Instructor(s):

PHYSICS DEPARTMENT

PHY 2049, Spring 2012 Midterm 1 February 17, 2012

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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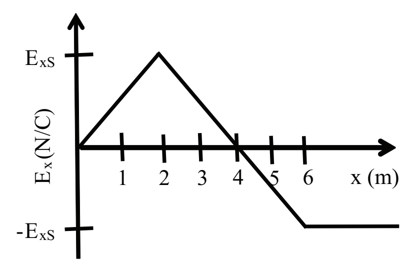
1. A graph of the x component of the electric field as a function of x in a region of space is shown in figure. The scale of the vertical axis is set by $E_{xs} = 20.0$ N/C. The y and z components of the electric field are zero in this region. If the electric potential at the origin is 30 V, what is the electric potential (in V) at $x = 4.0$ m,

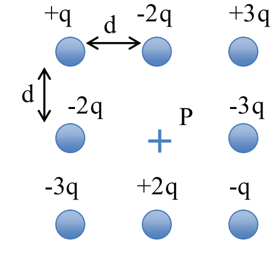


(1) -10 (2) 70 (3) 0 (4) -40 (5) 30

2. Two point-like objects with electric charges $q_1 = +0.5$ nC and $q_2 = -0.3$ nC are separated by a distance of 0.4 m. How much work (in J) is required to transport a third charge $q_3 = +0.2$ nC from infinitely far away to a position exactly at the midpoint of the line connecting the two other charges?

(1) 1.8×10^{-9} (2) 9×10^{-9} (3) 9 (4) 3.6×10^{-9} (5) 0

3. In the figure shown, what is the net electric potential at point P, which is at the center of a square array of eight particles with the listed electric charges, if $V = 0$ at infinity?



(1) $-5q/(4\pi\epsilon_0 d)$
(2) $-q/(4\pi\epsilon_0 d)$
(3) $+q/(4\pi\epsilon_0 d)$
(4) $+2q/(4\pi\epsilon_0\sqrt{2}d)$
(5) $(9 - 8/\sqrt{2})q/(4\pi\epsilon_0 d)$

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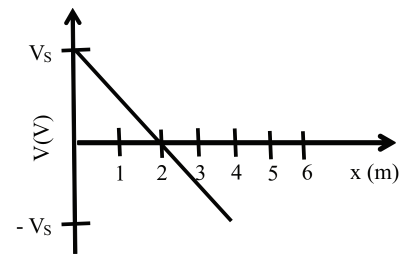
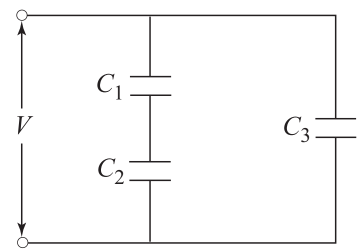
4. A proton is placed in a region where the electric potential only varies with x as shown. The scale of the vertical axes is set by $V_S = 500$ V. What is the x component of the electric force (in N) on the proton when it is placed at $x = 2$ m? The proton has charge $q = +e = 1.6 \times 10^{-19}$ C.



(1) 4×10^{-17} (2) -4×10^{-17} (3) -8×10^{-17} (4) 2×10^{-17} (5) 0

5. In the shown figure, a potential difference of $V = 24$ V is applied across the arrangement of capacitors with capacitances of $C_1 = C_2 = 2\,\mu$F, and $C_3 = 3\,\mu$F. What is the charge q_2 on capacitor C_2?

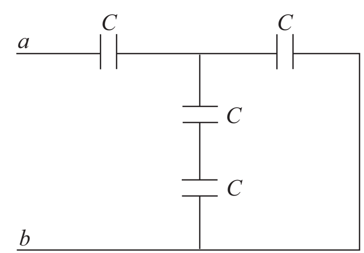


(1) $24\,\mu$C
(2) $96\,\mu$C
(3) $72\,\mu$C
(4) $12\,\mu$C
(5) $48\,\mu$C

6. A potential difference of $V = 12$ V is applied across a $1\,\mu$F capacitor until it is fully charged, and then it is disconnected. If the charged capacitor is then connected in parallel with a second (initially uncharged) capacitor, and if the potential difference across the first capacitor subsequently drops to 9 V, what is the capacitance of this second capacitor?

(1) $0.33\,\mu$F (2) $1.33\,\mu$F (3) $1\,\mu$F (4) $3\,\mu$F (5) $9\,\mu$F

7. What is the equivalent capacitance between terminals a and b if each capacitor shown in the figure has capacitance C?



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

8. A certain parallel plate capacitor with capacitance $12\,\mu$F is connected to a source of EMF with potential 3 V. A dielectric material with $\kappa = 4$ is then inserted between the plates of the capacitor. By how much does the energy stored in the capacitor *change*?

(1) 1.6×10^{-4} J (2) 5.4×10^{-5} J (3) 1.2×10^{-5} J (4) 1.4×10^{-6} J (5) 0 J

9. How much power is dissipated in a copper wire that is 15 m long and 1 mm in diameter when it is connected across a potential difference of 6 V? The resistivity of copper is $\rho = 1.7 \times 10^{-8}\,\Omega\,$m.

(1) 110 W (2) 0.32 W (3) 4×10^{16} W (4) 12 W (5) 4×10^{9} W

10. A 1800 W space heater is constructed to operate at 120 V. What is the current in the heater when the unit is operating?

(1) 15 A (2) 8 A (3) 0.07 A (4) 27,000 A (5) 1 A

11. Three equal charges, each of $+7\mu$C are arranged at the corners of an equilateral triangle of side length 10 cm. What is the magnitude of the total force (in N) acting on each of the charges?

(1) 76 (2) 44 (3) 88 (4) 38 (5) zero

12. A negative charge $-Q$ and a positive charge $2Q$ are placed along the x-axis at $x = 0$ and $x = 1$ m, respectively. At what point along the x-axis (in meters) does the electric field equal zero?

(1) -2.4 (2) 2.4 (3) -0.4 (4) 0.4 (5) There is no such point.

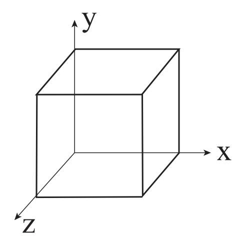
13. A thin bar of length L is placed along the x-axis as shown. The bar is charged with non-uniform density that can be described as $\lambda(x) = cx^2$, where c is some constant. Find the magnitude of the electric field at $x = 0$.

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

14. An electron with a speed of 2×10^6 m/s moves into a uniform electric field of 500 N/C that is parallel to the electron's motion. How long does it take, in nanoseconds, for the electron to come to rest?

(1) 23 (2) 35 (3) 12 (4) 1200 (5) never

15. What is the flux leaving the surface of the shown cube if the electric field is given by $\vec{E} = -2x\hat{i} + 3y\hat{j}$ and the cube has a side length of 2?

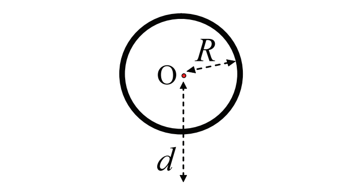


(1) 8
(2) -16
(3) 16
(4) -8
(5) 0

16. There are 4 nested shells of radii $R = 1, 2, 3, 4$ m, all centered on the same point O. The shells, starting from the inner and moving outward, carry charges -1, 2, -3, 4 nC. Find the electric field magnitude in N/C at a distance $r = 2.5$ m from the point O.

(1) 1.4 (2) 2.9 (3) 4.3 (4) 5.8 (5) 14.4

17. A uniformly charged thin non-conducting shell (hollow sphere) of radius R with the total positive charge Q is placed at a distance d away from an infinite non-conducting sheet carrying a uniformly distributed positive charge with a density σ. The distance d is measured from shell's center (point O). What is the magnitude of the total electric field at the center of the shell?

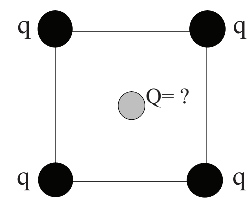


(1) $\dfrac{\sigma}{2\epsilon_0}$ (2) $\dfrac{Q}{4\pi\epsilon_0 R^2} + \dfrac{\sigma}{2\epsilon_0}$ (3) $\dfrac{Q}{4\pi\epsilon_0 R^2} + \dfrac{\sigma}{\epsilon_0}$ (4) $\dfrac{Q}{4\pi\epsilon_0 R^2}$ (5) $\dfrac{Q}{4\pi\epsilon_0 R} + \dfrac{\sigma}{\epsilon_0}$

18. A charge Q is placed in the center of a shell of radius R. The flux of electric field through the shell surface is Φ_0. What is the new flux through the shell surface, if its radius is doubled?

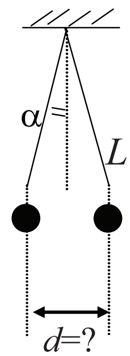
(1) Φ_0 (2) $2\Phi_0$ (3) $4\Phi_0$ (4) $\Phi_0/2$ (5) $\Phi_0/4$

19. Four charges of the same sign and value q are placed in the corners of a square and free to move. One more charge Q is placed in the center of the square so that the entire system of the five charges has become statically stable, *i.e.,* net forces on each of the five charges are equal to zero. Find the value of charge Q in terms of q.



(1) −0.96q (2) −1.41q (3) −1.12q (4) −4q (5) −0.71q

20. Two very small spheres have equal masses m, carry charges of the same sign and value q, and hang on strings of length L as shown in figure. Due to the repulsive force, the spheres are separated by some distance d—find this distance. Assume that $d \ll L$ so that you can use the approximation $\tan\alpha \approx \sin\alpha \approx \alpha$.



(1) $\sqrt[3]{2L\frac{q^2k}{mg}}$ (2) $\sqrt[3]{L\frac{q^2k}{mg}}$ (3) $\sqrt[2]{2L\frac{q^2k}{mg}}$ (4) $\sqrt[2]{L\frac{q^2k}{mg}}$ (5) $\sqrt[2]{\frac{Lq^2k}{2mg}}$