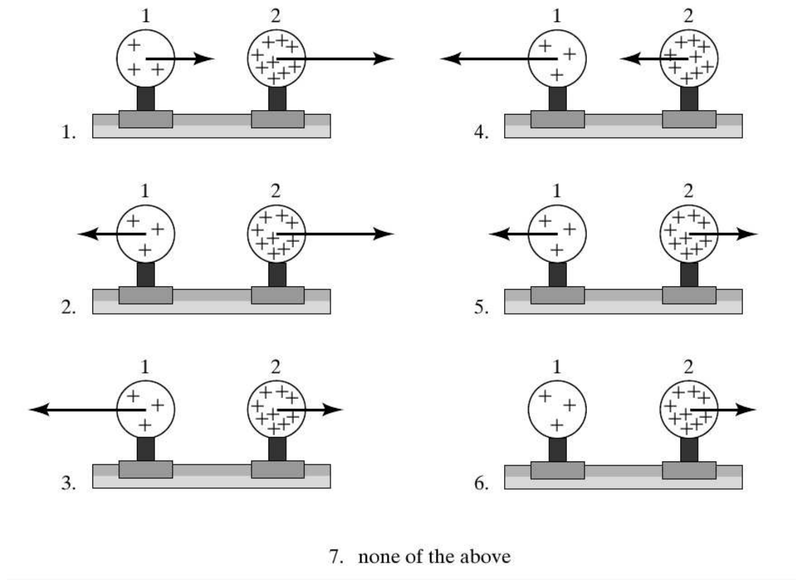

Figure 1:

Name:

Physics 122-02 Test 2B

Instructions:

No paper on desk. Show short answers on paper or in margins. Substantial work should be done on back of exam pages or scratch paper. All paper used must be submitted before you leave. Problems 1-5 require *only* an answer. You *may* provide an explanation for 1-5 if you want an opportunity for partial credit. Problems 6-15 require work to be shown in an orderly fashion. *IDEA* method is recommended but not required.

Formulae are on page 4.

1. *(5 pts.)* Two uniformly charged spheres (shown in Figure 1) are fastened to and electrically insulated from frictionless pucks on an air table. The charge on sphere 2 is three times that on sphere 1. Which force diagram correctly shows the direction and magnitude of the electrostatic forces?

2. *(5 pts.)* Fill in the missing metric prefix. I give an example to start off.

(example) 10^3 : Kilo

(a) 10^6 : ....

(b) 10^{-6} : ....

(c) 10^9 : ....

(d) 10^{-9} : ....

(e) 10^{-12} : ....

3. *(5 pts.)* Consider a point P in space where the electric potential (V) is zero. Which statement is correct?

(a) A charge placed at P would feel no electric force.
(b) The electric field at points around P is directed toward P.
(c) The electric field at points around P is directed away from P.
(d) Not enough information given to decide.

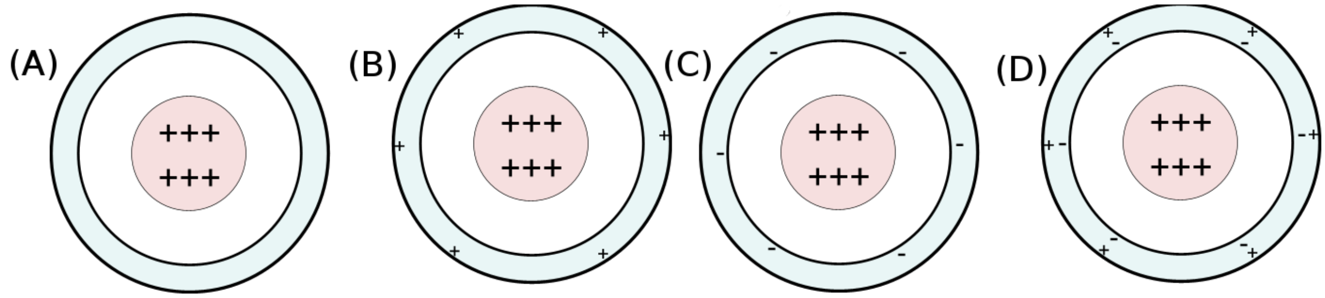

Figure 2:

4. *(5 pts.)* The table on page 4 gives the correct value in SI units for ϵ_0, the permittivity of vacuum. However, I omitted the units from the table. What are the SI units for $epsilon_0$?

5. *(5 pts.)* An initially uncharged conducting sphere is placed around a positively charged insulating sphere. Which picture in Figure 2 shows the charge distribution on the two spheres at equilibrium?

6. *(10 pts.)* Electric potential V is defined as follows: $V = -\int \vec{E} \cdot d\vec{r}$. For a point charge, the potential with respect to ∞ is $V(r) = \frac{kq}{r}$. Potential (Voltage) is only meaningful as a difference between two points. Derive the electric potential a distance r from a point charge Q and explain in a sentence why only one point appears in the formula. In your derivation the minus sign in the definition of potential should properly vanish. Point out when this happens, and why.

7. *(10 pts.)* Three charges of $Q = -5\ \mu C$ each are placed at the vertices of an equilateral triangle with sides of length $s = 6\sqrt{3}$ meters.

(a) What is the potential in the center of this triangle?

(b) What is the potential at the midpoint of one side of this triangle?

Note: Answers for "a" and "b" will be similar but not identical.

8. *(10 pts.)* [Note: This question has a calculation following the multiple choice part.] The proton mass, proton charge (same as an electron, but positive) and universal gravitational constant G are all given in the table on page 4. When two protons are 1 cm apart, their electrostatic repulsion is enormously greater than their gravitational attraction. Is it possible to adjust the distance between two protons such that the gravitational attraction and electrostatic repulsion balances?

(a) Yes, we must move the protons further apart.
(b) Yes, we must move the protons closer together.
(c) No, at any distance.

Calculate and compare the electrostatic repulsion and gravitational attraction at 1 mm. (They will both be very small numbers, but still very different.)

Finally use equations or discussion to justify your answer to the multiple choice part of this question.

9. *(10 pts.)* Calculate both components of the electric-field vector measured at point P in Figure 3. Sketch an arrow indicating the approximate direction of this electric field. Note that there is no charge at point P. $a = 6\ m$, $b = 8\ m$.

(a) For the case of figure 3-(left). In upper right corner, $Q = 1\ \mu C$. In lower left corner, $Q = 2\ \mu C$. In top left corner, $Q = 0$.
(b) For the case of figure 3-(right). In top left corner, $Q = -3\ \mu C$. The two charges from part (a) are still there.

10. *(10 pts.)* This problem requires you to make a sketch which will probably take up one half a page. Begin with two small circles representing equal and opposite charges of magnitude $Q = 1\ \mu C$. Separate the circles on your paper by about 5 cm (i.e. give yourself plenty of room.)

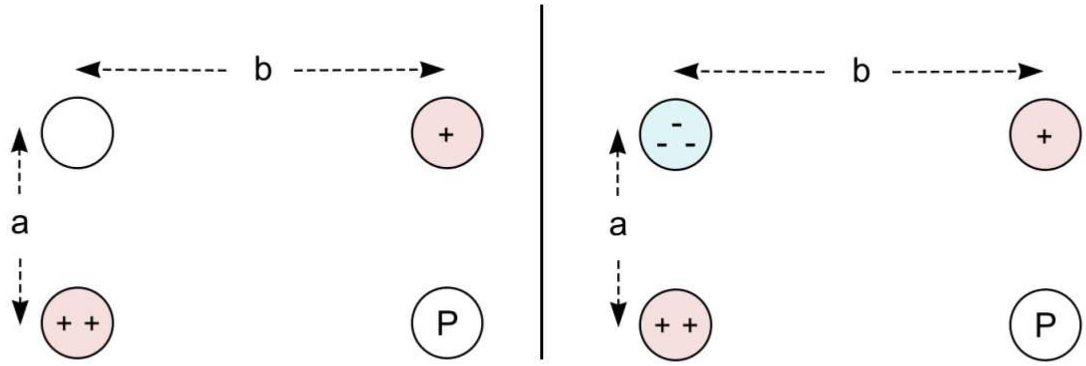

Figure 3:

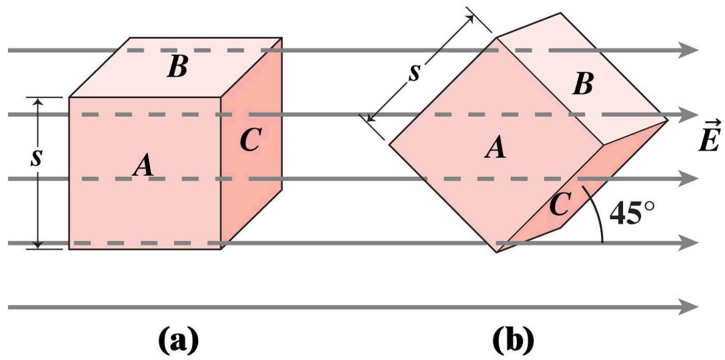

Figure 4:

(a) Draw six to eight solid curves representing the electric field lines in this problem. Put arrows on these lines indicating which direction the field is pointing.
(b) After finishing part (a), add six to eight equipotential curves to the sketch. Use dashed lines, or a different color ink, to distinguish the equipotentials from the field lines. Make sure the equipotentials intersect the field lines at approximately the correct angle. Label the equipotential curves from lowest to highest. The lowest number corresponds to the lowest potential. Highest number is highest potential. The numbers DO NOT have to be proportional to the actual potentials. The numbers should just rank the equipotential curves from low to high.
(c) Be sure to include the equipotential that represents zero volts. Explicitly label this as the zero volt potential.

11. *(5 pts.)* The potential as a function of position in a region is given by $V(x) = \frac{x^3}{3} - \frac{x^2}{2} - 2x$, with x in meters and V in Volts. Find all points on the x-axis where the electric field (E) is zero.

12. *(10 pts.)* Figure 4 shows cubes (a) and (b), with sides of length s placed in a uniform electric field of magnitude E_0 and direction indicated in the figure.

(a) What is the flux through face A of cube (a)?
(b) What is the flux through face C of cube (a)?
(c) What is the flux through face B of cube (b)?
(d) What is the total flux through cube (b) (all six faces)?

13. *(10 pts.)* Figure 5 shows a charged conducting wire inside a charged conducting cylinder. Assume the wire

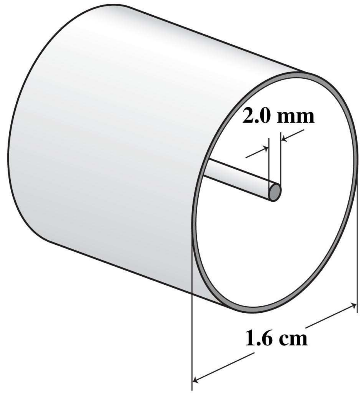

Figure 5:

and cylinder are "infinite" (very long), and that the linear charge density of the wire is $\lambda_W = 0.5$ nC/m, while the charge density of the cylinder is $\lambda_C = -1.5$ nC/m. Calculate the electric field strength and direction:

(a) 0.5 mm from the center of the wire.
(b) 4.0 mm from the center of the wire.
(c) 4.0 cm from the center of the wire.

14. *(10 pts.)* Older CRT-type televisions have hot filaments which emit slow-moving electrons, then accelerate them in a vacuum with a 15,000 V potential to hit the back of the TV screen, making one dot in a TV image. If an electron were emitted moving at neglible speed, how fast would it be moving when it hit the TV screen?

Useful Formulae

All are correct.	Some are relevant.	
$c = 3.00 \times 10^8\ m/s$	$k = 9.0 \times 10^9\ Nm^2/C^2$	$G = 6.67 \times 10^{-11} Nm^2/kg^2$
$q_{electron} = 1.6 \times 10^{-19}\ C$	$\epsilon_0 = 8.86 \times 10^{-12}$	$n_1\, sin(\theta_1) = n_2\, sin(\theta_2)$
proton mass $= 1.67 \times 10^{-27}$ kg	electron mass $= 9.11 \times 10^{-31}$ kg	$E_x = -dV/dx$
$\int \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$	$V = -\int \vec{E} \cdot d\vec{r}$	pV = nRT
$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$	$U = qV$	$\text{M} = -\frac{s'}{s}$
E = h f	$\text{p} = \frac{h}{\lambda}$	$d\, sin(\theta) = m\lambda$