

PHYS 272 Fall 2010

Practice 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).

Machine Answer Sheet:

Using a pencil, fill in Last Name, First Name, & Middle Initial, plus your 10-digit Purdue University ID number. Enter Instructor (Chen/Manfra), Course (PHYS 272), Date (), and Test (1). **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.

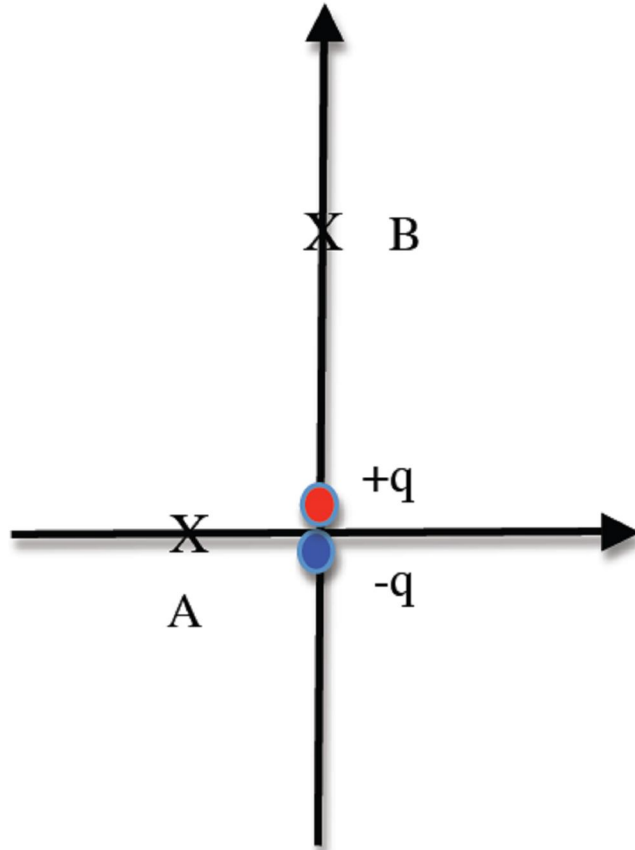
When finished with both parts, bring them to the front of the classroom, show your Purdue ID card to the Instructor, and turn in the machine-graded answer sheet and the hand-graded answer sheet at the same time. These two parts together are worth 120 points total. Your grades will appear in the CHIP 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 10 points.

Problem 1 [5 points]

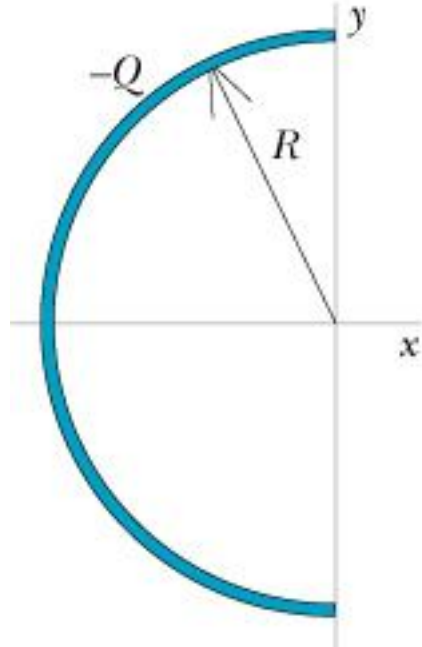
The magnitude of the electric field due to a small dipole is measured to be 100 N/C at a location "A" on the axis perpendicular to the dipole 3 cm from its center. Approximately what is the magnitude of the electric field due to the dipole at a location 6 cm from the center of the dipole along an axis 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
6. 3.125 N/C
7. 1.0 N/C

Problem 2 [5 points]

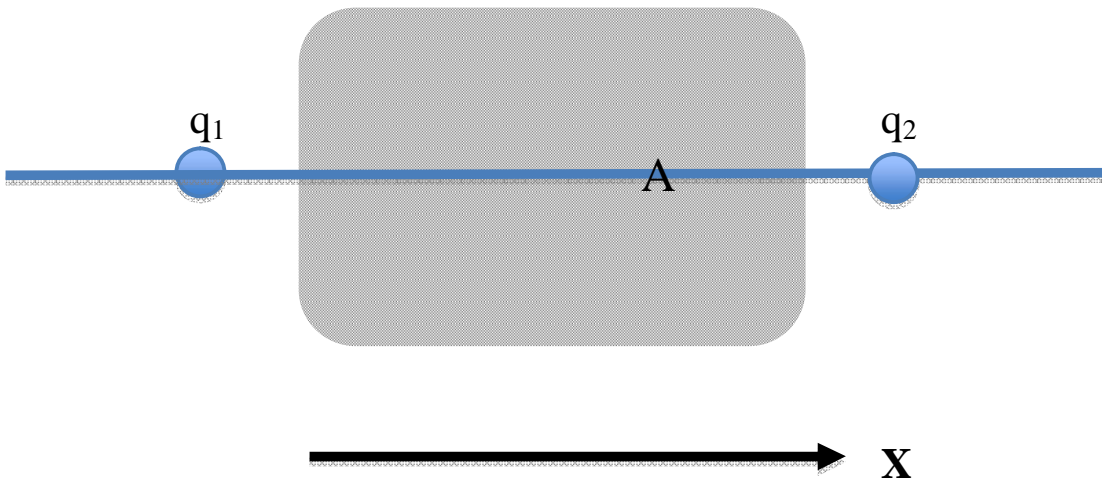
A charge of $-Q$ is uniformly distributed over the surface of a thin semispherical shell of radius R . In what direction does the electric field point at the origin? ($Q > 0$)



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

Problem 3 [5 points]

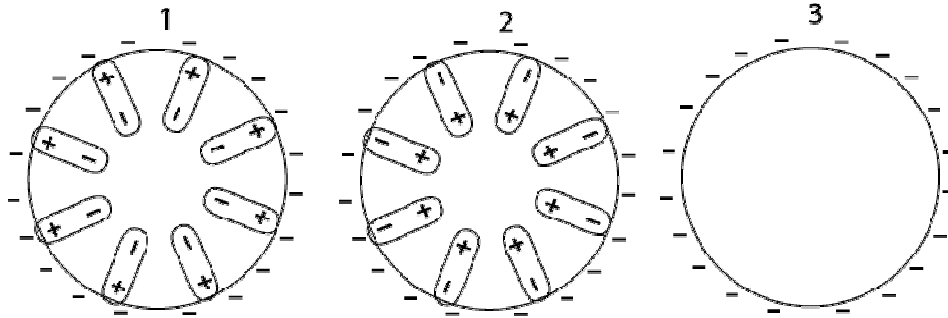
Below is a neutral, solid piece of metal that is placed near two point charges, $q_1 = -5 \text{ nC}$ and $q_2 = +5 \text{ nC}$. What is the magnitude and direction of the electric field at point A due only to the induced surface charges on the metal piece? The distance between point A and q_1 is 10 cm, while that between point A and q_2 is 5 cm. Point A is collinear with the two charges.



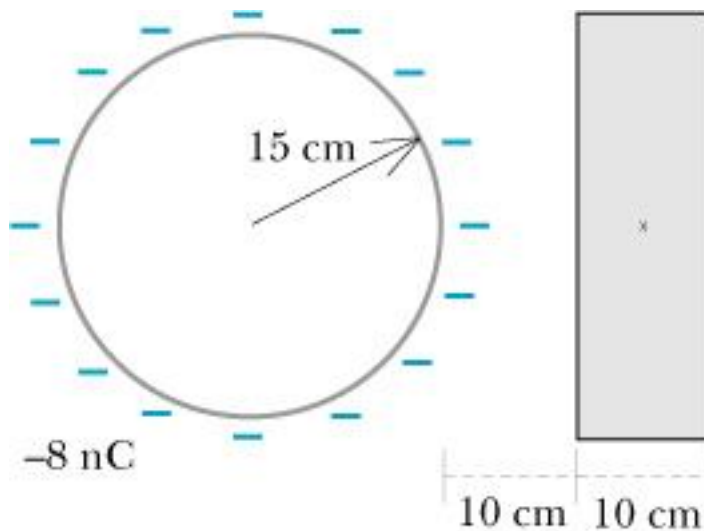
1. 0 N/C
2. $4,680 \text{ N/C}, \hat{x}$
3. $4,680 \text{ N/C}, -\hat{x}$
4. $4,320 \text{ N/C}, \hat{x}$
5. $4,320 \text{ N/C}, -\hat{x}$
6. $22,500 \text{ N/C}, \hat{x}$
7. $22,500 \text{ N/C}, -\hat{x}$
8. $13,500 \text{ N/C}, \hat{x}$
9. $13,500 \text{ N/C}, -\hat{x}$

Problem 4 [5 points]

A solid plastic ball has been rubbed all over with a piece of wool so that negative charge is uniformly spread over its surface. Which diagram best shows the polarization of molecules inside the ball? [3]



Problem 5 [5 points]



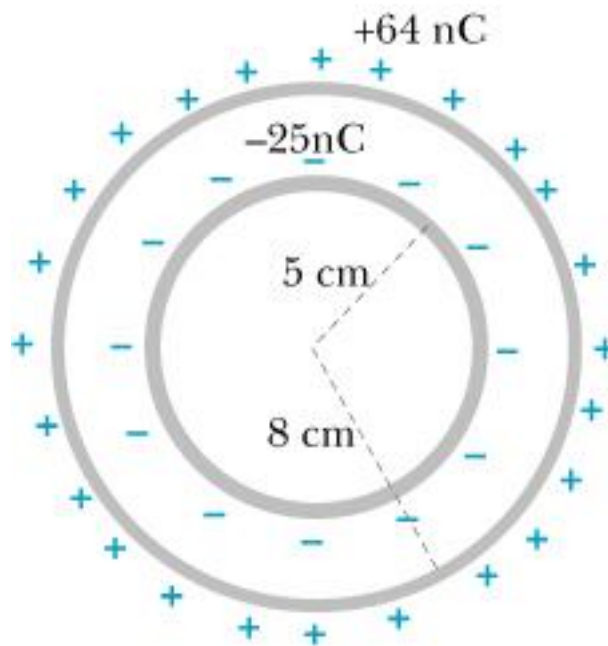
A very thin spherical plastic shell of radius 15 cm carries a uniformly distributed negative charge of -8 nC on its outer surface. An uncharged solid metal block is placed nearby. The block is 10 cm thick, and it is 10 cm away from the surface of the sphere. The magnitude of the electric field at the center of the metal block due only to the charges on the block itself is: [4]

1. 1152 N/C
2. 3200 N/C
3. 0 N/C
4. 800 N/C
5. 1800 N/C

Problem 6 [5 points]

A thin plastic spherical shell of radius 5 cm has a uniformly distributed charge of -25 nC on its outer surface. A concentric thin plastic spherical shell of radius 8 cm has a uniformly distributed charge of +64 nC on its outer surface. The magnitude of the electric field at 6 cm from the center of the spheres is: [2]

1. 9.75×10^4 N/C
2. 6.25×10^4 N/C
3. 9.0×10^4 N/C
4. 0 N/C



Problem 7 [5 points]

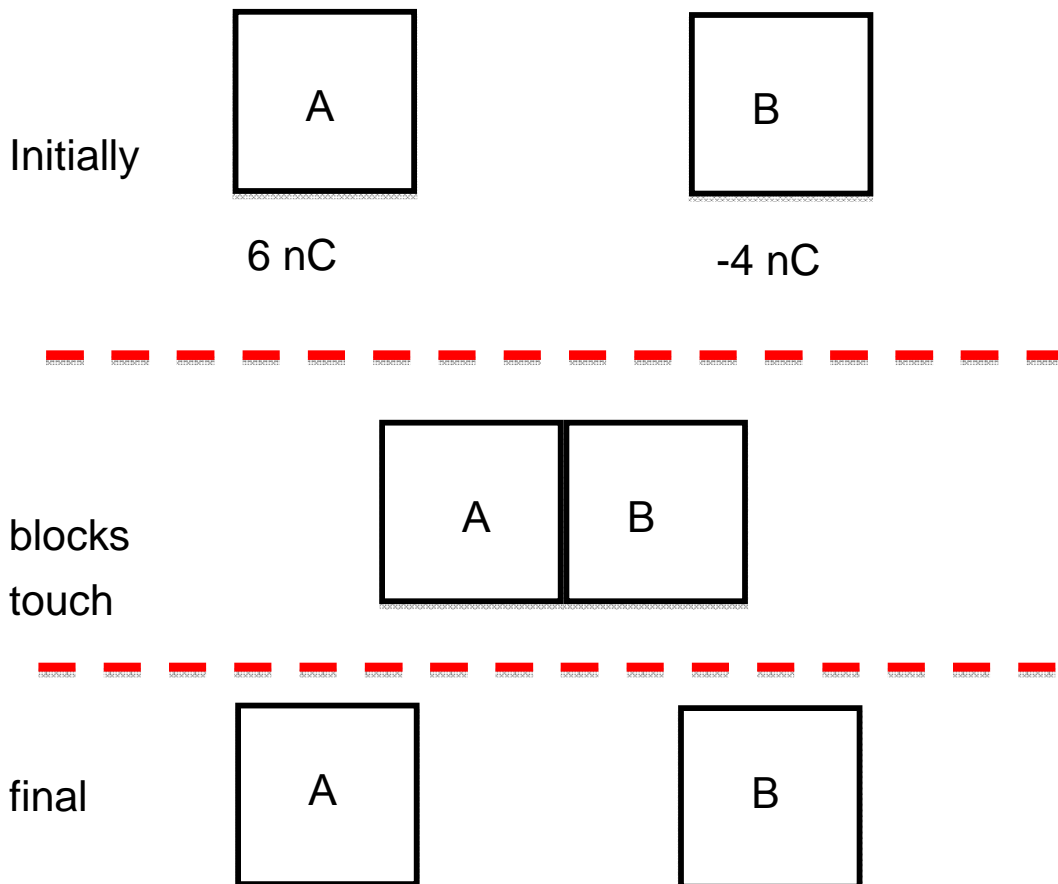
The magnitude of the electric field a distance 24 cm from the center is [2]

1. 1.0×10^4 N/C
2. 6.1×10^3 N/C
3. 1.4×10^4 N/C
4. 1.5×10^3 N/C
5. 0 N/C

Problem 8 [5 points]

In the diagram below, A and B are identical metal blocks. What is the final charge of block B? There are no external electric fields. [5]

1. +6 nC
2. -4 nC
3. 0 nC
4. -1 nC
5. +1 nC



Part 2: Hand-Graded part

Name (Print): _____

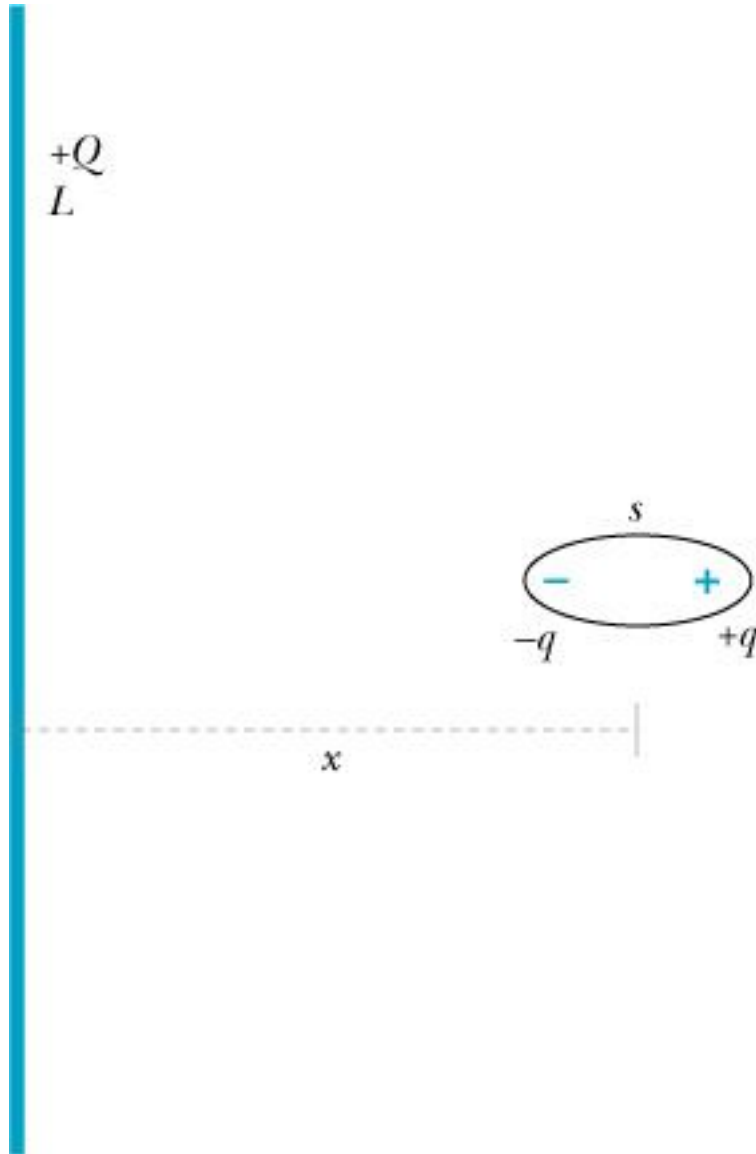
Signature: _____

PUID: _____

Problem 9 [40 points]

A water molecule is a permanent dipole with a known dipole moment $p (=qs)$. There is a water molecule in the air a very short distance x from the midpoint of a long glass rod of length L carrying a uniformly distributed positive charge $+Q$. The axis of the dipole is perpendicular to the rod. Note that $s \ll x \ll L$. The charged rod induces an increase in the dipole moment of the water molecule. (This is very small compared to the water molecules permanent dipole moment and can therefore be neglected.) Recall that for

small z , $\frac{1}{1+z} \approx 1 - z$



a) [8 points] Write the expression for the electric field due to the charged rod at the location of $-q$. Be sure to use vector notation, $\langle x, y, z \rangle$.

Since the charge $-q$ is located a distance of $(x-s/2)$ from the rod, the electric field magnitude is $E = \frac{1}{4\pi\epsilon_0} \frac{2(Q/L)}{x-s/2}$. It is along the $+x$ direction, so the electric field in vector notation is $\langle \frac{1}{4\pi\epsilon_0} \frac{2(Q/L)}{x-s/2}, 0, 0 \rangle$.

b) [8 points] Write the expression for the electric field due to the charged rod at the location of $+q$. Be sure to use vector notation, $\langle x, y, z \rangle$.

Since the charge $+q$ is located a distance of $(x+s/2)$ from the rod, the electric field magnitude is $E = \frac{1}{4\pi\epsilon_0} \frac{2(Q/L)}{x+s/2}$. It is along the $+x$ direction, so the electric field in vector notation is $\langle \frac{1}{4\pi\epsilon_0} \frac{2(Q/L)}{x+s/2}, 0, 0 \rangle$.

c) [4 point] Write an expression in vector form for the electric **force** acting on $-q$.

Ans:

$$\vec{F} = (-q)\vec{E} = \left\langle -\frac{1}{4\pi\epsilon_0} \frac{2q(Q/L)}{x-s/2}, 0, 0 \right\rangle = \left\langle -\frac{1}{2\pi\epsilon_0} \frac{qQ}{L(x-s/2)}, 0, 0 \right\rangle$$

d) [4 point] Write an expression in vector form for the electric **force** acting on $+q$.

Ans:

$$\vec{F} = (+q)\vec{E} = \left\langle \frac{1}{4\pi\epsilon_0} \frac{2q(Q/L)}{x+s/2}, 0, 0 \right\rangle = \left\langle \frac{1}{2\pi\epsilon_0} \frac{qQ}{L(x+s/2)}, 0, 0 \right\rangle$$

e) [4 point] Write an expression in vector form for the net force on the water molecule.

Ans:

$$\begin{aligned} \vec{F}_{net} &= \left\langle -\frac{1}{2\pi\epsilon_0} \frac{qQ}{L(x-s/2)}, 0, 0 \right\rangle + \left\langle \frac{1}{2\pi\epsilon_0} \frac{qQ}{L(x+s/2)}, 0, 0 \right\rangle = \frac{qQ}{2\pi\epsilon_0 L} \left\langle \frac{1}{(x+s/2)} - \frac{1}{(x-s/2)}, 0, 0 \right\rangle \\ &= \frac{qQ}{2\pi\epsilon_0 Lx} \left\langle \frac{1}{(1+s/2x)} - \frac{1}{(1-s/2x)}, 0, 0 \right\rangle \approx \frac{qQ}{2\pi\epsilon_0 Lx} \left\langle (1-s/2x) - (1+s/2x), 0, 0 \right\rangle = \left\langle -\frac{sqQ}{2\pi\epsilon_0 Lx^2}, 0, 0 \right\rangle \end{aligned}$$

f) [12 points] Express the net force in terms of the quantities Q , L , x and p ($=qs$).

Ans:

$$\vec{F}_{net} = \left\langle -\frac{sqQ}{2\pi\epsilon_0 Lx^2}, 0, 0 \right\rangle = \left\langle -\frac{pQ}{2\pi\epsilon_0 Lx^2}, 0, 0 \right\rangle$$

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.

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

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

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

$$|\vec{E}_{capacitor}| = \frac{Q/A}{\epsilon_o} \text{ for } +Q \text{ and } -Q \text{ disks; } |\vec{E}_{fringe}| = \frac{Q/A}{\epsilon_o} \left(\frac{s}{2R} \right) \text{ just outside capacitor}$$

$$|\vec{E}_{dipole,x}| \approx \frac{1}{4\pi\epsilon_o} \frac{2qs}{x^3} \text{ along dipole axis, where } x \gg s; \quad |\vec{E}_{dipole,y}| \approx \frac{1}{4\pi\epsilon_o} \frac{qs}{y^3} \text{ along perpendicular axis, for } y \gg s$$

electric dipole moment $p = qs$

Physical constants

$$\frac{1}{4\pi\epsilon_o} = 9 \times 10^9 \frac{N \cdot m^2}{C^2}$$

$$\epsilon_o = 9 \times 10^{-12} \frac{C^2}{N \cdot m^2}$$

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

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

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

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

$$g = 9.8 \text{ N/kg}$$

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

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

Geometry

$$\text{area of circle} = \pi r^2 \quad \text{circumference of circle} = 2\pi r \quad \text{area of curved surface of cylinder} = 2\pi rL$$

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