Instructor(s): *Profs. Korytov, Takano*

PHYSICS DEPARTMENT

PHY 2049, Spring 2016 Midterm 1 February 15, 2016

Name (print): _____ Signature: _____

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

DIRECTIONS

(1) **Code your test number on your answer sheet (use 76–80 for the 5-digit number)**. Code your name on your answer sheet. **Darken circles completely (errors can occur if too light)**. Code your student number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work.
(4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know.
(5) If you think that none of the answers is correct, please choose the answer given that is closest to your answer.
(6) **Blacken the circle of your intended answer completely, using a number 2 pencil**. Do not make any stray marks or the answer sheet may not read properly. Completely erase all incorrect answers, or take a new answer sheet.
(7) As an aid to the examiner (and yourself), in case of poorly marked answer sheets, please circle your selected answer on the examination sheet. Please remember, however, that in the case of a disagreement, the answers on the bubble sheet count, NOT what you circle here. Good luck!!!

>>>>>>>>**WHEN YOU FINISH** <<<<<<<<

Hand in the answer sheet separately.

Constants			
$e = 1.6 \times 10^{-19}$ C	$m_p = 1.67 \times 10^{-27}$ kg	$m_e = 9.1 \times 10^{-31}$ kg	$\epsilon_o = 8.85 \times 10^{-12}$ C^2/N·m^2
milli (m) $= 10^{-3}$	micro (μ) $= 10^{-6}$	nano (n) $= 10^{-9}$	pico (p) $= 10^{-12}$
$k = 1/(4\pi\epsilon_o) = 9 \times 10^9$ N·m^2/C^2		Sphere: $A = 4\pi R^2$	$V = \frac{4\pi}{3}R^3$

1. If the magnitudes of the proton and electron charges were different by as little as one part in million, what would be the force of the electrostatic repulsion between two droplets of water, each with mass of 1 milligram, placed 10 cm apart? A water molecule (H_2O) consists of two atoms of hydrogen (one proton and one electron) and one atom of oxygen (8 protons, 8 neutrons, and 8 electrons). Assume that a neutron has the same mass as a proton.

(1) 2.5×10^3 N (2) 1.6×10^2 N (3) 1.0×10^4 N (4) 6.5×10^5 N (5) 1.7×10^6 N

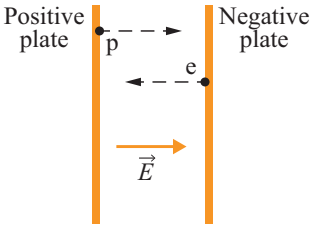
2. Two identical charges $+2\ \mu$C are placed in the (x,y)-plane and have coordinates (0,3) and (0,−3). All distances are in meters. Find the magnitude of the electric field at point (4,0).

(1) 1.2×10^3 N/C (2) 1.4×10^3 N/C (3) 1.6×10^3 N/C (4) 1.8×10^3 N/C (5) 2.0×10^3 N/C

3. Three identical charges q are placed in the (x, y)-plane and have coordinates $(0, 0)$, $(0, -d)$, and $(-2d, 0)$, where d is some positive number. Find the direction of the force on the charge placed at the origin of the coordinate system with respect to the x-axis.

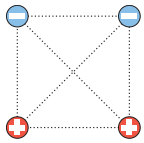
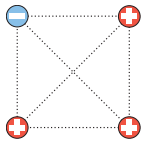
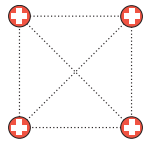
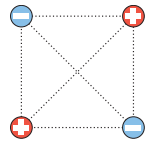
(1) 76° (2) 14° (3) 56° (4) 30° (5) 60°

4. Two large parallel copper plates are 6.76 cm apart and have a uniform electric field of magnitude E = 7.22 N/C between them (see the figure). An electron is released from the negative plate at the same time that a proton is released from the positive plate. Neglect the force of the particles on each other and find their distance from the positive plate when they pass each other.

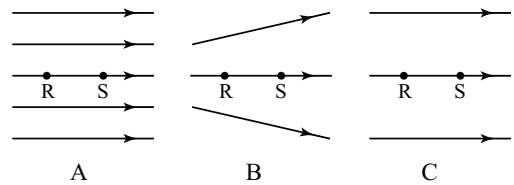


(1) 3.68×10^{-2} mm (2) 3.38 cm (3) 3.83 μm (4) 8.36×10^{-5} m (5) 8.33 μm

5. Which of the four-charge configurations has the strongest electric field at its center? The plus symbol indicates a positive charge $+q$, and the minus symbol indicates a negative charge $-q$.

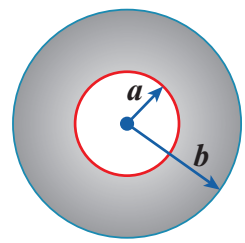
(1)  (2)  (3)  (4)  (5) Insufficient information

6. The figure shows the electric field lines in three different regions of space. The points labeled R and S are the same distance apart in each region. A proton is let go from rest at point R in each region. Rank order the proton momentum on reaching S for the three cases.



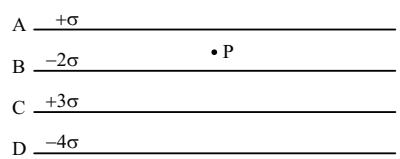
(1) $A > B > C$ (2) $C > B > A$ (3) $B > C > A$ (4) $B > A > C$ (5) $A > C > B$

7. A solid conducting sphere of radius $b = 2$ m has a spherical hole in it of radius $a = 1$ m and has a net charge of $+5\ \mu$C. A point charge $-1\ \mu$C (not a part of the $+5\ \mu$C charge on the sphere) is located at the center of the hole. What is the net charge on the conductor outer surface?



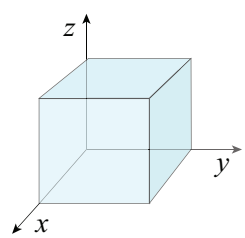
(1) $+4\ \mu$C
(2) $+5\ \mu$C
(3) $+6\ \mu$C
(4) $+1\ \mu$C
(5) 0

8. Four parallel infinite sheets of charge spaced by 4 cm between adjacent sheets are shown edgewise in the figure. Their surface charge densities are as indicated with $\sigma = 2.0\,\mu\text{C/m}^2$. What is the magnitude of the electric field (in N/C) at point P located midway between two sheets as shown? (Hint: Electric fields are vectors that add as such.)



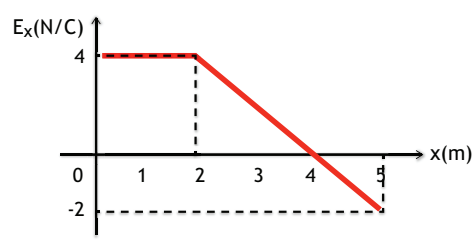
(1) 4.5×10^5 (2) 2.3×10^5 (3) 1.13×10^5 (4) 9.0×10^5 (5) 0

9. A non-uniform electric field given by $\vec{E} = 5.5\hat{\imath} - 2.1\hat{\jmath} + (4.6z^2 - 3)\hat{k}$ N/C pierces a cube with sides 3 m, as shown in the figure. The cube has its rear corner at the origin. What is the total charge inside the cube?



(1) +3.3 nC
(2) −2.4 nC
(3) +0.37 nC
(4) −5.2 nC
(5) +2.8 nC

10. The x-component of electric field, E_x, changes with x-distance as shown in the graph. If potential at $x = 0$ is set to be zero, what is the potential at $x = 5$ m?



(1) -11 V
(2) $+11$ V
(3) -13 V
(4) $+13$ V
(5) 0 V

11. Three identical charges $q = -1\ \mu$C are placed in the (x, y)-plane at coordinates $(-1, 0)$, $(1, 0)$, and $(0, 1)$. How much work is needed to move the last charge in the list to a new position, $(0, 0)$, while holding the other two in their original positions? All distances are in meters.

(1) 5.2 mJ (2) 2.6 mJ (3) 9.0 mJ (4) 4.5 mJ (5) 1.3 mJ

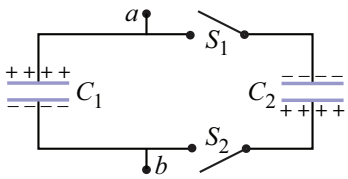
12. Potential (in volts) is described by the following function: $1/(xyz)$, where coordinates x, y, and z are in meters. What is the magnitude of the electric field (in N/C) at point $P(1, 2, 3)$?

(1) 0.19 (2) 0.31 (3) 0.16 (4) 0.48 (5) 0

13. Two identical charged spherical raindrops have the same potential V on their surfaces, relative to the zero potential at infinity. Initially the droplets are far apart. If they coalesce and merge to make one spherical droplet, then what is the potential on its surface?

(1) $1.6 \cdot V$ (2) $2.0 \cdot V$ (3) $0.5 \cdot V$ (4) $1.3 \cdot V$ (5) $1.4 \cdot V$

14. In the figure the capacitances are $C_1 = 0.89\ \mu$F and $C_2 = 2.5\ \mu$F, and both capacitors are charged to a potential difference of $V = 10$ V but with opposite polarity as shown. Switches S_1 and S_2 are now closed. What is now the potential difference, $V_b - V_a$, between points a and b?

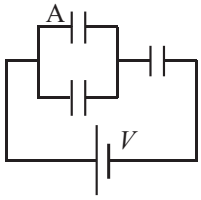


(1) 4.7 V (2) -4.7 V (3) 7.4 V (4) -7.4 V (5) 0 V

15. A parallel-plate capacitor with plates of area $A = 63\,\text{cm}^2$ and separation $d = 5$ mm is charged to a potential difference $V = 40$ volts. The charging battery is then disconnected, and the plates are pulled apart until their separation is $2\,d$. Find the work required to separate the plates (in joules).

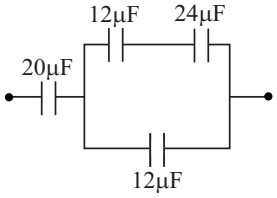
(1) 8.9×10^{-9} (2) 1.8×10^{-8} (3) 3.6×10^{-8} (4) 5.4×10^{-8} (5) 7.1×10^{-8}

16. In the figure at right, all the capacitors have the value of 1 μF, and the voltage of the battery is 6 V. What is the charge on the capacitor marked A?



(1) 2 μC
(2) 3 μC
(3) 4 μC
(4) 5 μC
(5) 6 μC

17. What is the equivalent capacitance of the combination shown?



(1) 10 μF
(2) 12 μF
(3) 40 μF
(4) 29 μF
(5) 25 μF

18. A wire has resistance R. The wire is uniformly stretched to become 10% longer, while maintaining its volume. What is its new resistance?

(1) $1.2R$ (2) $1.3R$ (3) $1.1R$ (4) $1.05R$ (5) R

19. A copper wire has a radius of 1 mm and carries current 1 A. What is the drift velocity of electrons? Copper has one free electron per atom. The atomic mass of copper is 63.5 times the mass of a proton. The copper density is 8.94 g/cm^3.

(1) 0.024 mm/s (2) 0.074 mm/s (3) 0.037 mm/s (4) 0.012 mm/s (5) 0.061 mm/s

20. A certain resistor dissipates 0.5 W when connected to a 3 V potential difference. When connected to a 1 V potential difference, this resistor will dissipate:

(1) 0.056 W (2) 0.167 W (3) 1.5 W (4) 0.5 W (5) 0.25 W