Instructor(s):

PHYSICS DEPARTMENT

PHY 2049, Fall 2013 Midterm 1 September 25, 2013

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 $\quad m_p = 1.67 \times 10^{-27}$ kg $\quad m_e = 9.1 \times 10^{-31} kg \quad \epsilon_o = 8.85 \times 10^{-12} C^2/N \cdot m^2$

$k = 1/(4\pi\epsilon_o) = 9 \times 10^9\, N \cdot m^2/C^2 \quad$ nano $= 10^{-9} \quad$ micro $= 10^{-6} \quad$ pico $= 10^{-12}$

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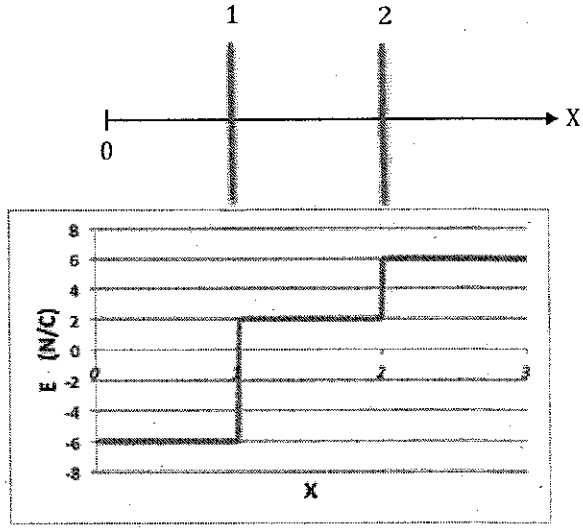
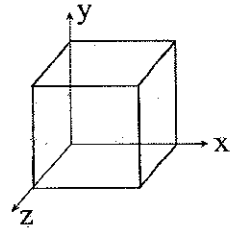
1. The figure shows two non-conducting plastic sheets that are large, parallel, and uniformly charged. The graph below the figure gives the component of the net electric field (in N/C) along an X axis perpendicular through the sheets. What is the charge density of sheet 2?



(1) ϵ_0
(2) 0
(3) $4\,\epsilon_0$
(4) $8\,\epsilon_0$
(5) $2\,\epsilon_0$

2. What is the net enclosed charge in the shown cube if the electric field is given by $\vec{E} = 2(x-1)\,\hat{i} + 4\,\hat{j}$ and the cube has a side length of 2?



(1) $16\,\epsilon_0$
(2) 0
(3) $32\,\epsilon_0$
(4) $8\,\epsilon_0$
(5) $4\,\epsilon_0$

3. A sphere of radius 1 cm contains a positive charge density whose magnitude grows linearly with radius: $\rho = \rho_0\, r$, where $\rho_0 = 3\ \mu\text{C/m}^4$. What is the magnitude of the electric field 0.5 cm from the center of the sphere? (You may need the relation $\int dV = \int 4\pi r^2 dr$ in spherical coordinates.)

(1) 0 (2) 565 N/C (3) 5400 N/C (4) 2.1 N/C (5) 8.5 N/C

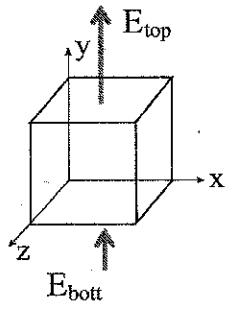
4. A linear charge density $\lambda(x) = 4\text{nC/m}^2 \times |x|$ (**Note the absolute value function** $|x| = \text{Abs}(x)$) is distributed on the x axis from $x = -.4$ m to to $x = +.4$ m. What is the electric field vector at the point $(x, y, z) = (0, .3m, 0)$?

(1) 14 N/C $\hat{j}$ (2) 43 N/C $\hat{j}$ (3) 85 N/C $\hat{i}$ (4) 0 (5) 29 N/C $\hat{j}$

5. Suppose the electric potential is $V(x, y, z) = axy^2z^3$, where a is a constant. What is the z component of the electric field?

(1) $-axy^2z^2$ (2) $-a(y^2z^3 + 2xyz^3 + 3xy^2z^2)$ (3) $+3axy^2z^2$ (4) $-3axy^2z^2$ (5) $+axy^2z^2$

6. The figure indicates an electric field directed only in the $+\hat{j}$ direction passing through a cube, with the length of the arrows indicating the magnitude of the field at the bottom and top faces. What can be concluded about the net charge contained within the cube?



(1) It is positive
(2) It must be moving
(3) Insufficient information
(4) It is zero
(5) It is negative

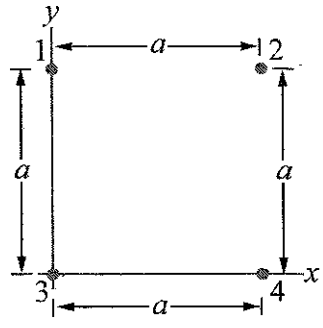
7. Consider two square parallel conducting plates of side length 2 cm, which hold ± 4 nC of charge and are separated by a 3 mm slab of dielectric with $\kappa = 1.5$. How much work (in μJ) must be done to withdraw the dielectric slab?

(1) 6.8 (2) 4.5 (3) 2.3 (4) 0 (5) 3.4

8. Consider three charges which are arranged at intervals of 60 degrees around a circle of radius R. The first charge is $q_1 = q$. The second charge is $q_2 = -q$ and lies 60 degrees around in the counter-clockwise direction. The third charge is $q_3 = +q$ and lies 60 degrees further around in the counter-clockwise direction. What is the electric potential energy of this system of three charges in units of $q^2/(4\pi\epsilon_0 R)$?

(1) $1/\sqrt{3}$ (2) $-2 + 1/\sqrt{3}$ (3) $-1/\sqrt{3}$ (4) $2 + 1/\sqrt{3}$ (5) 0

9. Four charges are arranged on the vertices of a cube of side length $a = 4$cm. The charges are $q_1 = 100$nC, $q_2 = 200$nC, $q_3 = 300$nC and $q_4 = 400$nC. What are the x and y components of the force on q_1?



(1) $F_x = -0.25$N, $F_y = +0.19$N
(2) $F_x = +0.34$N, $F_y = -0.39$N
(3) $F_x = -0.34$N, $F_y = +0.39$N
(4) $F_x = -0.19$N, $F_y = +0.25$N
(5) $F_x = +0.19$N, $F_y = -0.25$N

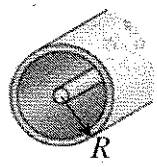
10. Suppose a 5 F capacitor is charged up using a 3 volt battery, then disconnected after it has been fully charged, and connected to a 4 volt battery. How much additional energy does it draw from the 4 volt battery in becoming fully charged?

(1) 22.5 J (2) 40 J (3) 35 J (4) .7 J (5) 17.5 J

11. Two charges are held fixed on the x axis. The first charge Q is at $x = 0$ and the other charge $2Q$ is at $x = L$. At what value of x can we place an unknown charge so that the force on it from the first two charges vanishes?

(1) $x = \frac{1}{3}L$ (2) Insufficient information. (3) $x = (\sqrt{2}+1)L$ (4) $x = (\sqrt{2}-1)L$ (5) $x = \frac{1}{2}(1-\sqrt{3})L$

12. A rod of charge per unit length λ is surrounded by a conducting, concentric cylinder of radius R (see figure) that has no net charge. What is the charge per unit length on the inner surface of the conductor?

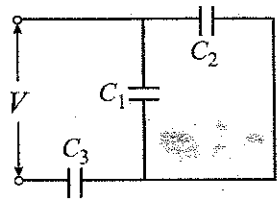


(1) $-\lambda$ (2) $\frac{\lambda}{2\pi\epsilon_0 R}$ (3) $\frac{-\lambda}{2\pi\epsilon_0 R}$ (4) 0 (5) λ

13. A 1 nF capacitor is formed by two concentric spheres. If the outer sphere has radius 1 m, what is the radius of the inner sphere?

(1) .9 m (2) .6 m (3) .8 m (4) .5 m (5) .7 m

14. All three capacitors shown in the figure have the same capacitance C. What is the capacitance of three together?



(1) $\frac{2}{3}C$ (2) C (3) $\frac{1}{3}C$ (4) $3C$ (5) $\frac{3}{2}C$

15. Consider a charge of 5 pC which is distributed uniformly along the x axis from $x = -2$ cm to $x = 0$. If we define the electric potential to vanish at infinity, what is its value on the x axis at $x = +3$ cm?

(1) 1.1 V (2) -0.9 V (3) 2.2 V (4) -2.5 V (5) 0.8 V

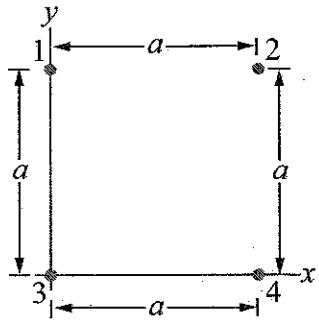
16. Consider a total charge of 5 pC which is uniformly distributed throughout a sphere of radius 10 cm. What is the magnitude of the electric field at a distance 5 cm from the center of the sphere?

(1) 28.2 N/C (2) 2.25 N/C (3) 2.25×10^{-4} N/C (4) 1.80×10^{-3} N/C (5) 18.0 N/C

17. Consider a negative cylindrically symmetric charge density whose magnitude which grows linearly with the distance s from the central axis. The charge density is $\rho(s) = -as$, where $a = 7$ nC/m^4. What is the potential difference from $s = 2$ cm and $s = 5$ cm?

(1) 1.6 mV (2) 23 mV (3) 10 mV (4) 280 mV (5) 15 mV

18. Suppose four unknown charges q_1, q_2, q_3 and q_4 are placed on the vertices of a square as shown in the figure. If the electric field at the center of the square is -5 N/C $(\hat{i}+\hat{j})$, which of the following statements can be correct?



(1) None of these statements can be correct
(2) $q_1 = q_4$ and $q_2 = -q_3 < 0$
(3) $q_2 = q_3$ and $q_1 = -q_4 < 0$
(4) $q_1 = q_4$ and $q_2 = -q_3 > 0$
(5) $q_2 = q_3$ and $q_1 = -q_4 > 0$

19. Suppose the electric field is $(E_x, E_y, E_z) = (1, 2, 3)$ N/C. What is the potential difference in moving from the starting point $(x, y, z) = (4, 5, 6)$ m to the stopping point $(x, y, z) = (7, 8, 9)$ N/C?

(1) +18 V (2) −18 V (3) −32 V (4) +54 V (5) +50 V

20. Suppose an electric dipole is located at the origina and points in the $-\hat{j}$ direction. What direction does the electric field at $(x, y, z) = (-1\text{m}, 0, 0)$ point?

(1) $+\hat{j}$ (2) $-\hat{i}-\hat{j}$ (3) $+\hat{i}$ (4) $-\hat{i}$ (5) $-\hat{j}$