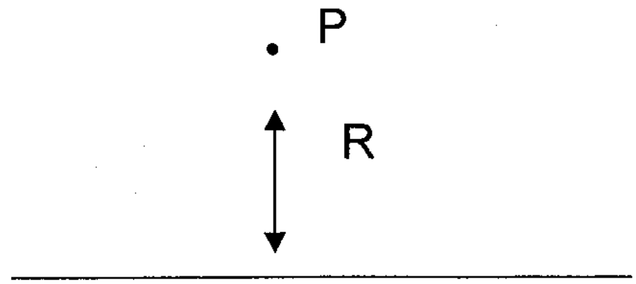
Question 8

The nucleus of an iron atom has a radius of $4 \bullet 10^{-15}$m and contains 26 protons. What is the magnitude of the electrostatic force between two protons separated by one radius?

(a) $1.4\ 10^{-6}$ N
(b) 14 N
(c) $5.2\ 10^{-4}$ N
(d) $3.6\ 10^{2}$ N
(e) $3.6\ 10^{5}$ N

Question 9

Use Gauss's Law to find the magnitude of the electric field at a point P a distance R from an infinitely long straight wire. The wire has a uniform charge density λ per unit length.



(a) $E = \frac{1}{2\pi\varepsilon_0} \lambda R^2$

(b) $E = \frac{1}{2\pi\varepsilon_0} \lambda R$

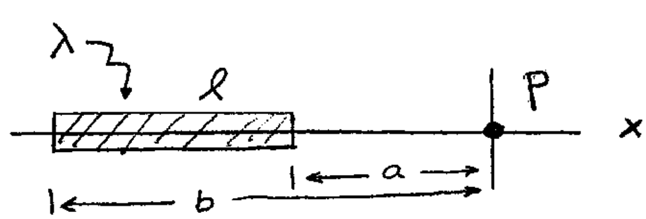
(c) $E = \frac{1}{4\pi\varepsilon_0} \lambda ln(R)$

(d) $E = \frac{1}{4\pi\varepsilon_0} \frac{\lambda}{R^2}$

(e) $E = \frac{1}{2\pi\varepsilon_0} \frac{\lambda}{R}$

Question 10

Find the electric **potential** due to a rod of length ℓ at point **P**, with uniform charge density λ, as shown in the Figure.



(a) $\frac{\lambda}{4\pi\varepsilon_0} \ln(b/a)$

(b) $\frac{1}{4\pi\varepsilon_0} \frac{(b-a)\lambda}{\ell^2}$

(c) $\frac{1}{4\pi\varepsilon_0} 3\lambda\left(\frac{b}{a}\right)^2$

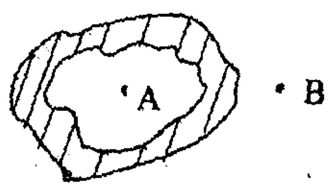
(d) $\frac{1}{4\pi\varepsilon_0} \frac{\lambda\ell}{(b-a)}$

(e) $\frac{1}{4\pi\varepsilon_0} \frac{\lambda\ell}{(b-a)^2}$

Question 11

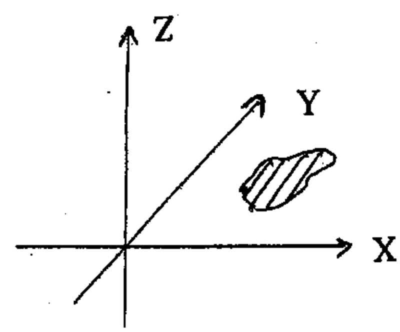
A conducting shell carries a total charge of +4 μC. A point charge A of +3 μC is inside the shell; a point charge B of -2 μC is outside the shell. What is the total charge on the outer shell of the conductor?

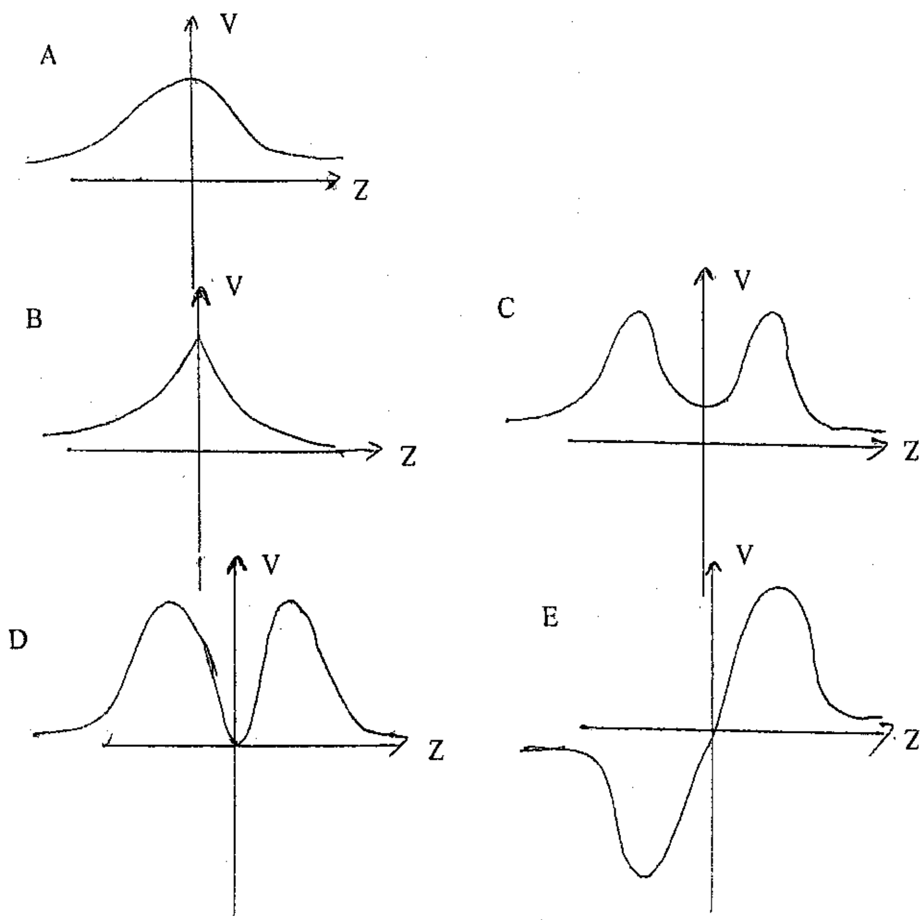
(a) +2 μC
(b) +1 μC
(c) +5 μC
(d) -5 μC
(e) +7 μC



Question 12

A plate carrying a uniform positive charge lies on the x-y plane **away** from the z-axis, as shown in the Figure. Which of the following graphs describes the electric **potential** on the z-axis? Note: The z-axis **does not** pass through the charge distribution.

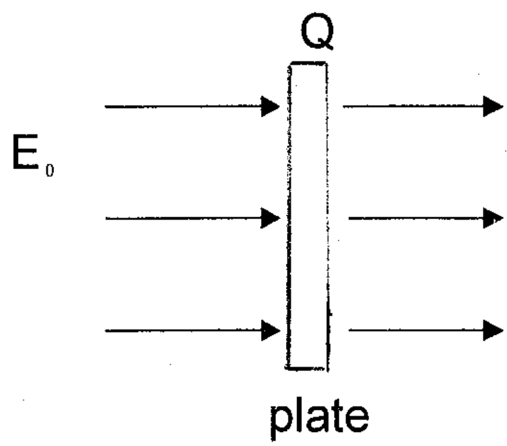




Question 13

Each side of a metal plate has a surface area of 0.1 m^2. The total charge on the plate is +10 nC, or +5 nC on each surface. It is placed in a uniform electric field of 10^4 V/m, with both surfaces perpendicular to the electric field. What are the final charges on each surface?

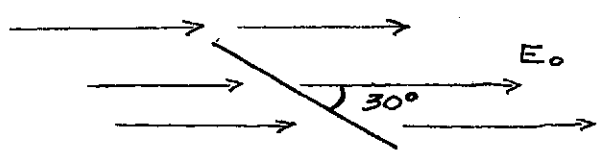
(a) -9 nC +9 nC
(b) -9 nC +19 nC
(c) -4 nC +14 nC
(d) -5 nC +9 nC
(e) -3.5 nC +8.5 nC



Question 14

A flat sheet of paper of area 0.25 m^2 is oriented so that the plane of the sheet is at an angle of 30° (as shown in the diagram) to a uniform electric field of magnitude 14 N/C. What is the magnitude of the electric flux through the sheet?

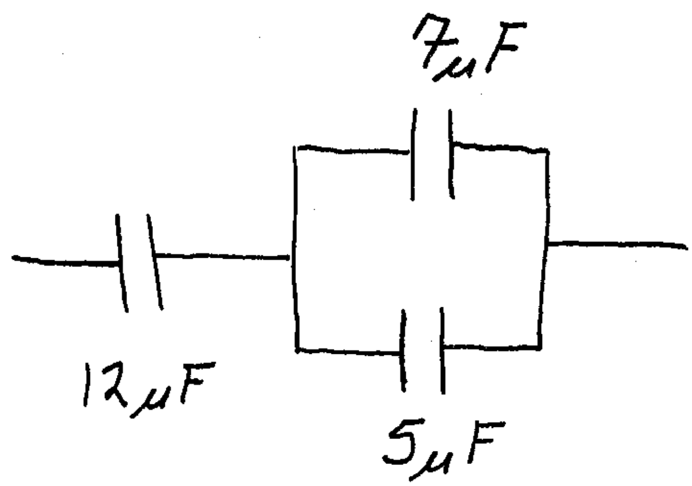
(a) 3.0 Nm^2/C
(b) 1.8 Nm^2/C
(c) 0
(d) 3.5 Nm^2/C
(e) 14 Nm^2/C



Question 15

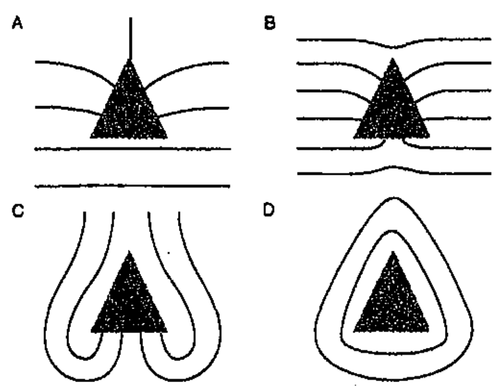
What is the equivalent capacitance of the circuit?

(a) 2 μF
(b) 6 μF
(c) 9 μF
(d) 12 μF
(e) 24 μF



Question 16

A triangular conductor is placed in an originally uniform electric field. Which picture best represents the static **equipotential** lines near the conductor?



Question 17

A point charge q is located a distance **a** from the center of a sphere of radius **2a**. A charge Q is distributed uniformly throughout the volume of the sphere. What is the magnitude of the electrostatic force between the point charge q and the sphere?

(a) $F = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{a^2}$

(b) $F = \frac{1}{8\pi\varepsilon_0}\frac{qQ}{a^2}$

(c) $F = \frac{1}{16\pi\varepsilon_0}\frac{qQ}{a^2}$

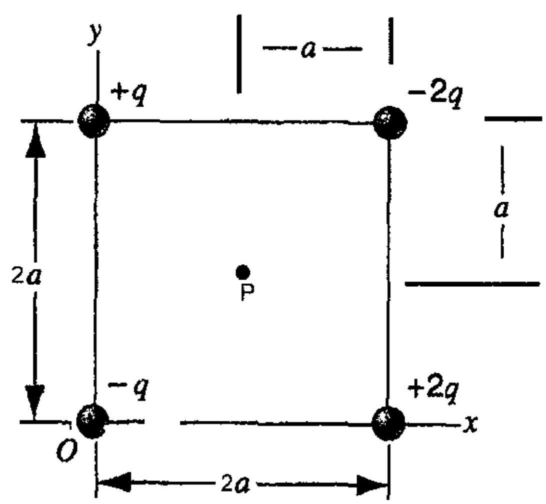
(d) $F = \frac{1}{32\pi\varepsilon_0}\frac{qQ}{a^2}$

(e) $F = \frac{1}{36\pi\varepsilon_0}\frac{qQ}{a^2}$

Question 18

Find the magnitude of the electric field at the center of the square in the figure if $q = 8nC$ and a = 0.1 m.

(a) $3.6 \cdot 10^3$N/C
(b) $5.1 \cdot 10^3$N/C
(c) $7.2 \cdot 10^3$N/C
(d) $1.4 \cdot 10^4$N/C
(e) $2.2 \cdot 10^4$N/C



Question 19

A thin glass rod is bent into a semicircle of radius r. The rod has a uniform charge per unit length $+\lambda$ on the upper half and $-\lambda$ on the low half. Find the magnitude of the electric field at P.

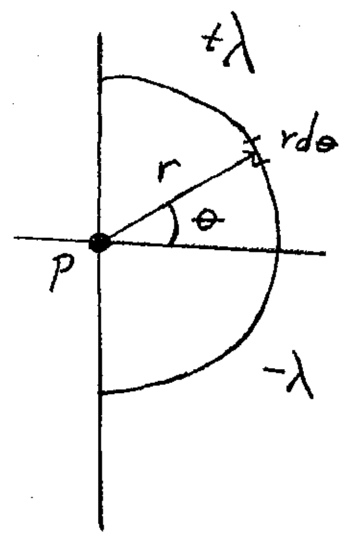
(a) 0

(b) $k\frac{2\lambda}{r^2}$

(c) $k\frac{\lambda}{\sqrt{2}r}$

(d) $\frac{4k}{3}\frac{\lambda}{r}$

(e) $2k\frac{\lambda}{r}$



Question 20

The electric potential varies along the x-axis as shown in the graph. Of the intervals shown, determine the interval in which E_x has its greatest value.

(a) 15 V/m
(b) 12 V/m
(c) 7 V/m
(d) 6 V/m
(e) 3 V/m