University of California at Berkeley
Department of Physics
Physics 7B, Spring 1998

Second Midterm
9:30 AM Tuesday March 17, 1998

You will be given 75 minutes to work this exam. You may use a single, handwritten sheet of notes. No printed matter or calculators capable of storing or displaying text are permitted. Your description of the physics involved in a problem is worth significantly more than any numerical answer. Show all work, and take particular care to explain what you are doing. Write your answers directly on the exam, and if you have to use the back of a sheet make sure to put a note on the front. Do not use a blue book or scratch paper.

The first 13 multiple choice questions are worth 2 points each. The remaining three problems are worth a total of 74 points, divided as shown. If you think there is more than or less than one correct answer to a multiple choice question, mark it that way and explain your reasoning briefly.

NAME: _____

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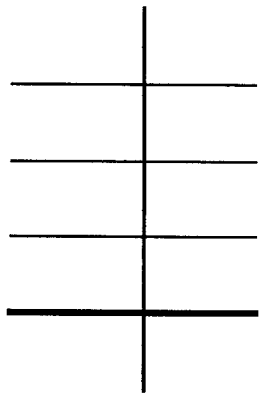
DISCUSSION SECTION DATE/TIME: _____



Read the problems carefully.

Try to do all the problems.

If you get stuck, go on to the next problem.

Don't give up! Try to remain relaxed and work steadily.

$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

$\pi = 3.141\ 592\ 653\ 589\ 793\ 238$

1) A neutral metal ball is suspended by a string. A positively charged insulating rod is placed near the ball, which is observed to be attracted to the rod. This is because

a) the ball becomes negatively charged by induction

b) the ball becomes positively charged by induction

c) the number of electrons in the ball is more than in the rod

d) the string is not a perfect insulator

e) there is a rearrangement of the electrons in the ball

2) A negatively charged rubber rod is brought near the knob of a positively charged electroscope. The result is that

a) the rod will lose its charge

b) the electroscope leaves will tend to collapse

c)the electroscope will become discharged

d) the electroscope leaves will tend to move farther apart

e) nothing noticeable will happen

3) The units of the electric field are

a) J / (C • m)

b)J / C

c) J • C

d) J / m

e) none of the above

4) A hollow conductor is positively charged. A small uncharged metal ball is lowered by a silk thread through a small opening in the top of the conductor and allowed to touch its inner surface. After the ball is removed, it will have:

a) a positive charge

b) a negative charge

c) no appreciable charge

d) a charge whose sign depends on what part of the inner surface it touched

e) a charge whose sign depends on where the small hole is located in the conductor

5) A certain physics textbook shows a region of space in which two electric field lines cross each other. We conclude that:

a) at least two point charges are present
b) an electric conductor is present
c) an insulator is present
d) the field points in two directions at the same place
e) the author made a mistake

6) An electric field exerts a torque on a dipole only if

a) the field is perpendicular to the dipole moment
b) the field is not perpendicular to the dipole moment
c) the field is parallel to the dipole moment
d) the field is not parallel to the dipole moment
e) the field is uniform

7) Charge is distributed uniformly on the surface of a large flat plate. The electric field 2 cm from the plate is 30 N/C. The electric field 4 cm from the plate is

a) 120 N/C
b) 60 N/C
c) 30 N/C
d) 15 N/C
e) 7.5 N/C

8) Positive charge is distributed uniformly throughout a non-conducting sphere. The highest electric potential occurs

a) at the center
b) at the surface
c) halfway between the center and the surface
d) just outside the surface
e) far from the sphere

9) If the plate separation of an isolated parallel plate capacitor is doubled

a) the electric field is doubled
b) the area charge density on each plate is doubled
c) the potential difference is halved
d) the charge on each plate is halved
e) none of the above

10) A charged capacitor stores 10 C at 40 V. Its stored energy is

a) 400 J
b) 200 J
c) 4 J
d) 0.2 J
e) 2.5 J

11) Eight identical spherical raindrops are each at a potential V, relative to a potential far away. They coalesce to make one spherical raindrop whose potential is:

a) V/8
b) V/2
c) 2V
d) 4V
e) 8V

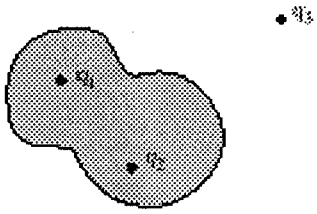
12) A positive charge moves in the direction of a uniform electric field.

a) It moves toward a position with lower electrical potential, and the charge's potential energy increases
b) It moves toward a position with lower electrical potential, and the charge's potential energy decreases
c) It moves toward a position with higher electrical potential, and the charge's potential energy increases
d) It moves toward a position with higher electrical potential, and the charge's potential energy decreases

13) Suppose two charged conducting spheres of different radii r and $R > r$ are connected by a conducting wire. Which sphere has the greater charge density on its surface?

a) R (the larger one) has the larger surface charge density
a) r (the smaller one) has the larger surface charge density
a) They have the same surface charge density
a) It depends on something (what?) that has not been specified, so we can't say

14) (25 points) The figure depicts three charges and a Gaussian surface.



(a) Which charges contribute to the net flux through the Gaussian surface?

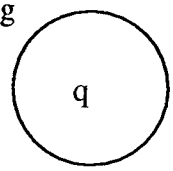
(b) Which of the charges contribute to the field at a given point on the surface?

(c) Compare your answers to (a) and (b) and explain why they are the same or different.

(d) Suppose the net charge enclosed by a surface is zero. Does it follow that the field is zero at all points on the surface? Why or why not?

(e) Is the reverse true (i.e., if the field is zero at all points on the surface, is the net charge enclosed zero)?

15) (20 points) A point charge q is at the center of a spherical conducting shell. There is a point charge Q outside the shell. Both Q and q are positive charges.



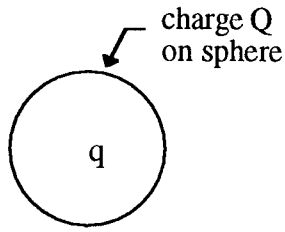
Q

(a) Does q experience a force? If so, sketch the direction on the figure. If not, why?

(b) Does Q experience a force? If so, sketch the direction on the figure. If not, why?

(c) If there is a difference in the forces experienced by the charges, reconcile your answer with Newton's third law.

16) (29 points) A hollow conducting sphere of radius r_o has a concentric cavity of radius r_i. The conducting sphere is charged with a charge Q. In addition, there is a charge q at the center of the cavity.



Note that in parts (a) and (b) there are three regions of interest: inside the cavity, inside the conductor, and outside the conductor. Make sure you specify answers for all regions. There are no other charges nearby. Define zero potential at infinity.

a) Find the electric field magnitude and direction everywhere.

b) Find the potential V everywhere.

c) Determine the surface charge density at r_i and r_o.