Instructor: *Paul Avery, Selman Hershfield*

PHYSICS DEPARTMENT

PHY 2049 Exam 1 February 1, 2011

Name (print, last first): ______________________ 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**. 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 most questions demand.
(4) **Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink**. Do not make any stray marks or the answer sheet may not read properly.
(5) The answers are rounded off. Choose the closest to exact. There is no penalty for guessing.

>>>>>>>>>**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 $\quad m_e = 9.1 \times 10^{-31} kg \quad g = 9.8 m/s^2 \quad$ micro $= 10^{-6}$

$\epsilon_o = 8.85 \times 10^{-12} C^2/N \cdot m^2 \quad k = 1/(4\pi\epsilon_o) = 9 \times 10^9\, N \cdot m^2/C^2 \quad \mu_o = 4\pi \times 10^{-7} T \cdot m/A \quad$ nano $= 10^{-9} \quad$ pico $= 10^{-12}$

Coulomb's Law: $|\vec{F}| = \dfrac{|q_1||q_2|}{4\pi\epsilon_o r^2}$ (point charge)

Electric field: $\vec{E} = \dfrac{\vec{F}}{q} \qquad \vec{E} = \dfrac{q}{4\pi\epsilon_o r^2}\hat{r}$ (point charge) $\qquad \vec{E} = \int \dfrac{dq}{4\pi\epsilon_o r^2}\hat{r}$ (general) $\qquad E = \dfrac{\sigma}{2\epsilon_o}$ (plane)

Gauss' law: $\Phi = \hat{n} \cdot \vec{E}\, A = \oint \hat{n} \cdot \vec{E}\, dA = \dfrac{q_{enc}}{\epsilon_o}$

Energy: $W = \int \vec{F} \cdot d\vec{s} = \dfrac{1}{2} m v_f^2 - \dfrac{1}{2} m v_i^2 = K_f - K_i \qquad P = \vec{F} \cdot \vec{v}$ (mechanical power)

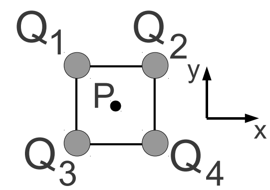
For conservative forces $U_f - U_i = -\int \vec{F} \cdot d\vec{s} \rightarrow K_i + U_i = K_f + U_f$

Electric potential: $V = \dfrac{U}{q} \qquad V = \dfrac{q}{4\pi\epsilon_o r}$ (point charge) $\qquad V = \int \dfrac{dq}{4\pi\epsilon_o r}$ (general)

$V_b - V_a = -\int_a^b E_x dx = -\int_a^b \vec{E} \cdot d\vec{s} \qquad E_x = -\dfrac{\partial V}{\partial x}, \qquad E_y = -\dfrac{\partial V}{\partial y}, \qquad E_z = -\dfrac{\partial V}{\partial z}$

---

1. Four charges are placed on the corners of a square of side 2 m as shown in the figure. If $Q_1 = 1\mu C$, $Q_2 = 3\mu C$, and $Q_3 = Q_4 = 2\mu C$, what is the magnitude of the electric field at point P at the center of the square?



   (1) 12700 N/C
   (2) 9000 N/C
   (3) 18000 N/C
   (4) 6400 N/C
   (5) 4500 N/C

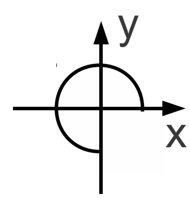
2. A dipole is allowed to rotate freely like the molecules in water. Which of the following statements is true?

   (1) The dipole will only be attracted to a positive charge.
   (2) The dipole will be repelled from a positive charge.
   (3) The dipole will be attracted to both a positive and a negative charge.
   (4) The dipole will experience no force in proximity to a positive charge.
   (5) The dipole will only be attracted to a negative charge.

3. Suppose we have an insulating spherical ball of uniform charge density ρ and radius R. At what radius or radii from the center of the sphere is the electric field strength reduced by a factor of 4 from the electric field strength at the surface?

   (1) Only at $R/4$ (2) $R/16$ and $4R$ (3) $R/4$ and $4R$ (4) $R/4$ and $2R$ (5) Only at $4R$

4. A line of charge in the form of an arc in a circle of radius 2 m is centered about the origin as shown in the figure. If the charge per unit length on the line is $\lambda = 5nC/m$, what is the electric field at the origin?



   (1) $-67.5V/m\,\hat{\imath} - 67.5V/m\,\hat{\jmath}$
   (2) $-45.0V/m\,\hat{\imath} + 45.0V/m\,\hat{\jmath}$
   (3) $-22.5V/m\,\hat{\imath} + 22.5V/m\,\hat{\jmath}$
   (4) $+22.5V/m\,\hat{\imath} - 22.5V/m\,\hat{\jmath}$
   (5) $+45.0V/m\,\hat{\imath} - 45.0V/m\,\hat{\jmath}$

5. A long, straight wire is uniformly charged with a linear charge density of 5.0 μC/m. The wire runs along the axis of a cylinder of radius 2.0 cm and length 30.0 cm. What is the total electric flux through the cylinder surfaces in N·m^2/C?

   (1) 1.13×10^4 (2) 7.19×10^5 (3) 1.69×10^5 (4) 5.23×10^5 (5) 0

6. A proton is located at $x = 0$ and an electron is located at $x = 2$ m. There is a uniform electric field of $5V/m\,\hat{\imath}$. If at $t = 0$ they are released from rest, at what time would they reach the same x-position? (Do not include the attraction between the proton and the electron.)

   (1) $3.3\mu s$ (2) $2.1\mu s$ (3) $5.7\mu s$ (4) $4.5\mu s$ (5) $1.5\mu s$

7. Particles 1, 2 and 3 are on the x-axis at $x = 0$ cm, 5 cm, and 10 cm, respectively. The charges of particles 1 and 2 are each 5 μC. The electrical potential energy of the three-particle system is 0, where potential energy at infinity is defined to be 0. What is the charge of particle 3 in μC?

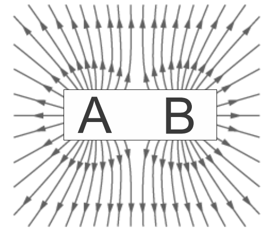
   (1) -7.5 (2) -3.3 (3) -5.0 (4) -10 (5) 0.0

8. A thin plastic rod 8.2 cm long carrying charge -0.022μC is bent into a circle. What is the potential at the center of the ring, assuming $V = 0$ at infinity? (1 KV = 1000 volts)

   (1) +99.7 KV (2) -49.8 KV (3) -7.93 KV (4) -5.05 KV (5) -15.2 KV

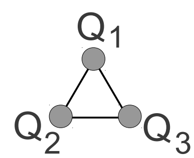
 21111

9. The electric field lines of two point charges, A and B, are shown in the figure. Which of the following is true of the point charges?



(1) Both point charges are positive.
(2) This configuration of field lines is not possible.
(3) A is negative, and B is positive.
(4) Both point charges are negative.
(5) A is positive, and B is negative.

10. Three charges are placed at the corners of an equilateral triangle of side 3 cm. If $Q_1 = 2\mu C$, $Q_2 = -1\mu C$, and $Q_3 = 3\mu C$, what is the magnitude of the net force on Q_3?



(1) 90 N (2) 30 N (3) 60 N (4) 50 N (5) 70 N

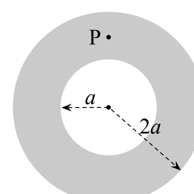
11. The rectangle shown in the figure has sides 5 cm and 8 cm. The charges are $q_1 = 6\mu$C and $q_2 = 9\mu$C. How much work is required to move a charge $q_3 = 4.0\mu$C from point A to point B?

(1) +0.81 J (2) 0 (3) −0.52 J (4) +4.42 J (5) −0.17 J

12. A solid conducting sphere of 15 cm radius is located at the center of a spherical conducting shell, whose inner radius is 21 cm and outer radius 42 cm. At a distance of 50 cm from the center of these concentric conductors, the electric field is 2.1×10^5 V/m and is pointing outward. The shell has a net charge of +3.1 μC. What is the net charge on the sphere at the center in μC?

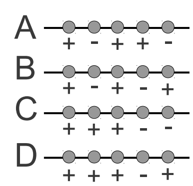
(1) +1.8 (2) −1.2 (3) +2.7 (4) 0.0 (5) −3.1

13. The figure shows a uniformly charged, nonconducting spherical shell of inner radius a and outer radius $2a$. If the electric field at the outer radius is E, what is the electric field at point P with radius $r = 1.5a$?



(1) $0.4E$ (2) 0 (3) $0.6E$ (4) $0.5E$ (5) E

14. Five charges are equally spaced along the x-axis. Each charge has the same magnitude, e, but some of the charges are $+e$ and some are $-e$. Four different configurations of charge are labelled A, B, C, D in the figure at right. Rank the magnitude of the force on the middle charge for the different configurations with largest first and smallest last.



(1) D, C, A, B (2) C, D, A, B (3) C, A, D, B (4) A, C, D, B (5) C, B, D, A

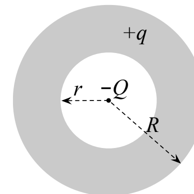
15. Two charges with charge $Q < 0$ are separated by 3 cm. There is a 1 N repulsive force between the charges. How many excess electrons are needed to make one of the charges, Q?

(1) 4×10^9 (2) 2×10^{14} (3) 6×10^5 (4) 2×10^{12} (5) 4×10^{18}

16. The potential (in volts) in a region is given by $V(x,y,z) = 2x^2 - 5y^2 + 4x^3z^2$, where x, y and z are expressed in meters. What is the magnitude of the electric field in V/m at the point (1,1,1)?

(1) 20.5 (2) 31.6 (3) 25.6 (4) 13.4 (5) 28.4

17. A thick conducting spherical shell has inner radius r and outer radius R, as shown in the figure. A point charge of $-Q$ is located at the center of the sphere and a charge of $+q$ is placed on the conducting shell. The charge on the outer surface of the conducting shell is:



(1) $+Q$ (2) $q + Q$ (3) $-Q$ (4) $q - Q$ (5) $+q$

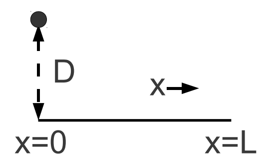
18. Two lead nuclei each with charge $+82e$ approach one another head-on from a great distance. Initially each has kinetic energy 50.0 MeV (1 MeV $= 1.6 \times 10^{-13}$ J). What is the closest distance in fm (1 fm $= 10^{-15}$ m) the nuclei will approach one another?

(1) 540 (2) 23 (3) 97 (4) 280 (5) 180

19. On the x-axis a $4\mu C$ charge is at $x = 0$ cm, and a $2\mu C$ charge is at $x = 5$ cm. What is the force on a $-1\mu C$ charge placed at $x = 3$ cm?

(1) $-5N\hat{\imath}$ (2) $+85N\hat{\imath}$ (3) $-85N\hat{\imath}$ (4) $+5N\hat{\imath}$ (5) $-40N\hat{\imath}$

20. A line of charge of length L and charge per unit length, λ, is located on the x-axis as shown in the figure. Which expression below gives the x-component of the electric field, E_x, at a distance D from the left end of the line?



(1) $-\int_0^L \frac{kD\lambda}{(x^2+D^2)^{3/2}}dx$ (2) $-\int_0^L \frac{kx\lambda}{(x^2+D^2)^{3/2}}dx$ (3) $-\int_0^L \frac{kD\lambda}{(x^2+D^2)}dx$ (4) $-\int_0^L \frac{kx\lambda}{(x^2+D^2)}dx$
(5) $-\int_0^L \frac{k\lambda}{(x^2+D^2)}dx$