Physics 227 - First Common Hour Exam
October 9, 2005
Prof. Coleman

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Your name sticker with **exam code**

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Your signature _____

Turn off and put away cell phones now!

1. The exam will last from 3:00 PM to 4:20 PM. 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 student ID.

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. 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 and have your student ID ready to show to the proctor during the exam.

Some possibly useful information:
c = speed of light = 3.00×10^8 m/s
$q_e = -e$ = charge on an electron = -1.602×10^{-19} Coulombs
$q_p = +e$ = charge on a proton = $+1.602 \times 10^{-19}$ Coulombs
m_e = electron mass = 9.11×10^{-31} kg
m_p = proton mass = 1.67×10^{-27} kg
$k_e = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$
$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$
$g = 9.80\ \mathrm{m/s^2}$
1 mC = 10^{-3} C 1 μC = 10^{-6} C
1 nC = 10^{-9} C 1 pC = 10^{-12} C

1. Calculate the magnitude of the dipole moment $|p|$ of two point charges of $+3e$ and $-3e$ (e is the fundamental charge) separated by 6.00 nanometers.

   a) 0 C-m
   b) 2.88×10^{-18} C-m
   c) 2.88×10^{-27} C-m **Correct**
   d) 5.76×10^{-27} C-m
   e) 1.80×10^{-8} C-m

2. A point charge of $+10.0\mu$C is located at the center of a cube with edge 0.0200 m. What is the flux of the electric field through one face of the cube?

   a) 1.88×10^{5} Nm^2/C **Correct**
   b) 1.68×10^{4} Nm^2/C
   c) -7.12×10^{4} Nm^2/C
   d) -1.68×10^{4} Nm^2/C
   e) none of the above

3. A charge of $+1.0$ μC is placed at $x = 0$. Where along the x-axis must a second charge of $+4.0$ μC be placed so that the electric field at $x = 10$ cm is zero?

   a) 30 cm **Correct**
   b) 20 cm
   c) 50 cm
   d) 60 cm
   e) 40 cm

4. A parallel-plate capacitor with a volume of $1m^3$ contains a material with dielectric constant $k = 4$. The energy stored in the capacitor when the electric field in the capacitor is $100V/m$ is ϵ_0 times

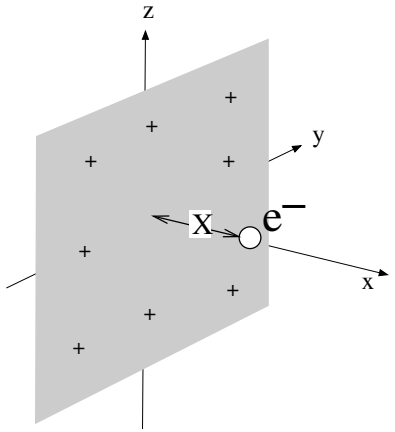
   a) $0.5 \times 10^4 J$
   b) $2 \times 10^4 J$ **Correct**
   c) $4 \times 10^4 J$
   d) $0.125 \times 10^4 J$
   e) 0.25J

5. Two small identical metal balls hold charges of -10 μC and $+6$ μC respectively. When placed a certain distance apart, the magnitude of the force between them is F. They are then allowed to touch and brought back to their original position. The force between them is now

   a) $F/15$, attractive
   b) $4F/15$, attractive
   c) $F/15$, repulsive **Correct**
   d) $4F/15$, repulsive
   e) $4F$, repulsive

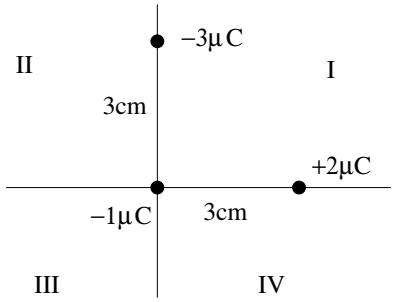
6. A positively charged, infinitely wide sheet with a uniform charge density σ extends along the y-z plane. An electron (with mass m_e) is located at position $X\hat{\mathbf{i}}$ in front of the plane. What is the acceleration a_x of the electron along the x-axis?

   a. $\frac{\sigma}{\epsilon_0}\left(\frac{e}{m_e}\right)$
   b. $-\frac{\sigma}{2\epsilon_0}\left(\frac{e}{m_e}\right)$ **Correct**
   c. $\frac{\sigma}{2\epsilon_0}\left(\frac{e}{m_e}\right)$
   d. $-\frac{\sigma}{\epsilon_0}\left(\frac{e}{m_e}\right)$
   e. $\frac{\sigma}{4\pi\epsilon_0 X^2}\left(\frac{e}{m_e}\right)$



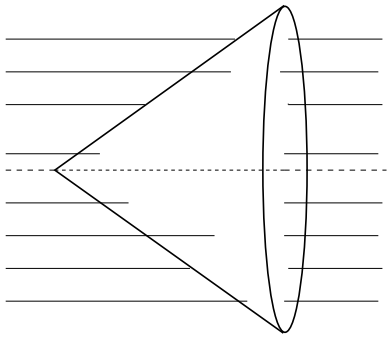
7. A charge of $+2.0\mu$C is fixed on the x-axis at x = 3 cm, while a charge of -3.0μC is fixed on the y-axis at y = 3 cm. The force on a third charge of -1.0μC placed at the origin is in the direction

a) 56.3° from the x-axis in quadrant II
b) 33.7° from the x-axis in quadrant I
c) 33.7° from the x-axis in quadrant IV
d) 56.3° from the x-axis in quadrant IV **Correct**
e) 56.3° from the x-axis in quadrant III



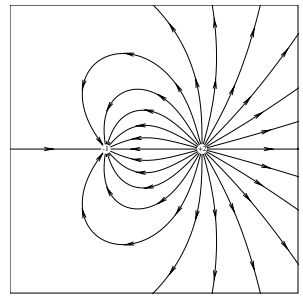
8. A cone with a circular base of radius 3 cm and height 4 cm is placed in a uniform electric field of magnitude 10 N/C oriented along the axis of the cone, as shown. What is the flux passing through the tapered surface of the cone?

a) 0.028 $\mathrm{Nm^2/C}$ **Correct**
b) 0.94 $\mathrm{Nm^2/C}$
c) 0.0022 $\mathrm{Nm^2/C}$
d) 0.35 $\mathrm{Nm^2/C}$
e) 2.80 $\mathrm{Nm^2/C}$



9. Which diagram best represents the field lines around a negative charge, -q, and a positive charge, +2q, as shown in the diagrams?

a) **Correct**



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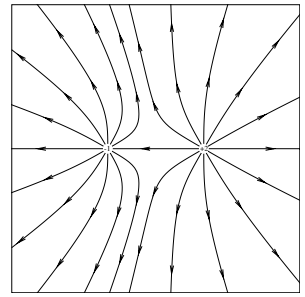

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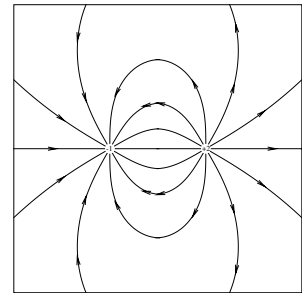

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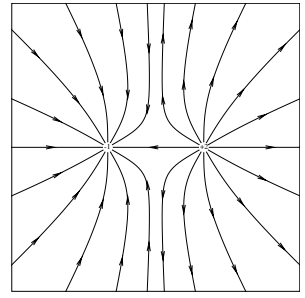

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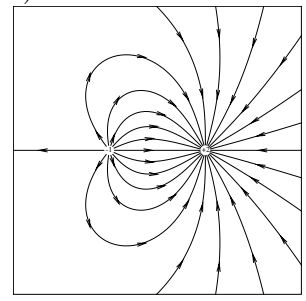
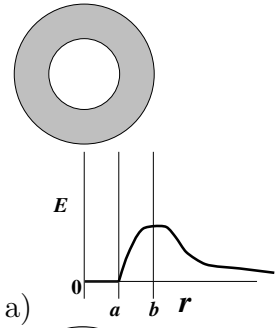
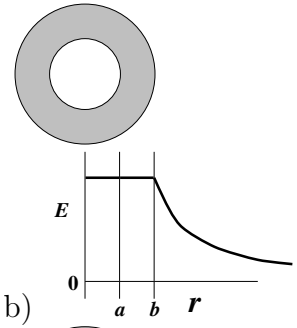
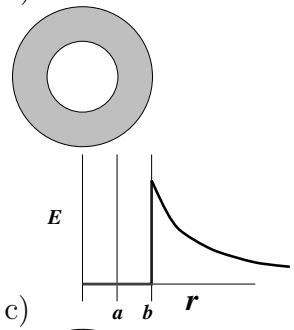


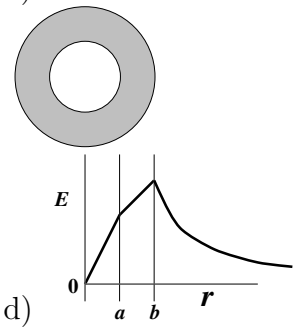
Note: in all figures, the $-q$ charge is on the left and the $+2q$ is on the right.

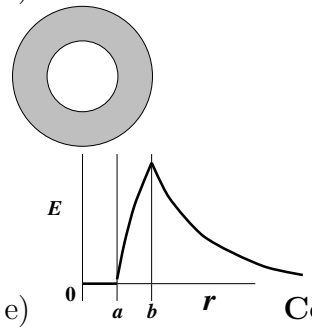
10. An *insulating* spherical shell of inner radius a and outer radius b is uniformly charged with a positive charge density. The radial component of the electric field, $E_r(r)$ has a graph

a) 

b) 

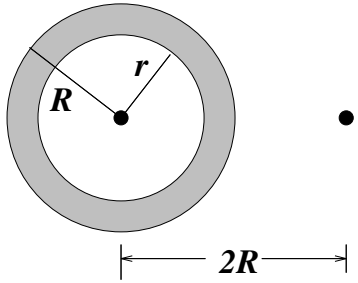
c) 

d) 

e) 

Correct

11. A *conducting* spherical shell of outer radius R and inner radius $r = 3R/4$ has no net charge on it. At its center there is a point charge q, and at a distance $2R$ from its center there is a point charge Q. The magnitude of the electrostatic force on the charge q at the center is



a) $k_e qQ/4R^2$
b) nonzero but less than $k_e qQ/4R^2$
c) 0 **Correct**
d) $k_e qQ/R^2$
e) $16k_e qQ/9R^2$

12. Two charges, one of $+7\ \mu$C and one of $-4\,\mu$C, are 0.3 m apart. How much work must be done to bring a charge of $-5\,\mu$C to form the third vertex of an equilateral triangle, 0.3 m from each of the others?

a) -1.5 J
b) -0.45 J **Correct**
c) 0
d) -1.29J
e) -0.84 J

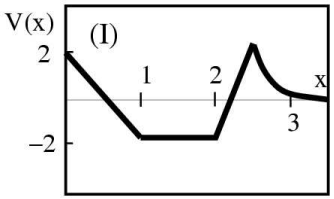
13. Two capacitors have capacitances of 7μF and 5μF respectively. They are connected in parallel to a battery. After the battery has charged them, the 7μF-capacitor has a stored energy of 2.24×10^{-4} J. What is the charge on the **other** capacitor, i.e. the 5μF-capacitor?

a) 40μC **Correct**
b) None of the other answers
c) 96μC
d) Zero
e) 56μC

14. A cube with side lengths 1 meter, has its corner at the origin and its sides are aligned with the x, y and z-axes. An electric field of strength $\mathbf{E} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} - 4z\hat{\mathbf{k}}$ N/C passes through the cube. The electric charge in the cube is ϵ_0 times

a) 0
b) -2C **Correct**
c) 2C
d) 6C
e) -5C

15. The electric potential $V(x)$ depends on x in the fashion shown in the first panel (I) below. Which of the figures shown below most precisely describes the electric field E_x in the x-direction?



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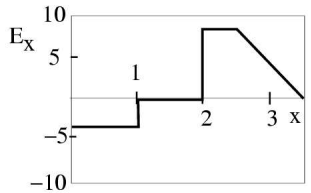

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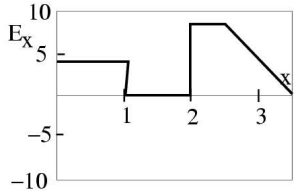

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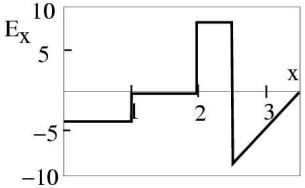

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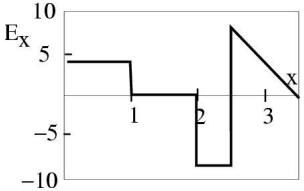
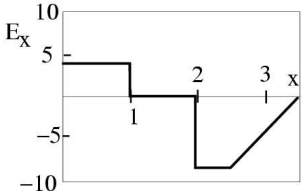
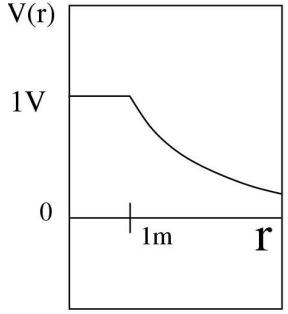


Correct

e)


16. A conducting sphere of radius 1m carries a charge of -0.111nC, Which of the figures in Fig. 2 correctly describes the radial dependence of the electric potential?

a)


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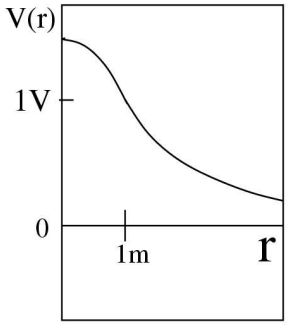

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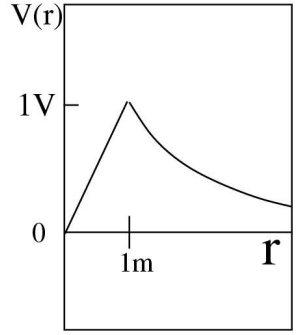

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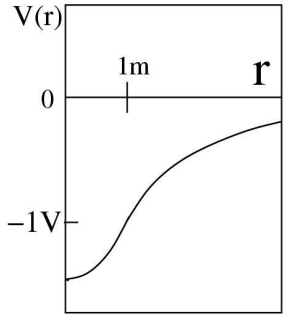

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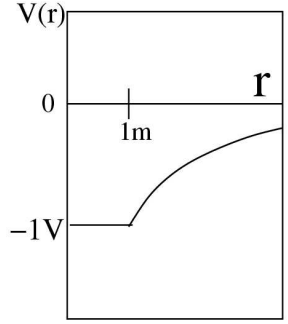

Correct