Physics 241
Exam 1
February 19, 2004

One (both sides) 8 1/2" x 11" crib sheet is allowed. It must be of your own creation.

$$k = \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ \frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}}$$

$$\varepsilon_0 = 8.85\times10^{-12}\ \frac{\mathrm{C^2}}{\mathrm{N\cdot m^2}}$$

$$e = 1.602\times10^{-19}\ \mathrm{C}$$

$$c = 2.99792458\times10^8\ \mathrm{m/s}\ \text{(speed of light)}$$

$$N_{Avogadro} = 6.022\times10^{23}\ \text{(number of atoms in 12 g of } {}^{12}\mathrm{C})$$

m 10^{-3} μ 10^{-6} n 10^{-9} p 10^{-12} f 10^{-15}

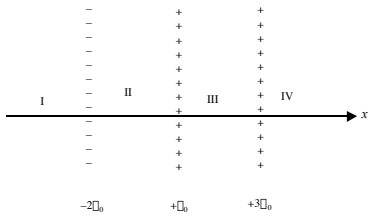
k 10^{3} M 10^{6} G 10^{9} T 10^{12} P 10^{15}

For $ax^2 + bx + c = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

1. Please sign the opscan sheet and print your name on it.
2. Use a #2 pencil to fill in your full name, your student identification number (old one), and finally the answers for problems 1–13.
3. Please be prepared to show your Purdue ID when you hand in your opscan sheet.

1. Consider the three infinite charge sheets shown on edge below.

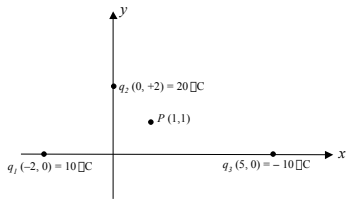


What is value of the electric field in region III?

	magnitude	direction
a)	$\frac{\sigma_0}{\varepsilon_0}$	$-x$
b)	$\frac{3\sigma_0}{2\varepsilon_0}$	$-x$
c)	$\frac{3\sigma_0}{2\varepsilon_0}$	$+x$
d)	$\frac{2\sigma_0}{\varepsilon_0}$	$-x$

e) none of the above

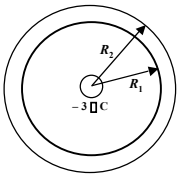
2. Consider the point charges $q_i(x_i, y_i)$ shown below:



x_i and y_i are in meters. What is the electric potential at point P, which is at $(x, y) = (1,1)$?

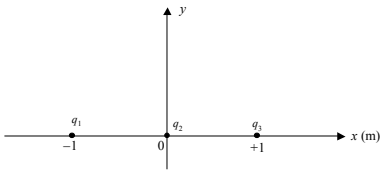
(a) 49 kV
(b) 105 kV
(c) 134 kV
(d) 178 kV
(e) None of the above

3. Consider two concentric conducting spheres as shown below. The outer sphere is hollow and has a total charge of +5 μC charge on it; its inner radius is R_1= 9 cm and its outer radius is R_2 = 10 cm. The inner sphere has a radius of 1 cm, is solid, and has a charge –3 μC on it. What is the potential of the inner surface of the spherical shell? I.e., what is $V(R_1 = 9\ \mathrm{cm})$? Assume that the potential at infinite distance is zero.



(a) 180 kV
(b) 200 kV
(c) 300 kV
(d) 720 kV
(e) none of the above

4. How much work must be done to place the three charges in the configuration shown below, in which $q_1 = -6\ \mu C$ is at $(x, y) = (-1\text{ m}, 0)$, $q_2 = 12\ \mu C$ is at $(0, 0)$, and $q_3 = 24\ \mu C$ is at $(+1\text{ m}, 0)$? Assume that the three charges were initially infinitely far away.

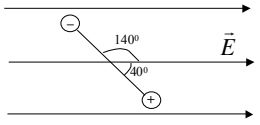


(a) – 0.65 J
(b) +1.6 J
(c) +1.3 J
(d) +3.9 J
(e) none of the above

5. Suppose a potential is described by $V(x,y,z) = \left(5x^2 - 2y^4 + z^3 + xy^2 - 2xz^2\right)$ volts where x, y, and z are in meters. What is E_x, the x-component of the electric field at $x = 1$ m, $y = 2$ m, and $z = 3$ m?

(a) 10 V/m
(b) 4 V/m
(c) – 1 V/m
(d) – 4 V/m
(e) none of the above

6. Two charges of equal magnitude but opposite sign are separated by 0.1 nm, thus forming an electric dipole. If they are oriented in a uniform electric field of 3000 V/m as shown below, what is the magnitude of the torque on the electric dipole? The magnitude of each of the charges is 1.60×10^{-19} C.

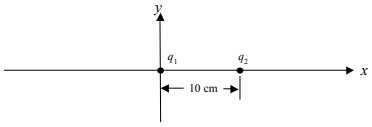


(a) 3.1×10^{-26} N·m
(b) 3.7×10^{-26} N·m
(c) 6.2×10^{-26} N·m
(d) 7.4×10^{-26} N·m
(e) none of the above

7. What is the magnitude and direction of the electric field needed to cancel the earth's gravitational force on an electron (e^-)? The mass of an electron is 9.11×10^{-31} kg and $\vec{g}_{earth} = -9.80\ \hat{j}$ m/s^2.

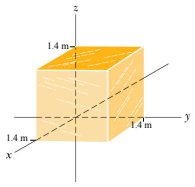
(a) $-8.9 \times 10^{30}\ \hat{j}$ N/C
(b) $5.6 \times 10^{-31}\ \hat{j}$ N/C
(c) $-5.6 \times 10^{-31}\ \hat{j}$ N/C
(d) $1.8 \times 10^{10}\ \hat{j}$ N/C
(e) none of the above

8. Point charges $q_1 = +1.0\ \mu C$ and $q_2 = -3.0\ \mu C$ are 10 cm apart as shown below. If q_1 is at $x = 0$, where would you place an electron (mass = 9.11×10^{-31} kg, charge = $e^- = -1.60 \times 10^{-19}$ C) so that no electrostatic force acts on it?



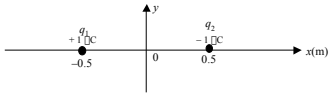
(a) $x = 23.7$ cm
(b) $x = 13.7$ cm
(c) $x = -3.7$ cm
(d) $x = -13.7$ cm
(e) none of the above

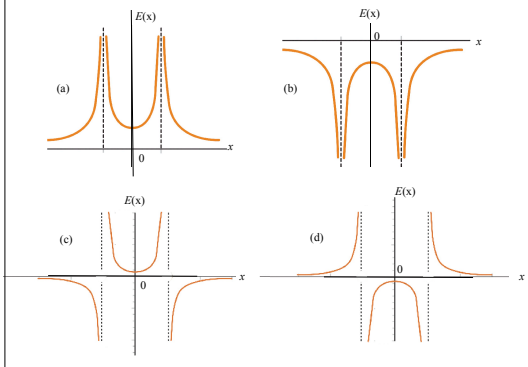
9. The cube shown below has edge lengths of 1.40 m and is placed such that the hidden corner is at the origin of the coordinate system. If $\vec{E} = 3.00y\,\hat{j}$, where $\vec{E}$ is in units of newtons/coulomb and y is in meters, what is $\Phi_{net} = \oint E_n dA$?



(a) 0
(b) 3.00 $\frac{N \cdot m^2}{C}$
(c) 8.23 $\frac{N \cdot m^2}{C}$
(d) 49.4 $\frac{N \cdot m^2}{C}$
(e) none of the above

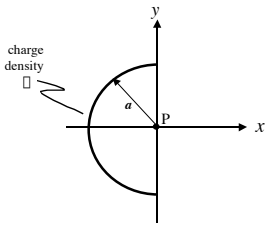
10. Charges q_1 and q_2 in the figure below are separated by 1 m. If q_1 has a charge of $+1\ \mu C$ and q_2 has a charge of $-1\ \mu C$, which of the plots below best describes $E(x)$? The origin is denoted by 0 in all figures.





(e) none of the above

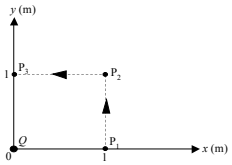
11. A uniform line charge is bent into a semi-circle of radius a.



What is the magnitude of the electric field at point P?

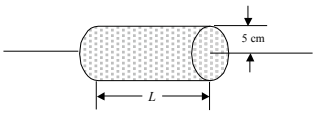
(a) $\frac{k\lambda}{a}$
(b) $\frac{k\lambda}{a^2}$
(c) $\frac{2k\lambda}{a}$
(d) $\frac{k\lambda}{a}$
(e) none of the above

12. A point charge Q = 100 nC is at the origin [$(x, y) = (0, 0)$] of the coordinate system shown below. A proton (mass = 1.67 x 10^{-27} kg, charge $+e$ = 1.60 x10^{-19} C) is initially at point P_1(x = 1 m, y = 0), moved to point P_2(x = 1 m, y = 1 m), and finally to point P_3(x = 0 m, y = 1 m) . What is the amount of work needed to accomplish this move (P_1 to P_2 to P_3)?



(a) 8.4 x 10^{-17} J
(b) 1.0 x 10^{-16} J
(c) 1.4 x 10^{-16} J
(d) 0 J
(e) none of the above

13. The cylinder of 5 cm radius and length 20 cm shown below has a uniform charge density throughout its volume. Its total charge is Q = 12 □C. What is the electric field at a distance of 3 cm from the axis of the cylinder? Consider the cylinder as one small segment of an infinitely long charged cylinder.



(a) 120 MV/m
(b) 36 MV/m
(c) 22 MV/m
(d) 13 MV/m
(e) none of the above

Physics 241
Answer key for blue Exam 1
2/19/04

1. (d) $\frac{2\rho_0}{\alpha_0}, \alpha x$
2. (c) 134 kV
3. (a) 180 kV
4. (c) 1.3 J
5. (b) 4 V/m
6. (a) $3.1\times10^{-26}\ \mathrm{N\cdot m}$
7. (c) $-5.6\times10^{-11}\,\hat{j}\ \mathrm{N/C}$
8. (d) -13.7 cm
9. (c) 8.23 $\frac{\mathrm{N\cdot m^2}}{\mathrm{C}}$
10. (c)
11. (c) $\frac{2k\rho}{a}$
12. (d) 0 J
13. (d) 13 MV/m