Physics 227– Exam I
October 15, 2006
Prof. Coleman

Your name sticker
with exam code ⇒

SIGNATURE: ______________

1. The exam will last from 3:00 p.m. to 4:20 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Identification Number.
4. Enter 227 under COURSE, and your section number (see label above) under SEC.
5. Under CODE enter the exam code given above.
6. During the exam, you may use pencils, a calculator, and one **handwritten** 8.5 x 11 inch sheet with formulas and notes, without attachments.
7. There are 16 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, **hand in the answer sheet and the cover page**. Retain this question paper for future reference and study.
8. When you are asked to open the exam, make sure that your copy contains all 16 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. Please SIGN the cover sheet under your name sticker. A proc will check your name sticker and yo the exam. Please have th ready.

Useful Information

c = speed of light = 3.00×10^8 m/s
$q_e = -e$ = charge on an electron = -1.602 × 10^{-19} Coulon
$q_p = +e$ = charge on a proton = +1.602 × 10^{-19} Coulomb
m_e = electron mass = 9.11×10^{-31} kg
m_p = proton mass = 1.67×10^{-27} kg
$k = 9 \times 10^9$ N m²/C²
$\epsilon_0 = 8.85 \times 10^{-12}$ $C^2/(Nm^2)$
$g = 9.80$ m/s²
1 $eV = 1.602 \times 10^{-19}$ J
1 mC = 10^{-3} C   1 μC = 10^{-6} C
1 nC = 10^{-9} C   1 pC = 10^{-12} C

Note : 2006 did not include chapter 25.

1. A charge of -3.0 nC lies on the x-axis at $x = +6$ cm, and another equal charge of -3.0 nC is at $x = -6$ cm. The magnitude of the electric field at the origin is

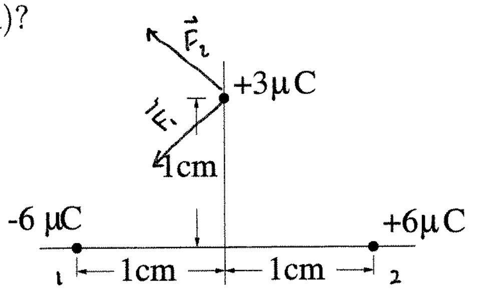
   a) Zero
   b) 7500 N/C
   c) 15000 N/C
   d) 450 N/C
   e) 900 N/C

$-3nC$ (1) $\xleftarrow{E_2}$ $\xrightarrow{E_1}$ $-3nC$ (2)

$\vec{E}_1 + \vec{E}_2 = 0$

2. A charge of $+6.00\,\mu$C is placed at $(x, y) = (+1.00\,\text{cm}, 0)$, and a charge of $-6.00\,\mu$C is placed at $(x, y) = (-1.00\,\text{cm}, 0)$. What is the magnitude and direction of the force on a charge of $+3.00\mu$C located at (x,y) = (0,+1.00 cm)?

   a) $-1620\hat{\imath}$ N
   b) $+1146\hat{\imath}$ N
   c) $+1620\hat{\imath}$ N
   d) $-573\hat{\imath}$ N
   e) $-1146\hat{\imath}$ N

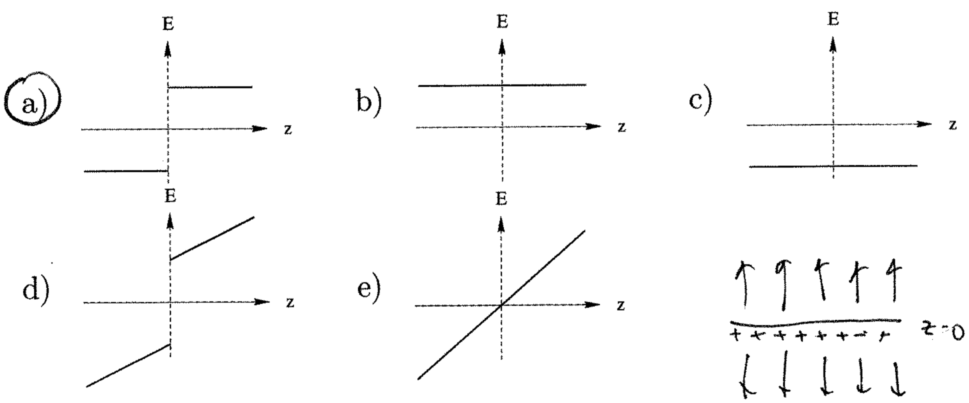


$F = |F_1| = |F_2| = \frac{K|q_1||q_2|}{r^2} = \frac{9\times10^9 \times 3\times10^{-6} \times 6\times10^{-6}}{2(0.1)^2} = 8.1\times10^2\,N$

$\vec{F}_1 = F\left(\frac{-1}{\sqrt{2}}, \frac{-1}{\sqrt{2}}\right)$ $\vec{F}_2 = F\left(\frac{-1}{\sqrt{2}}, \frac{+1}{\sqrt{2}}\right)$

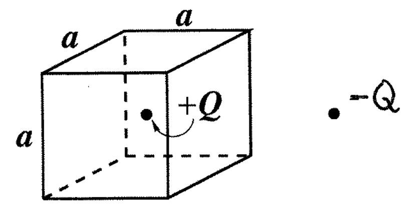
$\vec{F}_1 + \vec{F}_2 = (-F\sqrt{2}, 0) = -1.15\times10^3\,\hat{\imath}\,N.$

3. In an xyz-coordinate system, a plane of infinite extent with uniform surface charge density $+\sigma$ lies in the xy-plane (z=0). Which graph best represents the z-component of the electric field E vs. z along the z-axis?



4. Two point charges $+Q$ and $-Q$ are located as shown in the agram. The cube surrounding the charge $+Q$ has sides a.] total electric field flux through the surface of the cube is

   a) zero
   b) Q/ϵ_0
   c) $-Q/\epsilon_0$
   d) $2Q/\epsilon_0$
   e) $Q/6a\epsilon_0$



$\int E.ds = \frac{Q}{\epsilon_0}$

5. Consider two concentric spherical surfaces, one of radius 0.1 with a total charge of $+20\mu$C and the other of radius 0.20m w a total charge of -30μC. The charge on each surface is distribu uniformly. What is the electric field 0.30m from their comn center?

   a) $(1 \times 10^6)\,\hat{\mathbf{r}}$ N/C
   b) $(-1 \times 10^6)\,\hat{\mathbf{r}}$ N/C
   c) $(-5.0 \times 10^6)\,\hat{\mathbf{r}}$ N/C
   d) $(2.0 \times 10^6)\,\hat{\mathbf{r}}$ N/C
   e) $(-3.0 \times 10^6)\,\hat{\mathbf{r}}$ N/C

$Q_{TOT} = -30 + 20 = -10\mu C$

$E = \frac{kQ_{TOT}}{r^2}\hat{r} = -1\times10^6\,\hat{r}$ N/C

6. A metal sphere centered at the origin has a radius R and a charge Q. The electric field at the point $x = 5R$ is E_0. The sph is replaced by a different metal sphere centered at the origin w radius $2R$ and a net charge Q'. The field at $x = 5R$ is still E_0. Therefore, we can deduce:

   a) $Q' = \frac{1}{2}$Q
   b) $Q' = 2$Q
   c) $Q' =$
   d) $Q' = \frac{1}{4}$Q
   e) $Q' =$ Q

$\frac{kQ}{r^2} = \frac{kQ'}{r^2} \Rightarrow Q = Q'$

7. Consider a conductor in electrostatic equilibrium. Which of the following statements is **false**?

a) Any net charge on the conductor must reside on the surface.
b) The electric field at the surface cannot have a component parallel to the surface
c) No work is done by the electric field in moving a charge on the surface.
(d) The conductor cannot be given a net charge.
e) The electric potential must be constant inside the conductor.

8. Two large parallel conducting plates are 10 cm apart and carry equal but opposite charges on their facing surfaces. An electron placed midway between the two plates experiences a force of 1.6×10^{-15} N. The potential difference between the plates is

a) 10,000 V
b) 100 V
(c) 1000 V
d) 100,000 V
e) 1100 V

$F = qE = q\left(\frac{V}{d}\right) \Rightarrow V = \frac{Fd}{q}$

$V = \frac{1.6\times10^{-15}\times0.1}{1.6\times10^{-19}} = 10^3\ V$

9. An ion of charge +3e is accelerated from rest through a potential difference of 90V. It then acquires a kinetic energy (in electron volts) of

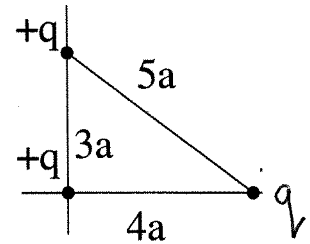
a) 4.32×10^{-17} eV
b) 90 eV
(c) 270 eV
d) 3 eV
e) 30 eV

$q = 3e$

$KE = 3e \times 90V$

$= \underline{270\ eV}$

10. Three identical charges are initially at rest infinitely far apa How much work is required to put the three charges together rest as shown in the figure?

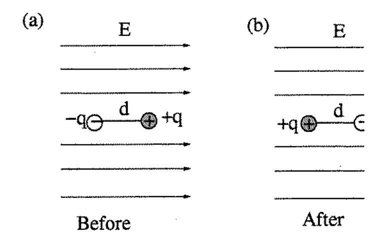


(a) $0.78kq^2/a$
b) $0.20kq^2/a$
c) $0.45kq^2/a$
d) $1.6kq^2/a$
e) $2.4kq^2/a$

$U = \sum_{i>j} \frac{kq_iq_j}{r_{ij}} = k\left(\frac{q^2}{3a} + \frac{q^2}{4a} + \frac{q^2}{5a}\right) = \frac{kq^2}{a}\left(\frac{1}{3}+\frac{1}{4}+\frac{1}{5}\right) = 0.783\frac{kq^2}{a}$

11. A dipole consists of a charge q and a charge $-q$ separated b distance d. Suppose the dipole moment is in a field E, with dipole moment pointing in the direction of the field ((a) in figure). If the dipole is flipped around to point in the direct opposite to the field ((b) in the figure), by how much does potential energy change?

(a) +2qdE
b) +4qdE
c) -2qdE
d) -4qdE
e) 0.

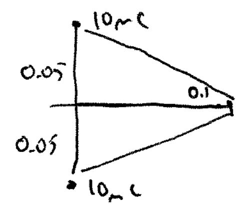


$U = -pE\cos\theta$
$p = qd$

$U = -qdE$ $\quad U = qdE$
$\Delta U = 2qdE$.

12. Two +10μC charges are placed at (x,y)=(0.00 m, 0.05 m) anc (x,y)=(0.00 m, −0.05 m). What is the electric potential at (x,y)= 0.1m m,0.0 m)?

a) 0 V
b) -1.6×10^6 V
(c) 1.6×10^6 V
d) 1.6×10^4 V
e) -1.6×10^4 V



$V = k\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$

$= \frac{2kq}{\sqrt{(0.05)^2+(0.10)^2}} = \frac{2\times9\times10^9\times10\times10^{-6}}{\sqrt{(0.05)^2+(0.1)^2}}$

$= 1.61\times10^6 V$ (c)

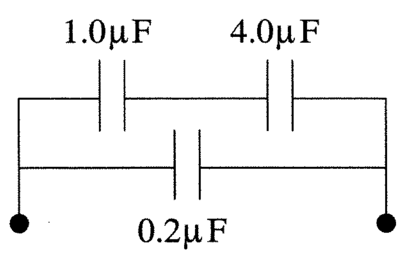
13. A parallel plate capacitor is charged by transferring a charge of +2.0 C from one plate to the other. If the resulting voltage between the plates is 4.0 V, the capacitance is

a) 0.5 F
b) 2.0 F
c) 8.0 F
d) 1.0 F
e) not enough information is given

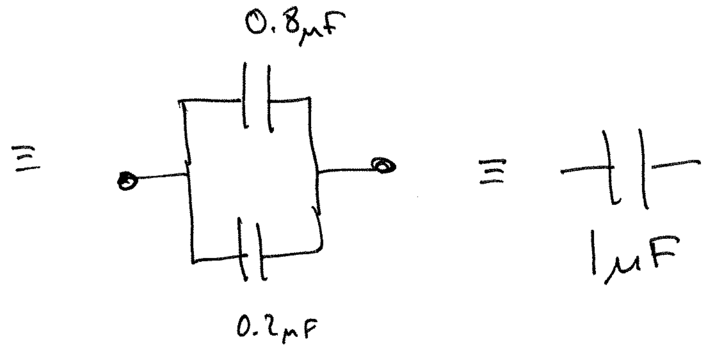
$Q = 2C$
$V = 4.0V$
$C = \frac{Q}{V} \Rightarrow \frac{2}{4} = 0.5F$

14. The equivalent capacitance of the three capacitors is

a) $0.16\mu F$
b) $0.19\mu F$
c) $1.00\mu F$
d) $5.20\mu F$
e) $6.25\mu F$



$\frac{1}{1} + \frac{1}{4} = \frac{5}{4} = \frac{1}{C'} \Rightarrow C' = \frac{4}{5}\mu F$



15. A parallel plate capacitor has two plates of area $4.0m^2$, separated by a distance $d = 2.0cm$. If voltage of $10kV$ is applied across the plates, how much energy is stored in the capacitor?

a) 88.5J b) 11.1J c) 88.5×10^{-6} J d) 177J
e) 0.0885J

$C = \frac{\epsilon_0 A}{d} = \frac{8.854 \times 10^{-12} \times 4.0}{0.02} = 1.77 \times 10^{-9} F$

$U = \frac{1}{2} C V^2 = \frac{1}{2} \times 1.77 \times 10^{-9} \times (10^4)^2 = 8.85 \times 10^{-2} J$