Physics 227 - First Hour Exam
2 October 2003
Profs. Shapiro and Conway

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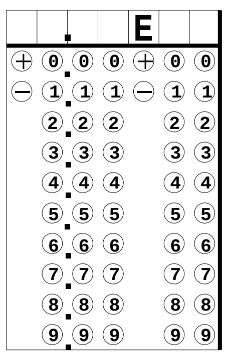
Your name sticker with **exam code**

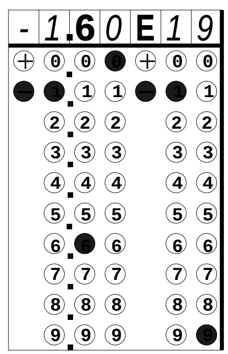
Turn off and put away cell phones now!

1. **THIS EXAM INCLUDES QUESTIONS WHICH REQUIRE A NUMERICAL ANSWER.**

The format on the machine-graded answer sheets requires that you express your answer is a very specific format. Several examples are shown below:
5.30 should be entered as **+5.30+00**
437 should be entered as **+4.37+02**
0.62458 should be entered as **+6.25−01**



Form for numerical answers.



The electron's charge entered.

$-1.602176 \times 10^{-19}$ should be entered as **−1.60−19**.
Note that all answers should be accurate to three **significant** digits. A sample fragment of the mark-sense form is shown.

NOTE THAT MULTIPLE CHOICE QUESTIONS START WITH THE FIFTH QUESTION, BUT ITS NUMBER IS 16; ENTER THE ANSWERS ON THE MARK SENSE FORM ACCORDING TO THEIR PROBLEM NUMBERS, WHICH INCREASE HORIZONTALLY ACROSS THE FORM.

2. The exam will last from 8:00 pm to 9:20 pm Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
3. 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.
4. Under STUDENT # enter your 9-digit student ID.
5. Enter 227 under COURSE, and your section number (see label above) under SEC.
6. Under CODE enter the exam code given above.
7. During the exam, you may use pencils, a calculator, and one **handwritten** 8.5 x 11 inch sheet with formulas and notes, without attachments.
8. There are 16 questions on the exam. Several questions require you to enter a numerical answers as described above. **Be sure to fill in the circles as well as writing your answer in the boxes.** The remainder are multiple-choice. For each multiple-choice 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.
9. 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.
10. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

electromagnetic permittivity ϵ_0	8.854×10^{-12} C^2/N-m^2
electromagnetic constant $k_e \equiv \frac{1}{4\pi\epsilon_0}$	8.9875×10^{9} N-m^2/C^2
magnitude of electron charge	1.602×10^{-19} C
electron mass	9.11×10^{-31} kg
proton mass	1.67×10^{-27} kg
magnetic permeability μ_0	$4\pi\times10^{-7}$ T-m/A
speed of light in vacuum	2.998×10^{8} m/s

1. A point charge of 1 μC is placed at the origin. Calculate the point along the positive x-axis (in meters) where the electric field is equal to 15.0 kN/C.

2. Calculate the electric field near a large, thin, flat non-conducting sheet with a charge per unit area of 1.77 nC/m^2, in V/m.

3. If we define electric potential to be zero at infinity, then calculate the electric potential at a point 1 mm away from a point charge of 0.1 nC, in volts.

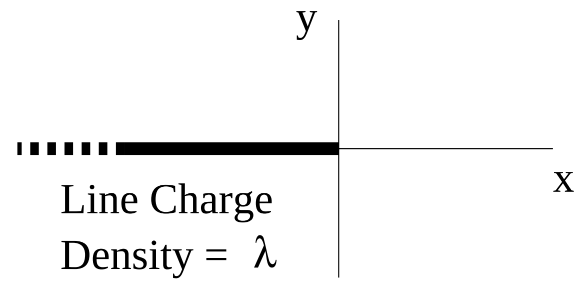
4. A 20 μF parallel plate capacitor is connected in series with a 1.5V battery. Calculate the charge on on the positive plate, in μC.

16. A charge A of +200 μC is placed at $(x, y) = (3, 4)$m. Another charge, B, of +30 μC is at the origin. The electrostatic force on B is

    a) $1.30\hat{\imath} + 1.73\hat{\jmath}$ N
    b) $2.16\hat{\imath}$ N
    c) $-1.73\hat{\imath} - 1.30\hat{\jmath}$ N
    d) $-1.30\hat{\imath} - 1.73\hat{\jmath}$ N
    e) $-1.73\hat{\imath} + 1.30\hat{\jmath}$ N

17. A semi-infinite line charge of uniform density λ lies along the negative x-axis from $x = 0$ to $x = -\infty$. The magnitude of the electric field at any point x on the positive x-axis is $1/4\pi\epsilon_0$ times

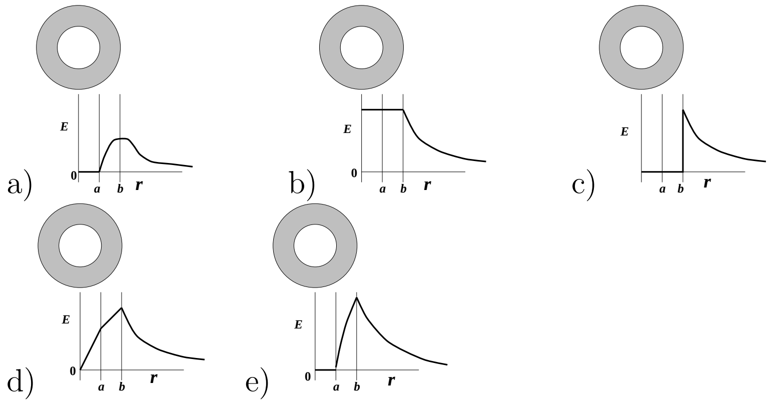
    a. λ/x
    b. λ/x^2
    c. $2\lambda/x$
    d. $\lambda/2x$
    e. None of the other answers



18. A –20 μC charge is placed at (x,y) = (0.2m, 0.0m) and a +10 μC is placed at (x,y) = (0.0m, 0.1m). The electric field at the origin could be set equal to zero by placing:

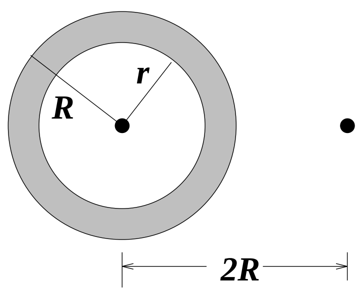
    a) a (+) charge in quadrant I [upper right].
    b) a (–) charge in quadrant II [upper left].
    c) a (–) charge in quadrant I [upper right].
    d) a (+) charge along the y-axis.
    e) a (–) charge in quadrant IV [lower right]

19. 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

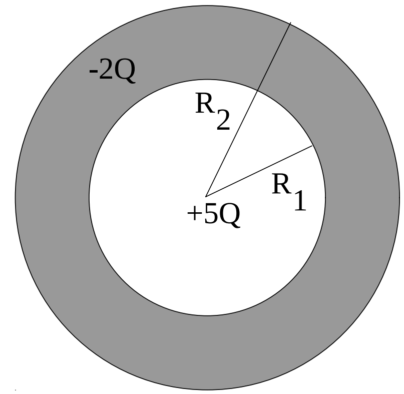


20. A conducting spherical shell of outer radius R and inner radius $r = 3R/4$ has no net charge on it. At its center there is a point charge q, and at a distance $2R$ from its center there is a point charge Q. The magnitude of the electrostatic force on the charge q at the center is

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



21. A charge of $+5Q$ is at the origin. Concentric with it is a conducting spherical shell of inner radius R_1 and outer radius R_2. This shell is given a **net** charge of $-2Q$. The distance r is measured from the origin. In the region $r > R_2$, the electric field is $1/4\pi\epsilon_0$ times

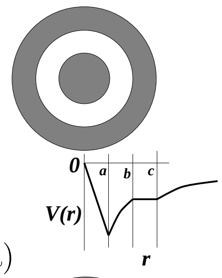


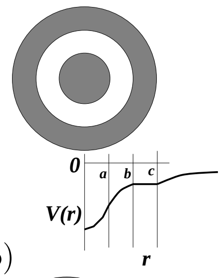
a) $[-2Q/r^2]\hat{r}$
b) $[3Q/r^2]\hat{r}$
c) $[5Q/r^2]\hat{r}$
d) $[7Q/r^2]\hat{r}$
e) Zero

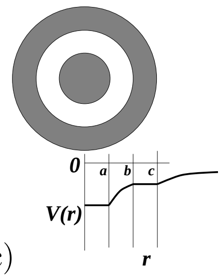
22. A charge of +25 nC is at the point (x,y,z) = (0.2 m, 0.3 m, 0). What is the potential due to this charge at the point x = -0.2 m, y=0.6 m, z=0.

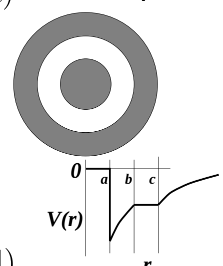
a) 623 V
b) 355 V
c) 749 V
d) $-719\hat{\imath} + 539\hat{\jmath}$ V
e) 450 V

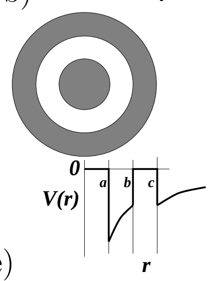
23. A conducting sphere with radius a is concentric with and surrounded by a conducting spherical shell with inner radius b and outer radius c. The inner sphere has a negative charge on it, while the spherical shell has no net charge. The potential $V(r)$ as a function of distance from the center is given by

a) 

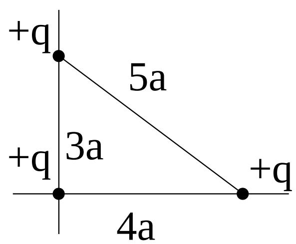
b) 

c) 

d) 

e) 

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

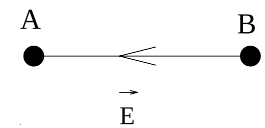


a) $0.78kq^2/a$
b) $0.20kq^2/a$
c) $0.45kq^2/a$
d) $1.6kq^2/a$
e) $2.4kq^2/a$

25. 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

26. Consider two points A and B. An electric field points from B towards A, and is constant in magnitude, so that $E_B = E_A$. How are the electric potentials at A and B related?



a. $V_B = V_A$
b. $V_B > V_A$
c. $V_B < V_A$
d. $V_B < V_A$ only if a positive charge is moved from B to A
e. $V_B < V_A$ only if a negative charge is moved from B to A

27. Two large conducting disks, each of area A, are placed parallel to each other a distance 0.3 cm apart. They are connected by conducting wires respectively to the two terminals of a 12 V battery. Find the **surface charge density** (*i.e.* the charge per unit area) on the plate connected to the positive terminal of the battery.

a) $\epsilon_0 A \times (12/.003\ \mathrm{V/m})$
b) $3.54 \times 10^{-8}\ \mathrm{C/m^2}$
c) $7.08 \times 10^{-8}\ \mathrm{C/m^2}$
d) $0.106\ \mathrm{nC/m^2}$
e) $0.212\ \mathrm{nC/m^2}$