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PHYSICS DEPARTMENT

PHY 2049 Exam 1 September 21, 2010

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 <u>blue</u> or <u>black</u> 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: $W = \int \vec{F} \cdot d\vec{s} = \dfrac{1}{2}mv_f^2 - \dfrac{1}{2}mv_i^2 = K_f - K_i \qquad P = \vec{F} \cdot \vec{v}$ (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)

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

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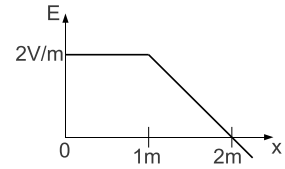
1. The electric field as a function of position in one dimension is shown in the figure. If the electrical potential at $x = 0$ m is 4 V, what is the electrical potential at $x = 2$ m?

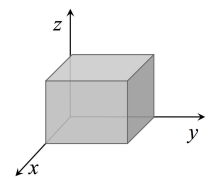


(1) 8 V (2) 0 V (3) 1 V (4) 7 V (5) 3 V

2. A very long insulating cylinder has radius of 4 mm. The cylinder is uniformly charged with charge density $\rho = 5nC/m^3$. What is the magnitude of the electric field at a distance of 2 mm from the center of the cylinder?

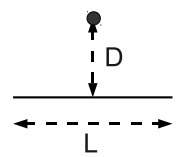
(1) 565 N/C (2) 11.3 N/C (3) 0.56 N/C (4) 1130 N/C (5) 1.13 N/C

3. A cube of side 3 m has one corner at the origin as shown in the figure. If the electric field is equal to $\vec{E} = (20 - 10x)\hat{i}$ with x measured in meters and the electric field measured in N/C, what is the net charge enclosed in the cube?



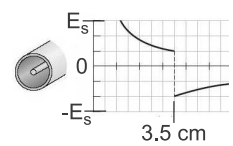
(1) +2.4 nC (2) +0.8 nC (3) +1.2 nC (4) −2.4 nC (5) −0.8 nC

4. A wire segment of length L has constant linear charge density $\lambda > 0$. Which of the following expressions gives the magnitude of the electric field a distance D from the center of the wire (see figure)?



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

5. A narrow charged solid cylinder is coaxial with a larger charged cylindrical shell (see figure). Both are nonconducting and thin and have uniform surface charge densities on their outer surfaces. The graph shows the radial component E of the electric field versus radial distance r from the common axis. If $E_s = 7 \times 10^3 N/C$, what is the charge per unit length on the *charged solid cylinder* (not the shell)?



(1) 13.6×10^{-9} C/m (2) -9.1×10^{-9} C/m (3) 9.1×10^{-9} C/m (4) 4.5×10^{-9} C/m (5) -4.5×10^{-9} C/m

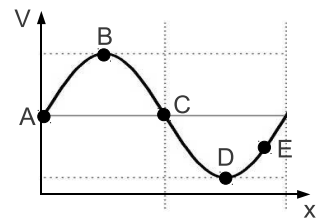
6. The electrical potential as a function of position is equal to $V = 2 - x^2$, where V is measured in volts and the position, x, is measured in meters. A proton is released from rest at $x = 1$ m. What is the velocity of the proton when it reaches $x = 2$ m?

(1) 10 km/s (2) 17 km/s (3) 20 km/s (4) 14 km/s (5) 24 km/s

7. A and B are identical conducting spheres. Sphere A is initially charged to 1 C, and sphere B has no charge initially. The following five steps are done.
   (i) Sphere A is touched to sphere B.
   (ii) The spheres are separated and sphere B is grounded.
   (iii) Sphere A is again touched to sphere B.
   (iv) The spheres are separated and sphere B is grounded.
   (v) The spheres are touched together one last time.
   What is the charge of sphere A after these five steps?

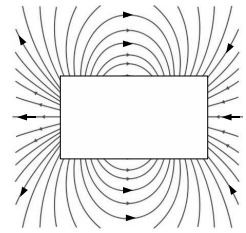
(1) 0.0625 C (2) 0.5 C (3) 0.25 C (4) 0.125 C (5) 0

8. The electrical potential as a function of position is shown in the figure. At which of the labeled points is the x-component of the electric field its maximum positive value?



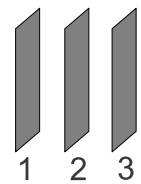
(1) E
(2) A
(3) C
(4) D
(5) B

9. The field lines for two point charges is shown at right. Based on the field lines, what are the signs of the charges?



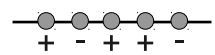
(1) both charges are positive
(2) positive charge on right, negative charge on left
(3) positive charge on left, negative charge on right
(4) both charges are negative
(5) none of the other answers is correct

10. Three large charged insulating sheets have charge per unit area of $\sigma_1 = +1\mu C/m^2$, $\sigma_2 = -2\mu C/m^2$, σ_3. What is the charge density of sheet 3, σ_3, in order for the electric field to be zero in the region between sheets 2 and 3.



(1) $+1\mu C/m^2$ (2) $+3\mu C/m^2$ (3) $-1\mu C/m^2$ (4) $+2\mu C/m^2$ (5) $-2\mu C/m^2$

11. Five charges of magnitude e and sign indicated in the figure are placed on a line. The separation between the charges is d. What is the magnitude and direction of the force on the middle charge?



(1) 1.5 ke^2/d^2, right (2) 1.5 ke^2/d^2, left (3) 0 (4) 2.5 ke^2/d^2, right (5) 2.5 ke^2/d^2, left

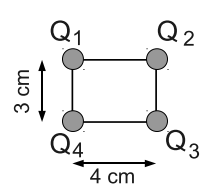
12. An electron is initially 10^{-10} m from a proton. The electron is moved to a distance of 2×10^{-10} m from the proton. What is the change in the potential energy of the electron, $U_f - U_i$?

(1) -1×10^{-18} J (2) 1×10^{-24} J (3) 1×10^{-28} J (4) 1×10^{-18} J (5) -1×10^{-18} J

13. An electron with initial velocity of 500 km/s is traveling in the direction of a uniform electric field with magnitude 2 V/m. How long will it take the electron to return to its initial position?

(1) 1.4 nano-sec. (2) 0.7 micro-sec. (3) 2.8 micro-sec. (4) 2.8 nano-sec. (5) 1.4 micro-sec.

14. Four charges are placed at the corners of a rectangle as shown in the figure. If $Q_1 = 1\,\mu$C, $Q_2 = -2\,\mu$C, $Q_3 = 1\mu C$, and $Q_4 = 2\mu C$, what is the magnitude of the net force on Q_4?



(1) 25.1 N (2) 6.4 N (3) 11.4 N (4) 8.9 N (5) 36.6 N

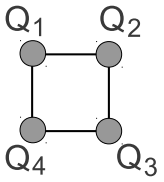
15. The following tests are made on an object X of unknown charge and material.
(i) A positively charged object is attracted to X. **(ii)** A negatively charge object is attracted to X.
Which of the following are possible explanations of this behavior?

(1) X is a positively charged insulator.
(2) X is a neutral conductor.
(3) X is spontaneously creating charge.
(4) None of the other answers is correct.
(5) X is a negatively charged insulator.

16. How many excess electrons are in $-2\mu C$ charge?

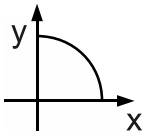
(1) 10^{13} (2) 10^{14} (3) 10^{19} (4) 10^{16} (5) 10^{12}

17. Four charges are placed at the corner of a square of side 5 cm. If the charges have values $Q_1 = 2nC$, $Q_2 = 3nC$, $Q_3 = -1nC$, and $Q_4 = -2nC$, what is the electrical potential at the center of the square?



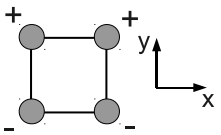
(1) 0 V (2) 1440 V (3) 250 V (4) 360 V (5) 510 V

18. A segment of a circular arc has charge per unit length $5nC/m$. As shown in the figure, the segment covers one quarter of a circle of radius 1 cm. What is the magnitude of the electric field at the center of the circle?



(1) 9.0 kV/m (2) 4.5 kV/m (3) 6.4 kV/m (4) 12.8 kV/m (5) 15.2 kV/m

19. In the figure four charges with the same magnitude and indicated charge are placed on the corners of a square. What is the direction of the resulting electric field at the center of the square?



(1) $+\hat{j}$ (2) $-\hat{j}$ (3) $+\hat{i}$ (4) $\vec{E} = 0$ (5) $-\hat{i}$

20. A conducting sphere of radius 1 cm is surrounded by a conducting spherical shell of inner radius 3 cm and outer radius 4 cm. If the electric field at $r = 2$ cm is going outwards with magnitude 300 V/cm and at $r = 5$ cm is also going outwards with magnitude 300 V/cm, what is the net charge on conducting spherical shell?

(1) 9 nC (2) 8 nC (3) 7 nC (4) 10 nC (5) 0 nC