Physics 241
Fall 2009
Exam 1

September 30, 2009

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.

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Sign Name **Student ID**

If during the exam you feel there is an equation that should be on the equation sheet contact one of the exam proctors. Your request will be considered and placed before all the students, if your request is deemed acceptable.

If you feel any of the questions are ambiguous or unclear, complete the problems according to your interpretation of the problem. Include all your work and calculations clearly. Turn in the paper version of the exam along with your optical scan sheet. This will allow you to argue your case, if your solution does not agree with that given as the answer.

Physics 241, Exam 1
Equation Sheet

$k = 9 \bullet 10^9 \dfrac{Nm^2}{C^2}$ $\quad k = \dfrac{1}{4\pi\varepsilon_o}$ $\quad \varepsilon_o = 9 \bullet 10^{-12} \dfrac{C^2}{Nm^2}$ $\quad 1eV = 1.6 \bullet 10^{-19} J$ $\quad e = 1.6 \bullet 10^{-19} C$

$\vec{F} = k\dfrac{q_1 q_2}{r^2}\hat{r}$ $\quad \vec{E} = k\dfrac{q_1}{r^2}\hat{r}$ $\quad \vec{E}(p) = \sum \vec{E}_{ip}$ $\quad d\vec{E} = k\dfrac{dq_1}{r^2}\hat{r}$ $\quad E = \dfrac{\sigma}{\varepsilon_o}$ $\quad \Delta E = \dfrac{\sigma}{\varepsilon_o}$

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

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

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

$u = \dfrac{1}{2}\varepsilon_o E^2$ $\quad \varepsilon = \kappa\varepsilon_o$ $\quad \vec{E} = -\vec{\nabla}V$

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

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

Question 1.

A 20 pC ($20x10^{-12}$C) point charge q is placed next to another charge Q of 1 C at a distance $\boldsymbol{d}$ as shown. What is the ratio F_q/F_Q of the magnitude of the electric force acting on q to that of the electric force acting on Q?

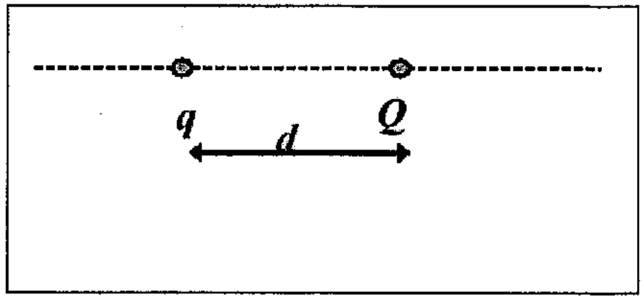
a) $20x10^{-12}$C

b) $4.5x10^{-6}$C

c) 1

d) $2.2x10^{5}$C

e) $5x10^{10}$C



Question 2.

In the region of space where there is a non-uniform electric field E as shown, how will the dipole move?

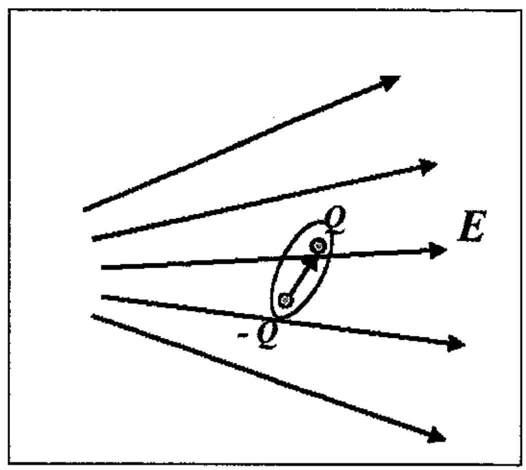
a) The dipole moves oscillates back and forth with respect to E.

b) Dipole moves towards smaller E

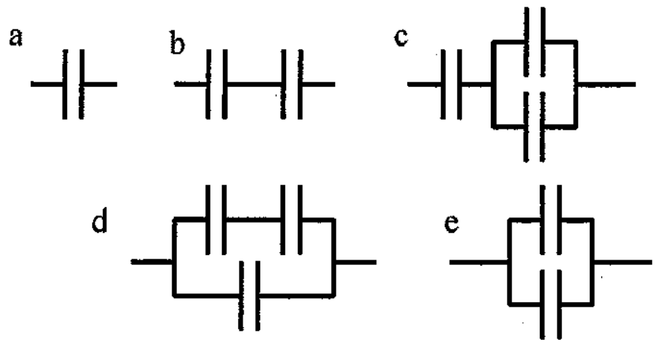
c) Dipole moves toward larger E

d) Dipole moment aligns with E and moves towards large E

e) Dipole moment aligns with E and moves towards smaller E



Question 3.
In the Figure all the capacitors are identical. Which combination has the largest equivalent capacitance?



Question 4
The upper half of a ring is uniformly charged with a positive charge density $+\sigma$, while the lower half is uniformly charged with a charge density of $-\sigma$. What is the direction of the electric field at the point X on the perpendicular axis of the ring as shown?

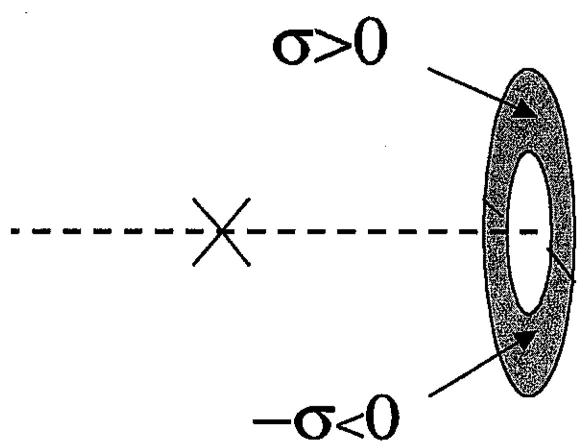
a) **E** is Zero

b) To the Right

c) To the Left

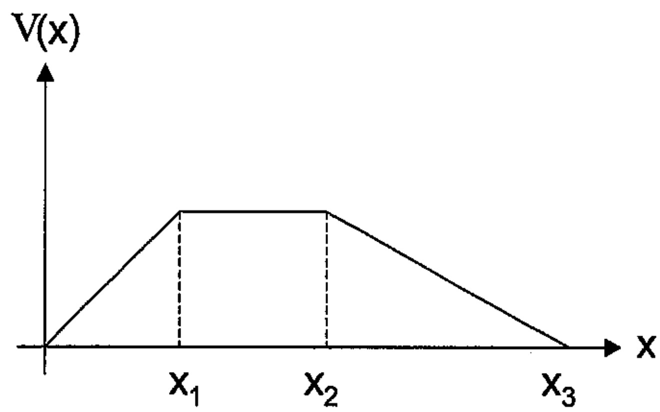
d) Up

e) Down

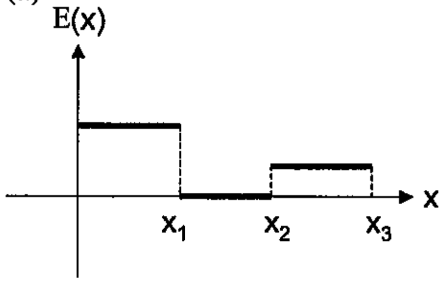


Question 5.

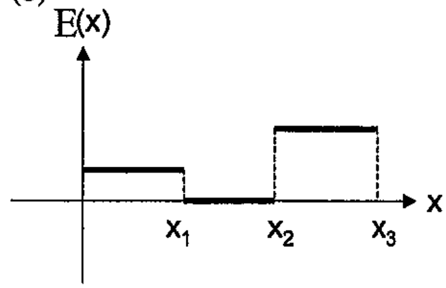
The graph on the right shows the electric potential, V(x) as a function of distance x. Which of the graphs represents the electric field, **E**(x)?

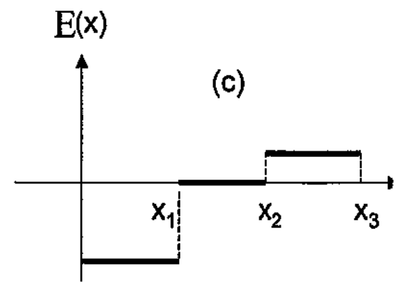


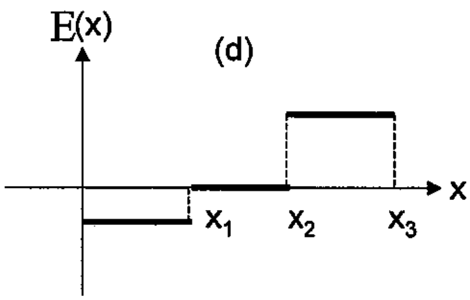
(a)

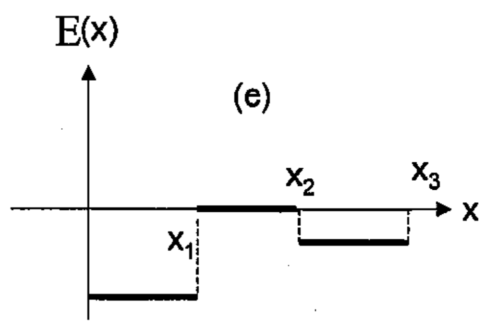


(b)

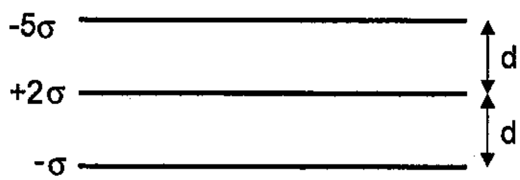








Question 6.



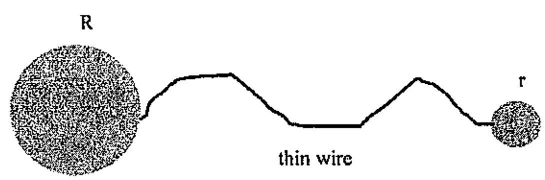
Three very large non-conducting charged planes are parallel to each other with the shown charge densities. If the plane at the bottom has an electric potential of zero, what is the electric potential of the plane in the middle?

(a) $+\sigma\frac{d}{\varepsilon_o}$ (b) $-3\sigma\frac{d}{\varepsilon_o}$ (c) $-4\sigma\frac{d}{\varepsilon_o}$

(d) $-\sigma\frac{d}{\varepsilon_o}$ (e) $+2\sigma\frac{d}{\varepsilon_o}$

Question 7

Two conducting spheres are placed far apart but are connected by a thin and negligible conducting wire. A charge Q is place on the spheres. What is the ratio E_r/E_R of the electric fields on the surface of the spheres?
(hint $Q = Q_R + Q_r$)



a) $\frac{E_r}{E_R} = \frac{R-r}{R+r}Q^2$ b) $\frac{E_r}{E_R} = \frac{R-r}{R+r}$ c) $\frac{E_r}{E_R} = \frac{r}{R}$

d) $\frac{E_r}{E_R} = \frac{R}{r}$ e) $\frac{E_r}{E_R} = \frac{R}{r}Q$

Question 8.

Two charged, parallel flat conducting plates are spaced 1 cm apart. The potential difference between the plates is 500 volts. An electron is projected from one surface directly towards the other. What is the initial speed of the electron if it stops just at the surface of the second? ($M_{electron}$= 9×10^{-31}kg)

a) 1.8×10^{14} m/sec

b) 1.3×10^{7} m/sec

c) 3.0×10^{8} m/sec

d) 500 m/sec

e) 4.5×10^{3} m/sec

Question 9.

An uncharged penny is brought into an external electric field of magnitude **2,200** V/m directed perpendicular to its faces. Find the magnitude of the charge density induced on each face of the penny, assuming the faces are planes.

a) 72 nC/m^2

b) 47 pC/m^2

c) 48 nC/m^2

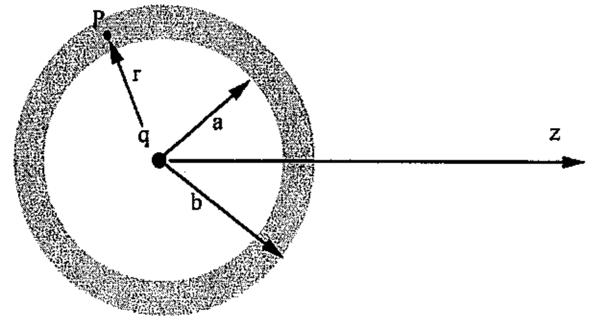
d) 20 nC/m^2

e) 20 pC/m^2

Question 10.
A hollow conducting spherical shell with a finite thickness has a charge placed at its center. If the potential is defined to be zero at infinity what is the potential at a point P within the conductor at a radius **r** from the center of the shell?

a) $k\frac{q}{r}$ b) $k\frac{q}{a}$ c) $k\frac{q}{b}$

d) $k\frac{q}{2}(\frac{1}{a}+\frac{1}{b})$ e) *zero*



Question 11.
Evaluate the integral

$$\oint \varepsilon_o \vec{E} \bullet d\vec{A}$$

over the surface in the figure.

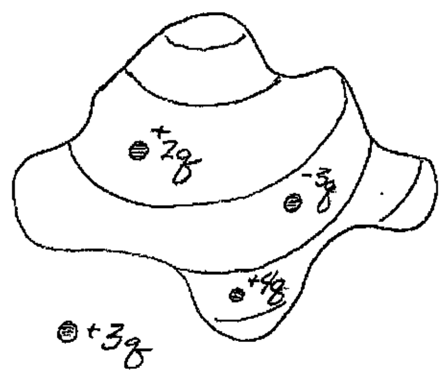
a) +9q

b) +3q

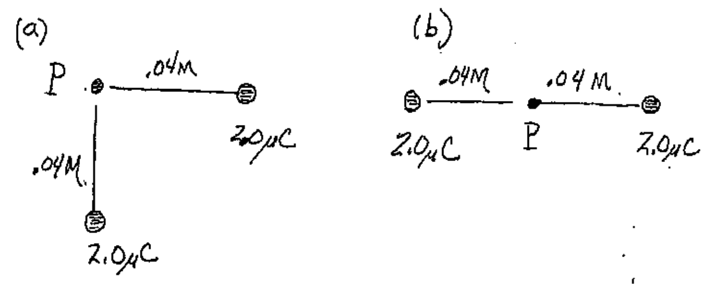
c) –3q

d) –9q

e) +6q



Question 12.
Two positive 2.0mC charges are placed as shown in part(a). The distance from each charge to the point **P** is 0.04m. Then the charges are rearranged as shown in part (b). which statement is now true after the rearrangement concerning **E** and V at the point **P**?



a) The electric field and the electric potential are both zero.

b) **E**=0, but V is the same as before the charges were moved.

c) V=0, but **E** is the same as before the charges were moved.

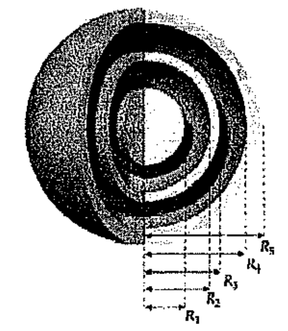
d) **E** is the same as before the charges were moved, but V is less than before.

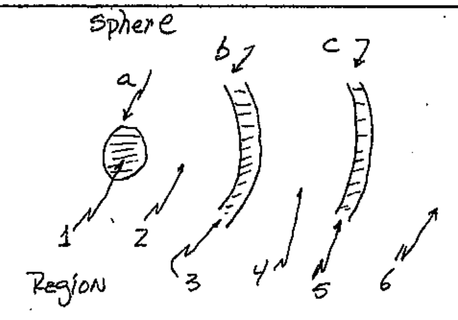
e) Both **E** and V have changed and neither is zero.

Question 13.
A parallel plate capacitor with a separation distance between the plates of **d** is initially connected to a battery and completely charged having an energy density $\mathbf{u_E}$. The battery remains connected and the distance between the plates is increased to **3d**. What is the new value of the energy density (joules/m^3).

$a)9u_E$ $\quad$ $b)3u_E$ $\quad$ $c)u_E$ $\quad$ $d)\frac{u_E}{3}$ $\quad$ $e)\frac{u_E}{9}$

For Questions 14, and 15.





Consider the concentric metal sphere and spherical shells that are shown in the figure. The inner most solid sphere that has radius R1. A spherical shell surrounds the sphere and has an inner radius R2 and an outer radius R3. The sphere and shell are both surrounded by a second spherical shell that has an inner radius R4 and an outer Radius R5.

None of these objects is initially charged. Then, a negative charge, -Q is placed on the inner most sphere (a) and a positive charge +Q is placed on the outer most shell(c).

Question 14.

From the table which row gives the correct final charge distribution once the charges come to equilibrium on each surface of the sphere and shells.

	Surfaces				
	Outer a	Inner b	Outer b	Inner c	Outer c
a)	-Q	0	+Q	-Q	+Q
b)	-Q	+Q	0	-Q	+Q
c)	-Q	+Q	-Q	+Q	0
d)	-Q	-Q	+Q	0	+Q
e)	-Q	0	0	0	+Q

Question 15. Which regions have no electric field?

a) Only Regions 1, 3 and 5

b) Only Regions 1, 3, 4, and 5

c) Only Regions 1,2, 3, and 5

d) Only Regions 1, 3, 5, and 6

e) Only Regions 1,3, 4, 5 and 6

Question 16.
A uniformly charged sphere has a potential on its surface of 1000 volts. At a radial distance of 3 meters from this surface, the potential is 200 volts. What is the radius of the sphere?

a) 0.1 m

b) 0.25 m

c) 0.5 m

d) 0.75 m

e) 1.0 m

Question 17.

During the process described by the photoelectric effect, ultraviolet light can be used to charge a piece of metal. If this light is incident on a slab of conducting material and the electrons are ejected with enough energy that they escape the surface of the metal, how long before the metal has a net charge of 1.5nC if 1.0×10^8 electrons are ejected per second?

a) 5400 seconds

b) 1500 seconds

c) 640 seconds

d) 94 seconds

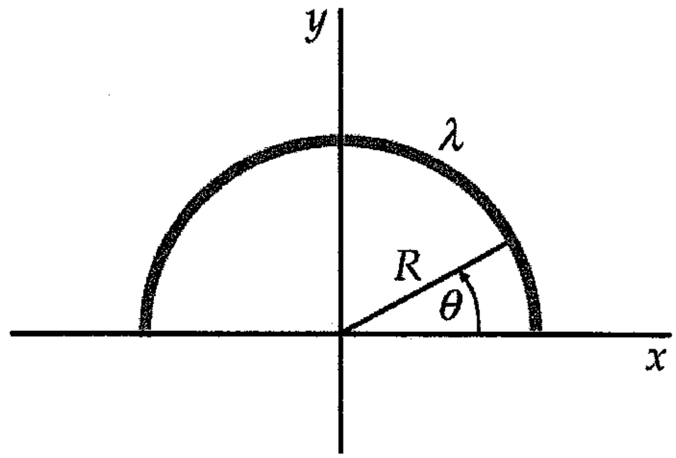
e) 7 seconds

Question 18.

A ring of radius R has a charge distribution

$\lambda(\theta) = +\lambda_o Sin(\theta)$

what is the electric field E at the center of the ring?
(Note: Integral table on equation sheet)



$a)\ \vec{E} = -\frac{1}{8\varepsilon_o}\frac{\lambda_o}{R}\sin(\frac{R}{\pi})\ \hat{y}$ $\quad b)\ \vec{E} = -\frac{1}{8\varepsilon_o}\frac{\lambda_o}{R}\ln(\frac{R}{\pi})\hat{y}$ $\quad c)\ \vec{E} = +\frac{1}{4\pi\varepsilon_o}\frac{\lambda_o}{R}\ \hat{y}$

$d)\ \vec{E} = -(\frac{1}{8\varepsilon_o} + \frac{1}{4\pi\varepsilon_o})\frac{\lambda_o}{R}\ \hat{y}$ $\quad e)\ \vec{E} = -\frac{1}{8\varepsilon_o}\frac{\lambda_o}{R}\ \hat{y}$

Question 19.
A flat sheet of paper of area $1.5m^2$ is oriented so that the plane of the sheet is at an angle of θ=25 degrees with respect to a uniform electric field of magnitude 35 N/C. What is the magnitude of the electric flux through the sheet?

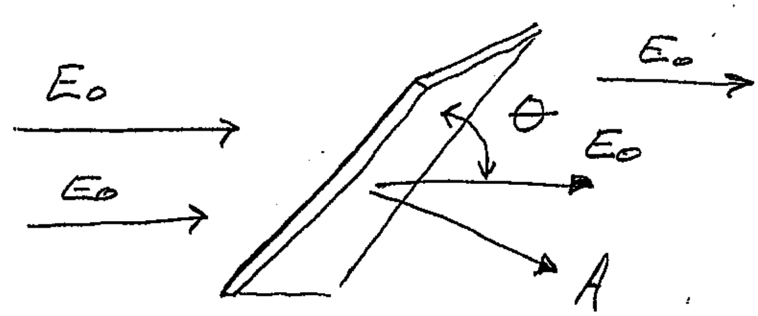
a) 3.0 Nm^2/C

b) 1.8 Nm^2/C

c) 22.2 Nm^2/C

d) 35 Nm^2/C

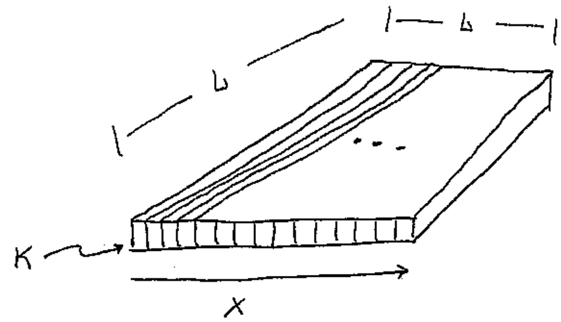
e) 140 Nm^2/C



Question 20.

A square parallel plate capacitor with plate separation **d** is filled with a long thin dielectric strips so that each strip has an increasing dielectric constant as a function of x such that at x=0 k=1,

$$\kappa(x) = (\kappa_o x + 1)$$



What is the capacitance of this capacitor? (Hint: assume each strip has a thickness dx and the area of each strip is L dx)

$a)\ C = \dfrac{\varepsilon_o L^2 \kappa_o}{\ln(\kappa_o d + 1)}$ $\quad b)\ C = \dfrac{\varepsilon_o L^2}{d}\left(\dfrac{\kappa_o L}{2} + 1\right)$ $\quad c)\ C = \dfrac{\varepsilon_o L^2 \kappa_o}{d}$

$d) C = \dfrac{d}{\varepsilon_o L^2}\left(\dfrac{\kappa_o L}{2} + 1\right)$ $\quad e)\ C = \varepsilon_o L^2 \kappa_o \exp(-(\kappa_o d + 1))$