

Grading Exercise

Attached is a problem from an old midterm examination, together with six solutions to it. To help you develop a better feel for what it takes to convey your understanding of the material, we ask that you grade the solutions using the grading guidelines for this course (see below). The first solution is the “official” solution, which you do not need to grade; before you look at it, however, you should solve the problem yourself — it is impossible to grade a problem if you do not understand it completely. Use the blank copy of the problem for this purpose. If you have questions about the problem after seeing the official solution, ask for help *before* doing any grading.

The remaining five solutions are sample solutions. Mark them up, *noting the errors you find in the answers and in the reasoning*. Then assign a score to each solution by circling the appropriate number at the bottom of each sheet. Completing this grading exercise counts as one problem on the next Problem Set. To get credit you should:

1. Grade all five solutions by marking them up and assigning a grade to each of them.
2. Enter the grades on the Web site.
3. Turn in this marked-up and scored set along with the rest of Problem Set 2.

Grading guidelines

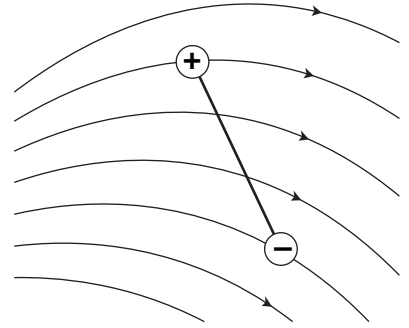
All problems should be graded “holistically” on a 5-point scale (no fractions) according to the grading key shown below. Do not give 1 point for part 1, 2 points for part 3, etc. Rather, read the entire solution and ask yourself the following question: Does this person understand the physics behind this problem? To receive full credit, the solution must convincingly demonstrate that the author understands the physics. This means not just providing the correct answer, but also showing how the answer was obtained. When using the grading key shown below, first pick the category on the left based on your overall evaluation of the solution (*i.e.*, complete, partial, or little understanding conveyed by solution). After that, it’s a binary choice within each category that depends on details of the solution (major or minor errors, justified or unjustified answers, etc.).

Understanding conveyed	Details	Grade
Solid	Correct reasoning and answer (very minor errors OK)	5
	Mathematical mistakes, answer not unreasonable	4
Partial	Physics errors (or correct setup, but no or incomplete execution)	3
	Major physics errors (or partial justification provided, even if answer correct)	2
Little (or impossible to determine)	Little of relevance (even if answer correct)	1
	Nothing (no justification at all, even if answer correct)	0

Name: _____
(no name, no score!)

6. A dipole is placed in a nonuniform electric field as illustrated at right

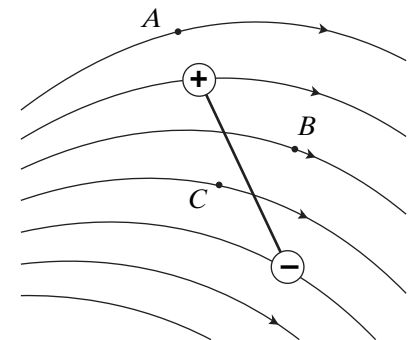
(a) In the diagram at right, draw the force exerted by the electric field on each end of the dipole in the diagram above. How do the two forces compare in magnitude? Explain.



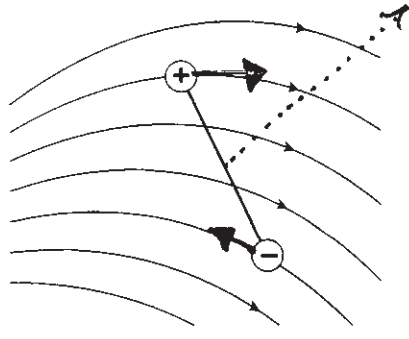
(b) In the diagram above, indicate in which direction the center of mass of the dipole accelerates after it is released. Explain.

(c) Is the torque exerted by the forces on the dipole, clockwise, counterclockwise, or zero? Explain.

(d) Does the presence of the dipole affect the total electric field at points *A*, *B*, and *C*? If so, qualitatively show the direction of the field at those three points and explain what, if any, effect this has on your answer to part *a*. If not, why not?



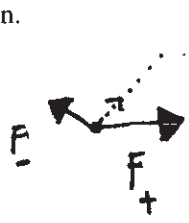
A dipole is placed in a nonuniform electric field as illustrated at right



(a) In the diagram at right, draw the force exerted by the electric field on each end of the dipole in the diagram above. How do the two forces compare in magnitude? Explain.

The force on the \ominus charge is smaller than the force on the \oplus charge because the density of field lines is greater around the \oplus charge.

(b) In the diagram above, indicate in which direction the center of mass of the dipole accelerates after it is released. Explain.



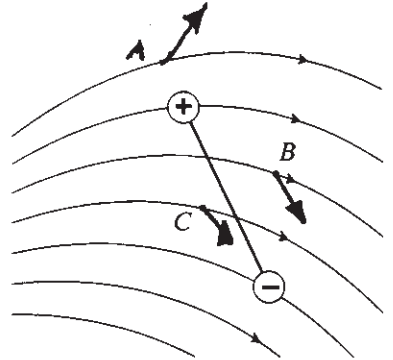
The resultant of these two forces points along the dotted line.

(c) Is the torque exerted by the forces on the dipole, clockwise, counterclockwise, or zero? Explain.

The torque is clockwise. The forces drawn would conspire to turn the dipole around its CM in a clockwise way.

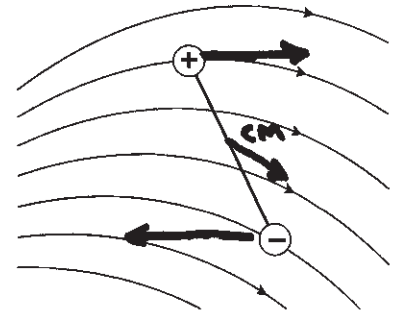
(d) Does the presence of the dipole affect the total electric field at points A, B, and C? If so, qualitatively show the direction of the field at those three points and explain what, if any, effect this has on your answer to part a. If not, why not?

The dipole affects the total electric field, due to the principle of superposition. This has no effect on the answer to part (a) because the dipole cannot exert a force on itself.



6. A dipole is placed in a nonuniform electric field as illustrated at right

(a) In the diagram at right, draw the force exerted by the electric field on each end of the dipole in the diagram above. How do the two forces compare in magnitude? Explain.



The forces on the two dipoles will be opposite in direction but the magnitudes will be the same because the vector sum of the forces on the dipole must be zero.

(b) In the diagram above, indicate in which direction the center of mass of the dipole accelerates after it is released. Explain.

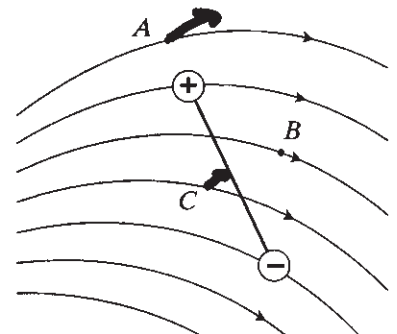
(c) Is the torque exerted by the forces on the dipole, clockwise, counterclockwise, or zero? Explain.

the torque τ will be clockwise



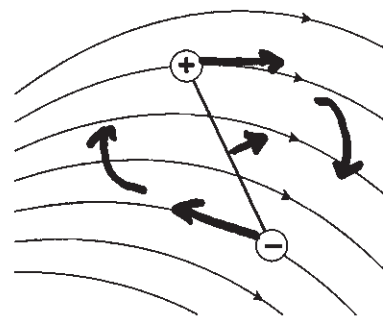
(d) Does the presence of the dipole affect the total electric field at points A, B, and C? If so, qualitatively show the direction of the field at those three points and explain what, if any, effect this has on your answer to part a. If not, why not?

A and C are affected but B is not.



6. A dipole is placed in a nonuniform electric field as illustrated at right

(a) In the diagram at right, draw the force exerted by the electric field on each end of the dipole in the diagram above. How do the two forces compare in magnitude? Explain.



The force on the dipole's positive end is stronger, as the electric field is stronger there (field lines are closer together).

(b) In the diagram above, indicate in which direction the center of mass of the dipole accelerates after it is released. Explain.

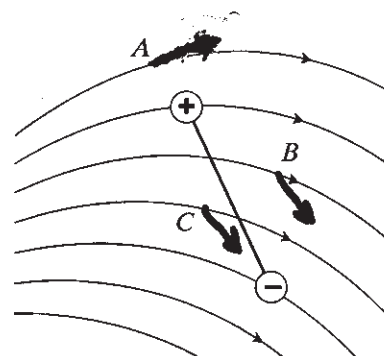
Up and to the right. The force on its positive end is stronger than that on its negative end, and both slightly up. Their sum is up and to the right.

(c) Is the torque exerted by the forces on the dipole, clockwise, counterclockwise, or zero? Explain.

Clockwise. Using center of mass as the axis, both torques push the dipole clockwise.

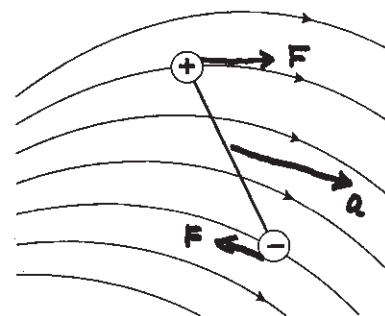
(d) Does the presence of the dipole affect the total electric field at points A, B, and C? If so, qualitatively show the direction of the field at those three points and explain what, if any, effect this has on your answer to part a. If not, why not?

Yes, it does affect the field. The positive end's field vector is still stronger, though, because the dipole's effect on the field is symmetrical. a's answer is unaffected.



6. A dipole is placed in a nonuniform electric field as illustrated at right

(a) In the diagram at right, draw the force exerted by the electric field on each end of the dipole in the diagram above. How do the two forces compare in magnitude? Explain.



The positive charge is closest to the source of the field and thus there is greater field line density here and, thus, a greater force, than that for the negative charge

(b) In the diagram above, indicate in which direction the center of mass of the dipole accelerates after it is released. Explain.

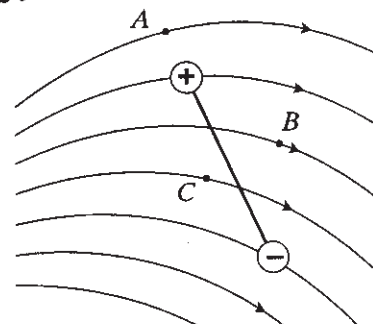
Acceleration is equal to the sum of the forces $\div m$. Since the force on the positive charge is greater than that on the negative charge, the direction of the acceleration will be as shown.

(c) Is the torque exerted by the forces on the dipole, clockwise, counterclockwise, or zero? Explain.

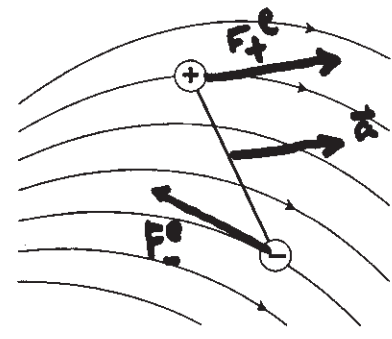
The torque is clockwise since the force on the positive charge is greater than that on the negative charge.

(d) Does the presence of the dipole affect the total electric field at points A, B, and C? If so, qualitatively show the direction of the field at those three points and explain what, if any, effect this has on your answer to part a. If not, why not?

There is no effect on the electric field - The field lines just represent the direction of the field if a charge were placed in the field - Thus, there is no effect.



6. A dipole is placed in a nonuniform electric field as illustrated at right



(a) In the diagram at right, draw the force exerted by the electric field on each end of the dipole in the diagram above. How do the two forces compare in magnitude? Explain.

The electric field force on the positive charge is greater since the field line density is greater at that point, and the magnitudes of the dipole charges are the same.

(b) In the diagram above, indicate in which direction the center of mass of the dipole accelerates after it is released. Explain.

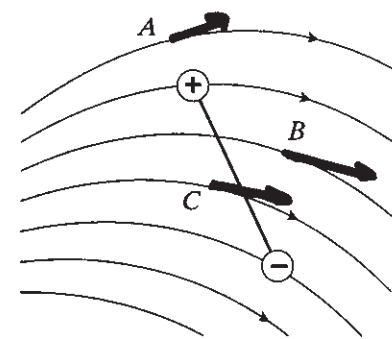
The center of mass accelerates to the right, since it is subjected to a stronger net repulsive force than attractive negative force.

(c) Is the torque exerted by the forces on the dipole, clockwise, counterclockwise, or zero? Explain.

The torque is ~~counterclockwise~~ clockwise since the electric field force on both ends of the dipole are in the clockwise direction.

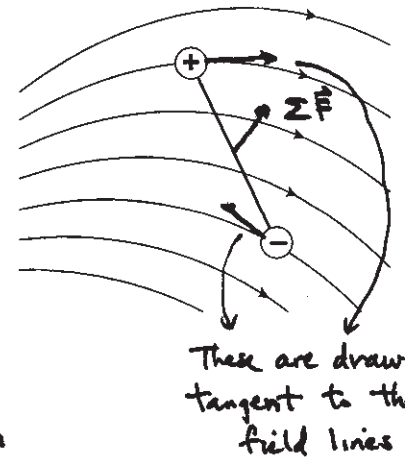
(d) Does the presence of the dipole affect the total electric field at points A, B, and C? If so, qualitatively show the direction of the field at those three points and explain what, if any, effect this has on your answer to part a. If not, why not?

The direction of the field will be tangent to the field lines at points A, B, and C. The presence of the dipole does not affect the total electric field because it is in the same direction as the field.



6. A dipole is placed in a nonuniform electric field as illustrated at right

(a) In the diagram at right, draw the force exerted by the electric field on each end of the dipole in the diagram above. How do the two forces compare in magnitude? Explain.



The force on \oplus is greater in magnitude than that on \ominus . This is because the electric field line density is greater where \oplus is than where \ominus is. (We can tell because the line spacing is greater where \ominus is.) Since $\vec{F} = \vec{E}q$, and the two q 's are equal in magnitude (total charge on dipole is 0), the force on \oplus must be greater than on \ominus .

(b) In the diagram above, indicate in which direction the center of mass of the dipole accelerates after it is released. Explain.

We vectorially sum the two forces drawn above. It is roughly this dotted vector, $\vec{\Sigma F}$.

(c) Is the torque exerted by the forces on the dipole, clockwise, counterclockwise, or zero? Explain.

The force on \oplus tends to rotate it clockwise around the center of mass. The force on \ominus tends to rotate it clockwise around the center of mass. Thus overall, the torque is clockwise.

(d) Does the presence of the dipole affect the total electric field at points A, B, and C? If so, qualitatively show the direction of the field at those three points and explain what, if any, effect this has on your answer to part a. If not, why not?

yes. But this does not affect my answer to (a). We know that this is a permanent dipole (since \vec{p} is not \parallel to \vec{E}). Thus the \oplus end does not feel an attraction to the \ominus end (and vice-versa):

this molecule has arranged itself as a permanent dipole because that is a stable configuration - no part of the molecule feels a net force due to the rest of the molecule. Thus, though the presence of the dipole affects the electric field that other objects feel,

