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

PHYSICS DEPARTMENT

PHY 2049, Spring 2017 Midterm 1 February 14, 2017

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	$\epsilon_o = 8.85 \times 10^{-12}\ \mathrm{C^2/N{\cdot}m^2}$
milli (m) $= 10^{-3}$	micro (μ) $= 10^{-6}$	nano (n) $= 10^{-9}$	pico (p) $= 10^{-12}$
$k = 1/(4\pi\epsilon_o) = 9 \times 10^9\ \mathrm{N{\cdot}m^2/C^2}$		Sphere: $A = 4\pi R^2$ $V = \frac{4\pi}{3}R^3$	

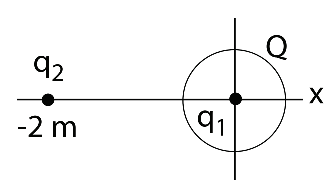
1. A conducting sphere of radius R is charged with q. At a distance of $3R$ from the center of the conductor is a point charge Q. q and Q are both positive. Which of the following relations is correct about the magnitude F of the electrostatic force exerted on the sphere by the point charge? Note that the sphere is a conductor and the distribution of the charge q may not be uniform in the present arrangement.

(1) $\frac{1}{9}kqQ/R^2 > F > \frac{1}{16}kqQ/R^2$ (2) $\frac{1}{4}kqQ/R^2 > F > \frac{1}{9}kqQ/R^2$ (3) $F = \frac{1}{16}kqQ/R^2$ (4) $F = \frac{1}{9}kqQ/R^2$ (5) $F = \frac{1}{4}kqQ/R^2$

2. Two identical conducting spheres, A and B, are separated by a distance much larger than their radius. Initially, they have the same amount of charge, and the electrostatic force between them is F_i. Subsequently, a third conducting sphere, C, which is identical to spheres A and B but uncharged, is brought in contact with A then with B, and taken away. During the entire procedure, sphere C is handled with an insulating pair of tweezers. What is the electrostatic force, F_f, between spheres A and B after the procedure?

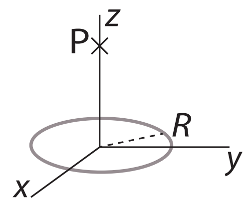
(1) $3F_i/8$ (2) $4F_i/9$ (3) $F_i/4$ (4) $F_i/3$ (5) $F_i/2$

3. As shown in the figure, a particle of charge $q_1 = +1.0\,\mu$C sits at the origin and is surrounded by a spherical, nonconducting shell of uniformly distributed total charge $Q = -1.0\,\mu$C, radius $r = 60.0$ cm, centered at the origin. Another charge $q_2 = +2.0\,\mu$C is located on the x axis at $x = -2.0$ m. What is the net electrostatic force on q_1, in unit vector notation?



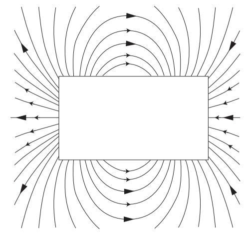
(1) $4.5 \times 10^{-3}\hat{\imath}$ N
(2) $3.2 \times 10^{-3}\hat{\imath}$ N
(3) $1.9 \times 10^{-3}\hat{\imath}$ N
(4) $5.6 \times 10^{-3}\hat{\imath}$ N
(5) 0

4. A circular ring of radius R, uniformly charged with total charge q, lies flat in the xy plane, as shown. The z axis runs through the center of the ring. Consider a point P on the z axis, at distance z from the center. At this point, what is the magnitude of the z component of the infinitesimal electric field due to charge dq on a very short piece of the ring?



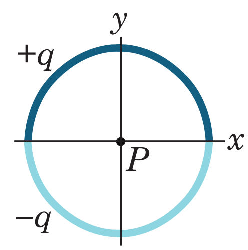
(1) $k\dfrac{zdq}{(R^2+z^2)^{3/2}}$ (2) $k\dfrac{dq}{(R^2+z^2)^{1/2}}$ (3) $k\dfrac{Rdq}{(R^2+z^2)^{1/2}}$ (4) $k\dfrac{dq}{(R^2+z^2)^{3/2}}$ (5) 0

5. The electric field lines for two point charges are shown in the figure. Based on the field lines, what is the correct statement about the charges which are located in the rectanglar region where field lines are not drawn?



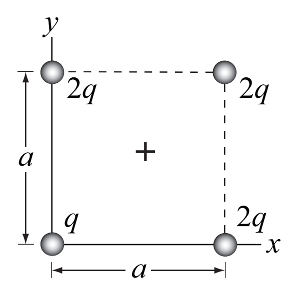
(1) Positive charge on left, and negative charge on right.
(2) Positive charge on right, and negative charge on left.
(3) Both charges are positive.
(4) Both charges are negative.
(5) None of the other answers is correct.

6. In the figure two identical plastic rods, one of charge $+q$ and the other of charge $-q$, form a circle of a 5.0 cm radius. The charge is distributed uniformly on both rods. If $q = 14\,\text{pC}$, what is the magnitude of the electric field at P, the center of the circle?



(1) $64\,\text{N/C}$ (2) $27\,\text{N/C}$ (3) $7.8\,\text{N/C}$ (4) $83\,\text{N/C}$ (5) 0

7. What is the x component of the electric field at the center of the square array of charged particles shown in the figure? The edge length of the square $a = 10\,\text{cm}$ and $q = +3.0\,\text{pC}$.

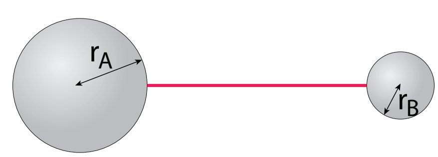


(1) $-3.8\,\text{N/C}$
(2) $+29\,\text{N/C}$
(3) $-9.3\,\text{N/C}$
(4) $+5.7\,\text{N/C}$
(5) $+1.6\,\text{N/C}$

8. A proton located at $x = 1$ m is released along the positive x direction in an electric potential of the form $V(x) = 5 - 4/x$, where x is measured in meters and V is measured in volts. What minimum initial speed is needed for the proton to be able to reach infinity?

(1) $2.8 \times 10^4\,\text{m/s}$ (2) $1.4 \times 10^4\,\text{m/s}$ (3) $3.7 \times 10^5\,\text{m/s}$ (4) $8.9 \times 10^3\,\text{m/s}$ (5) $6.3 \times 10^2\,\text{m/s}$

9. Two charged metal spheres A and B with radii $r_A = 10$ cm and $r_B = 5$ cm are connected by a very long copper wire of length $L \gg r_B$. If the electrical potential of sphere A is 10 V, what is the charge on sphere B?



(1) $5.6 \times 10^{-11}\,\text{C}$ (2) $8.4 \times 10^{-9}\,\text{C}$ (3) $3.1 \times 10^{-13}\,\text{C}$ (4) $2.5 \times 10^{-12}\,\text{C}$ (5) $1.3 \times 10^{-10}\,\text{C}$

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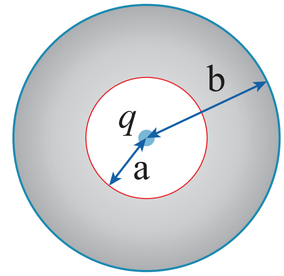
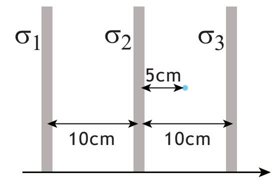
10. A solid conducting sphere of radius $b = 2\,\mathrm{m}$ contains a spherical hole of radius $a = 1\,\mathrm{m}$ and has a net charge of $+5\,\mu\mathrm{C}$. A point charge $-1\,\mu\mathrm{C}$ (not a part of the $+5\,\mu\mathrm{C}$ charge on the sphere) is located at the center of the hole. What is the net charge on the conductor's outer surface?



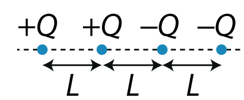
(1) $+4\,\mu\mathrm{C}$
(2) $+6\,\mu\mathrm{C}$
(3) $-1\,\mu\mathrm{C}$
(4) $+1\,\mu\mathrm{C}$
(5) $+5\,\mu\mathrm{C}$

11. Three large, parallel, nonconducting sheets are perpendicular to the x axis and separated by 10 cm from each other. Call them, from left to right, sheets 1, 2, and 3. Each sheet is charged only on one side, but uniformly, with surface charge densities $\sigma_1 = 3 \times 10^{-22}\,\mathrm{C/m^2}$, $\sigma_2 = -2 \times 10^{-22}\,\mathrm{C/m^2}$, and $\sigma_3 = -1 \times 10^{-22}\,\mathrm{C/m^2}$. What is the electric field half way between sheets 2 and 3?



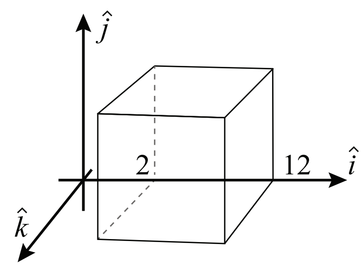
(1) $1.1 \times 10^{-11}\,\mathrm{V/m}$ (2) $3.4 \times 10^{-11}\,\mathrm{V/m}$ (3) $6.8 \times 10^{-11}\,\mathrm{V/m}$ (4) $4.5 \times 10^{-11}\,\mathrm{V/m}$ (5) $3.7 \times 10^{-12}\,\mathrm{V/m}$

12. Four point charges are placed along a straight line, each separated by distance L from its immediate neighbor(s). The order of the charges is $+Q$, $+Q$, $-Q$, $-Q$. What is the total potential energy of the system? (The potential energy is set to zero when the point charges are infinitely far apart.)



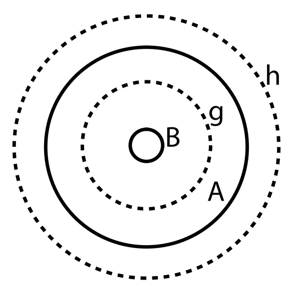
(1) $-k\dfrac{Q^2}{3L}$ (2) $4k\dfrac{Q^2}{L}$ (3) $-7k\dfrac{Q^2}{3L}$ (4) $5k\dfrac{Q^2}{2L}$ (5) 0

13. A cube of edge length 10 cm rests on the xz plane, with one edge placed on the x axis from $x = 2$ cm to $x = 12$ cm, as shown in the figure. A nonuniform field pierces the cube and is described by $E(x) = Bx$ (in N/C) pointing in the x direction. Here x is in meters, and the constant B is 7.0×10^6 N/(Cm). How much charge is inside the cube?



(1) 62 nC (2) 46 nC (3) 3.7 nC (4) 12 nC (5) $5.1\,\mu\mathrm{C}$

14. Two charged concentric spherical shells are made of very thin nonconducting material. Shell B has a radius of 10 cm, shell A of 50 cm. The flux through a Gaussian shell g of radius $r = 30$ cm is $\Phi_g = 10^5\,\mathrm{Nm^2/C}$. The flux through a larger Gaussian shell h of radius $R = 1$ m is $\Phi_h = 10^6\,\mathrm{Nm^2/C}$. What is the ratio q_A/q_B of the charges on the two shells?

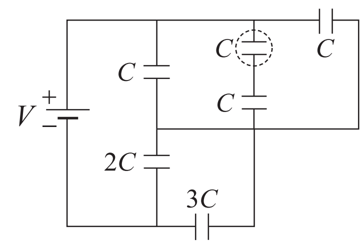


(1) 9 (2) 10 (3) 11 (4) 0.2 (5) 1

15. A parallel-plate capacitor, whose capacitance is C_0, is first charged with a battery that provides a potential difference of V_0. Subsequently, the battery is removed. What will be the amount of work required to increase the distance between the two plates of the capacitor by a factor of 3, from d to $3d$?

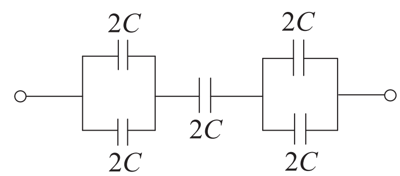
(1) $C_0V_0^2$ (2) $C_0V_0^2/2$ (3) $-C_0V_0^2/2$ (4) $C_0V_0^2/3$ (5) 0

16. In the figure, the battery has a potential difference V. Each of the four capacitors in the upper half of the figure has a capacitance C, whereas the capacitors in the lower half of the figure have capacitances $2C$ and $3C$. What is the potential difference across the circled capacitor which appears near the top?



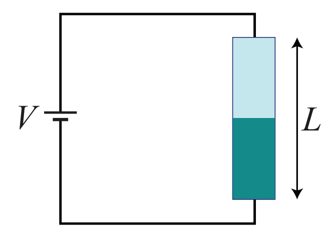
(1) $V/3$ (2) V (3) $V/2$ (4) $V/4$ (5) $V/6$

17. Five capacitors are connected as shown in the figure. What is the equivalent capacitance of the arrangement?



(1) C (2) $2C$ (3) $9C$ (4) $2C/5$ (5) $4C$

18. A battery is connected to a resistive rod, as shown in the figure. The rod consists of two sections with the same cross-sectional area A but different resistivities. The electric field is E in the first half and $2E$ in the second half of the rod, and the current through the rod is i. What is the resistance of the rod?



(1) $\frac{3}{2}EL/i$ (2) $\frac{3}{2}EL/A$ (3) $\frac{3}{2}kEL/i$ (4) $\frac{3}{2}kEL/A$ (5) kiL/A

19. A battery is connected to rod 1, whose length is L and cross-sectional area A. The drift speed of electrons in this rod is v_d. An identical battery is connected to rod 2, which is made of exactly the same material as rod 1, of length $2L$ and cross-sectional area $A/3$. What is the drift speed of electrons in rod 2?

(1) $v_d/2$ (2) $v_d/3$ (3) $v_d/6$ (4) $3v_d/2$ (5) $3v_d$

20. A resistor dissipates 0.5 W when a potential difference of 3.0 V is applied. When the potential difference is changed to 2.0 V, what will be the power dissipated in this resistor?

(1) 0.22 W (2) 0.36 W (3) 6.0 W (4) 2.1 W (5) 0.08 W