PHYS 272 Fall 20111

Exam 1

There are two parts to the Exam 1, part 1 is a machine-graded test (multiple choice problems) and part 2 is a separate test that you turn in to be graded by hand.
A formula sheet is provided (see end page of the machine-graded test).

Machine Answer Sheet:
Using a pencil, fill in Last Name, First Name, & Middle Initial, plus your 10-digit Purdue University ID number. Enter Instructor (Manfra/Chen), Course (PHYS 272), Date (09/26/2011), and Test (001). Do not fill in anything for the "Section". **You must include your Signature. Fill in circle "A" for Test Form.**

Hand-Graded Sheet:
Enter your Name, Signature, PUID, and circle your Recitation Section.

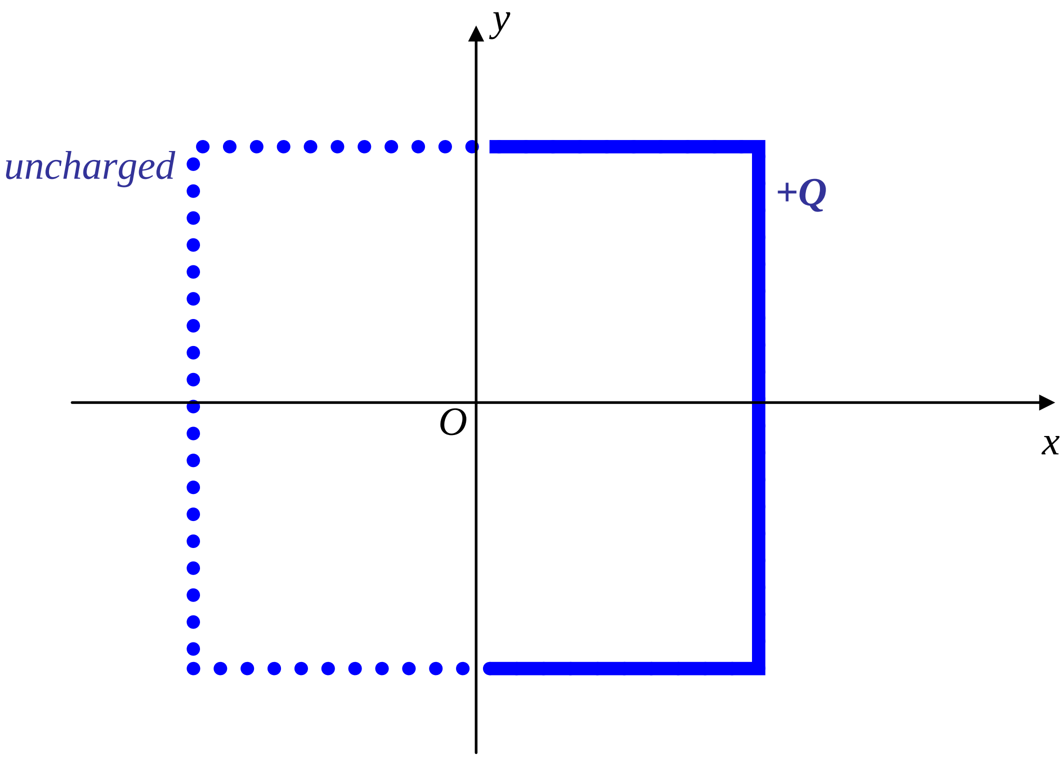
When finished with both parts, bring them to the front of the classroom, show your Purdue ID card to the Instructor/TA, and turn in the machine-graded answer sheet in the box (do not worry about the color code) and the hand-graded exam book on the correct envelop marked with your recitation TA's name. These two parts together are worth 100 points total. Your grades will appear in the CHIP grade book in a few days. You should keep this copy of the exam in case you have questions for your TA.

Part 1: Machine Graded Test

There is only one correct answer to each problem. Each problem carries 8 points. A problem may continue onto the next page so make sure you read the entire question.

Problem 1

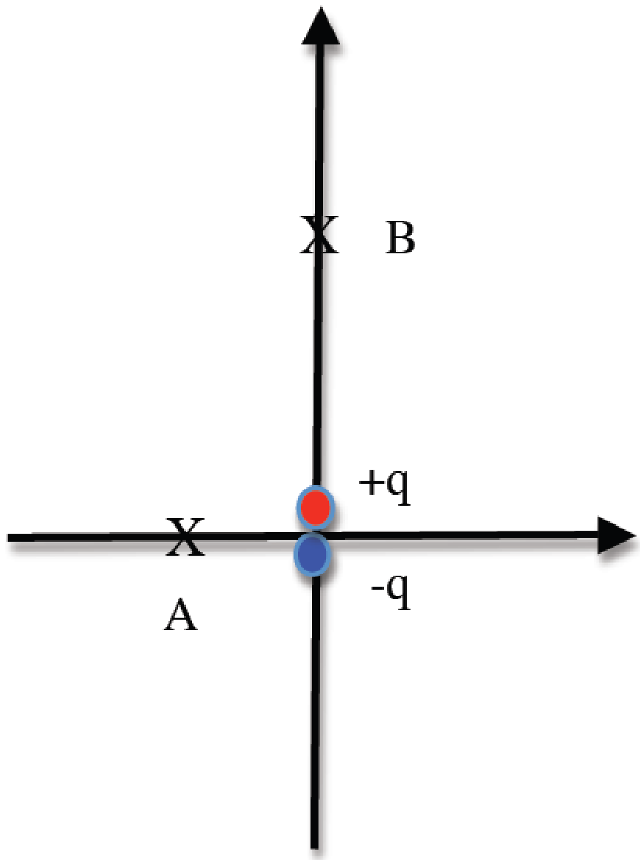
A charge of +Q (Q>0) is uniformly distributed on the right half surface (indicated by the thick solid line in the figure below) of a cubic box, while the left half is uncharged. In what direction does the electric field point at the origin (center of the box)?



1. $\hat{y}$
2. $-\hat{y}$
3. $\hat{x}$
4. $-\hat{x}$
5. The electric field is exactly zero at the origin.

Problem 2

The magnitude of the electric field due to a small dipole is measured to be 100 N/C at a location “A” on the axis perpendicular to the dipole 3 cm from its center. Approximately what is the magnitude of the electric field due to the dipole at a location 6 cm from the center of the dipole along an axis parallel to the dipole?

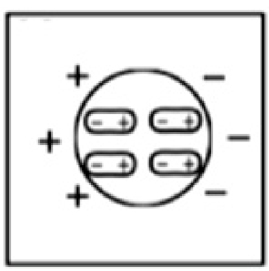


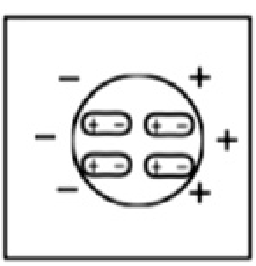
1. 16.7 N/C
2. 50 N/C
3. 25 N/C
4. 12.5 N/C
5. 6.25 N/C

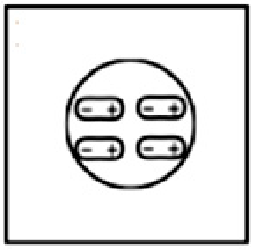
Problem 3

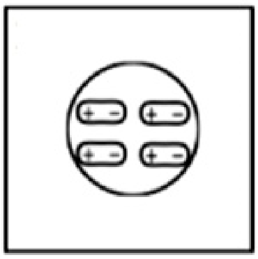
A negatively charged plastic pen is brought near a neutral solid plastic cylinder.

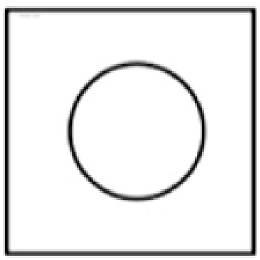
Which figure below shows the charge distribution for the plastic cylinder?

1. 

2. 

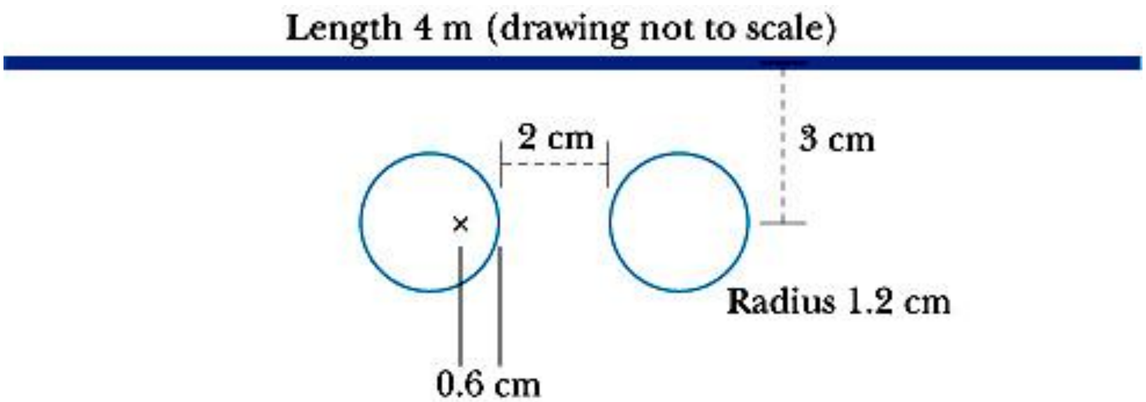
3. 

4. 

5. 

Problem 4

A very thin glass rod 4 meters long is rubbed all over with a silk cloth. It gains a uniformly distributed charge 2.3×10^{-6} C. Two small spherical rubber balloons of radius 1.2 cm are rubbed all over with wool. They each gain a uniformly distributed charge of -3×10^{-8} C. The balloons are near the midpoint of the glass rod, with their centers 3 cm from the rod. The balloons are 2 cm apart (4.4 cm between centers). Find the magnitude of the electric field at the location marked *x*, 0.6 cm to the right of the center of the left balloon. Also calculate the angle the electric field makes with the horizontal (define counter clockwise from the horizontal as positive). Consider +*x* to the right, +*y* upwards, and +*z* coming out of page.



1. 1.96×10^5 N/C; 61.54°
2. 1.96×10^5 N/C; -61.54°
3. 7.85×10^5 N/C; -61.54°
4. 3.92×10^5 N/C; 61.54°
5. 3.92×10^5 N/C; -61.54°

Problem 5

With the same setup as shown above in the previous problem, a neutral hydrogen atom is placed at the location marked *x*. The polarization of atomic hydrogen has been measured to be $\alpha = 7.4 \times 10^{-41}$ C m/(N/C). What is the distance between the center of the proton and the center of the electron cloud in the hydrogen atom? Remember the relationship: $p = \alpha E$.

1. 3.81×10^{-14} m
2. 3.63×10^{-16} m
3. 1.81×10^{-16} m
4. 0.91×10^{-16} m
5. 1.81×10^{-14} m

Problem 6

Two rings of radius 4cm are 12cm apart and concentric with a common horizontal x-axis. The ring on the left carries a charge uniformly distributed charge of +40nC while the ring to the right has a uniformly distributed charge of -40nC. If a charge of -2nC were placed midway between the rings, what would be the net force exerted on this charge by the rings?

1. 1.2×10^{-4} N in the –x direction
2. 2.3×10^{-4} N in the –x direction
3. 4.1×10^{6} N in the +x direction
4. 1.5×10^{-5} N in the +x direction
5. 4.3×10^{-6} N in the –x direction

Problem 7

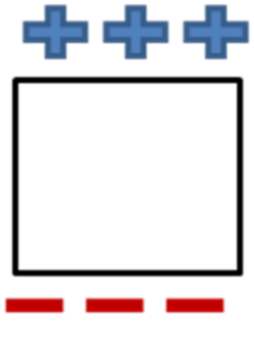
A small object with charge Q_1=6nC is located at the origin. A second small object with charge Q_2=-5nC is located at <0.05, 0.08, 0> m. What is the net electric field at location A <-0.04, 0.08, 0> m due to Q_1 and Q_2?

1. <2.54×10^{3}, 6.04×10^{3}, 0> N/C
2. <-1.34×10^{4}, 3.94×10^{3}, 0.03> N/C
3. <5.12×10^{-3}, 6.04×10^{2}, 0> N/C
4. <-4.43×10^{2}, 4.43×10^{2}, -2.02×10^{2}> N/C
5. <1.03×10^{3}, 1.35×10^{3}, 0> N/C

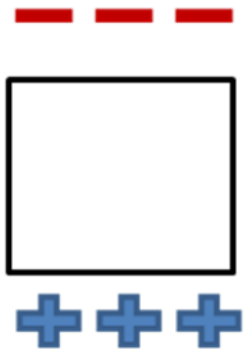
Problem 8

A negatively charged iron block is placed in a region where there is an electric field downward (in the –y direction) due to charges not shown. Which of the diagrams (1-5) below best describes the charge distribution in and/or on the iron block?

Answer: #3



1



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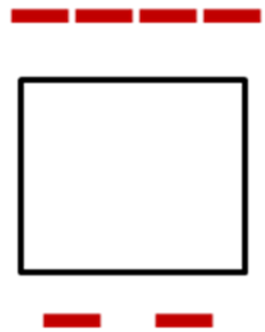

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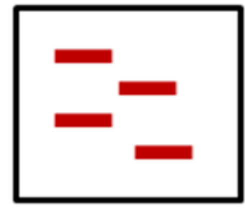

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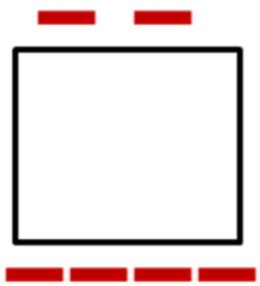

5

Fundamental Concepts

Equations you must know:

(1) Electric field of a point charge

(2) Relationship between electric field and electric force

Other fundamental concepts:

Conservation of charge

The Superposition Principle

Specific results

Electric field due to a uniformly charged spherical shell: outside shell, like point charge; inside shell, 0.

$\left|\vec{E}_{rod}\right| = \frac{1}{4\pi\varepsilon_o}\left[\frac{Q}{r\sqrt{r^2+(L/2)^2}}\right]$ a perpendicular distance r from the center; $\left|\vec{E}_{rod}\right| \approx \frac{1}{4\pi\varepsilon_o}\frac{2(Q/L)}{r}$ if $r << L$

$\left|\vec{E}_{ring}\right| = \frac{1}{4\pi\varepsilon_o}\frac{qz}{\left(z^2+R^2\right)^{3/2}}$ a distance z along the axis

$\left|\vec{E}_{disk}\right| = \frac{Q/A}{2\varepsilon_o}\left[1-\frac{z}{\left(z^2+R^2\right)^{1/2}}\right]$ a distance z along the axis; $\left|\vec{E}_{disk}\right| = \frac{Q/A}{2\varepsilon_o}\left[1-\frac{z}{R}\right]$ if $z << R$

$\left|\vec{E}_{capacitor}\right| = \frac{Q/A}{\varepsilon_o}$ for $+Q$ and $-Q$ disks;

$\left|\vec{E}_{fringe}\right| = \frac{Q/A}{\varepsilon_o}\left(\frac{s}{2R}\right)$ just outside capacitor

$\left|\vec{E}_{dipole,x}\right| \approx \frac{1}{4\pi\varepsilon_o}\frac{2qs}{x^3}$ along dipole axis, where $x >> s$; $\left|\vec{E}_{dipole,y}\right| \approx \frac{1}{4\pi\varepsilon_o}\frac{qs}{y^3}$ along perpendicular axis, for $y >> s$

electric dipole moment $p = qs$

Physical constants

$\frac{1}{4\pi\varepsilon_o} = 9x10^9\ \frac{N\cdot m_2}{C^2}$

$\varepsilon_0 = 9x10^{-12}\ \frac{C^2}{N\cdot m^2}$

$c = 3\text{x}10^8$ *m/s*

$e = 1.6\text{x}10^{-19}$ coulomb

$m_{\text{proton}} \approx m_{\text{neutron}} \approx m_{\text{hydrogen atom}} = 1.7\text{x}10^{-27}$ kg

$m_{\text{electron}} = 9\text{x}10^{-31}$ kg

$g = 9.8$ N/kg

$6.02\text{x}10^{23}$ molecules/mole Atomic radius $\approx 10^{-10}$ m Proton radius $\approx 10^{-15}$ m

Electric field necessary to ionize air, about $3\text{x}10^6$ N/C

Geometry

area of circle = πr^2 circumference of circle = $2\pi r$ area of curved surface of cylinder = $2\pi rL$

surface area of sphere = $4\pi r^2$ volume of sphere = $\frac{4}{3}\pi r^3$ arc length = $r\Delta\theta$