September 20, 2004

Greetings, new physics TFs

To help make your first semester of teaching enjoyable, we have made put together a small "TF starter pack" which will hopefully prove useful for you.

The TF Handbook is the work of David Morin, who has collected many years of wisdom. It contains lots of helpful advice on how to TF in physics department and how to organize your teaching so that it become a pleasure rather a source of stress.

The sample section notes are meant as one example of how one might structure a section. They are overly explicit and quite long since we've tried to include a lot of elements (analogies, lists, examples etc.) that can be useful in section. So don't be intimidated by their length, your actual section notes will probably be a lot shorter. Also, they are certainly *not* a template that you have to copy. You might have a very different style and approach — pick and choose and find a format that works for you and for the class you are TFing.

The *First day of class*-sheet has a few hints on how to get well through your first hour "on stage".

If you are looking for more information about TFing, the Bok Center has lots of materials on all aspects of teaching. They also have resources to help you with just about any teaching issue you might have, from how to deal with bossy students to help with improving your English for teaching. One of the Bok Center Senior Consultants, John Girash, is an astronomy grad student, so the they are well equipped to serve the needs of physics TFs. You can find info online at www.bokcenter.harvard.edu or by phoning them on 617-495-4869.

Together with Cindy Hancox (cindy@cua.harvard.edu), we are the physics Teaching Consultants. If you have any concerns or questions about TFing or about the Bok Center, you can mail us or come by our office. This is the first year we are distributing this starter pack, so we are very interested in hearing any comments, suggestions or criticisms you might have.

Have a great semester!

Rakhi Mahbubani (rakhi@physics, Jefferson...)
Morten Ernebjerg (morten@physics, Jefferson 459)

Information and Tips on Being a Physics TF

These notes contain a description of what a Physics TF's job entails, along with some suggestions I think you will find helpful. These suggestions should make your students happier and also make your life easier.

The two most important ingredients in being a good TF are:

- A desire to help the students. (Be nice, try hard, and show them you care.)
- A firm knowledge of the subject. (Prepare for section, and know how to do the homework problems.)

If, in addition, you happen to have fantastic public speaking skills, then more power to you. But it should be emphasized that such oratory skills are by no means necessary. The above two issues completely wash out any such considerations. The second one is actually implied by the first. That is, if you care about your students, then you will certainly prepare for section and make sure that you know the material well. If your students see that you care and that you're trying, then they'll be happy. Therefore, everything can basically be summed up in the one rule: Try to do a good job.

Note that caring for your students does not necessitate becoming best friends with them. Different TF's have different styles. Some go with an informal friend approach. Others take a more formal and reserved approach. As one TF noted, "TF'ing means that you are the person at the blackboard and that your most important mission is to help them understand the material in the class." Go with whatever method works best for you.

Before we get into the various weekly TF duties and tips for performing them, here are a few general comments/suggestions:

"Meet the TF": This is a splendid idea that will take only three hours of your time but will have many lasting positive effects. It is by no means required, but you are encouraged to do it. Here's the idea: Most of you will have a total of about 25-30 students, so at the beginning of the semester (at the first or second section), pick six half-hour blocks, and have your students sign up to come to your office in groups (limit of about five students in each) to talk about anything: the course, what else they're taking, their concentration, extracurriculars, where they're from, future plans, favorite food, music they like, etc. Any topic of conversation is dandy. The point is that they will find out where your office is, and they will know that you care. It will make everything easier in the future. In particular, your students will be more likely to talk in section, since they now know you better. This increased interaction will make everyone happier.

Use the course webpage: The course webpage contains lots of info for the teaching staff. The most useful thing is the pictures of your students. A few minutes of looking at these pictures and getting to know your students' names will definitely impress them, in addition to making your semester much more enjoyable. You can also use the webpage to easily email your students and do many other things.

Problem students: If you have students who are neglecting their work and/or falling behind, be sure to let the professor know about them. Send them a few emails encouraging them to come to section and office hours. Some students just need a little prodding. But there will inevitably be some who won't respond to any of your suggestions. In such cases, it is *very important* that you make this clear to the professor. Do this soon, to keep things from getting out of hand.

Bok Center: The Derek Bok Center is a valuable teaching resource. Microteaching sessions for first-time teachers are great for getting initial feedback, as well as for getting some of the butterflies out of your stomach. Also, having your section taped and reviewing it with a Bok Center consultant can be highly informative. The Bok Center's website is: bokcenter.harvard.edu. You can find lots of useful documents and pamphlets there. The Bok Center is also happy to help you with all sorts of specific teaching concerns, such as teaching if English is not your first language, and how to deal with problematic students, etc.

Study groups: Study groups often form by themselves, but to keep students from falling through the cracks, give them a list of suggested study groups. But make it clear that the groups are suggestions only. They may be set up course-wide or by section. Organizing the students by house is a common thing to do. Talk to your professor about the best way to set up the groups, and about who should do it. Students learn more if they work together responsibly (that is, if they don't just copy each other's homework), so encourage this.

A note to beginning TF's: Work hard at doing a good job, but don't try to save the world. You will quickly find that teaching can take up all of your time if you let it, so you have to set limits. After a couple weeks you'll see how much time the various tasks take up, so you can then work out a schedule of your time. It's better to work hard and stick to a schedule, than to go overboard and get stressed out, in which case your teaching will inevitably suffer, along with everything else. So…

Make your own personal schedule: Be organized. Make a list of things you need to do each week, and how much time they will take.

Let's now go through the various weekly TF responsibilities, along with some helpful tips for doing them.

Sections

- **Pass out an initial survey on the first day.** Ask anything you want: math courses taken, concentration, physics in high school, eventual plans, extracurriculars, house, favorite color, etc. You can use index cards, or you can print up a sheet. It will show your students that you care. And information is always a good thing.
- **Work through all the homework problems before each section** so that (1) you will be able to answers questions on them, and (2) you will know which problems they will have trouble with, which is relevant to…
- **Your section problems should be similar to the homework problems** that the students will have the most trouble with. The goal is to anticipate the questions

they will have, and to pick problems accordingly. Keep in mind, though, that if you base your section problems too much on the homework, you might not get the best coverage of all the material in the course. But in general this shouldn't be an issue, because the homework problems should be chosen to cover all of the material.

- **Many students like a brief outline of what was covered in lecture.** This can be useful, but be very careful to keep it brief – no more that 5-7 minutes. Students' eyes tend to glaze over if you start repeating too much of lecture. They mainly want practice in solving problems. You might also find it useful to alternate between reviewing and doing problems. That is, remind them of a concept and then illustrate it with a worked problem.
- **Give them 1-2 minutes to start solving each problem** in pairs or in small groups, before you work it out on the board. This will liven things up – it will get them talking, so they'll be more likely to speak up at a later time. Make it very clear that you're not giving them enough time to solve the problem, but rather just to get a feel for it. If you give them a longer period, you're simply not going to get through many problems, and the students who did end up solving the problem will be completely bored when you do it on the board. If for some reason this strategy doesn't work, ask your students directly what format they like.
- **Make sure that certain students don't take over the section.** It's great when students talk in section, but be wary of the situation where it's always the same one or two students. Try to encourage everyone to talk. Some students are simply shy, which is perfectly fine, but be on the lookout for students who want to speak but can't get a word in.
- **It's usually best if you do the problems** at the board. Some people may disagree, but I don't think it's a good idea to have the students do the problems at the board. If they stumble, the other students get impatient. There's only a finite amount of time to work with. And also, there is one person in the room who knows a lot more physics than anyone else. Take advantage of that.
- **Get student input as you do the problems.** To keep things lively, ask them for the next step in the solution as you're doing it. You'll get a feel for how often you want to ask.
- **Section handouts are great,** if you are so inclined. These aren't necessary, but your students will love you if you pass them out. If your handwritten solutions of your section problems are neat, you can just copy them for the students. But if polishing up section notes cuts into your section preparation time, then don't do it.
- **Use an early evaluation.** After a few weeks of section, hand out a questionnaire to get feedback on how things are going (several different model questionnaires are available online from the Bok Center[1]). This is a good way to check if you and the students are on the same wavelength. And if you introduce it like this, the students will consider it a strength rather than a weakness on your part. You will probably find that your students don't all agree on the best style, pace, etc. so try to strike compromises, and let your students know that you can't fulfill all wishes.
- **Don't worry if you can't answer a given question in section.** Just say that you'll have to think about it and that you'll get back to them. Then send them an

[1]The Bok Center can also offer assistance with going over feedback forms and extracting useful suggestions from them.

email with the answer, or save it for the next section if it's not urgent. If you make a mistake in section and then realize it afterwards, just send out a correction email. Your students will be impressed. Really.

- **There will inevitably be a time when you look out over the faces** in your section and conclude that everyone is completely and utterly bored. But don't panic and start jumping through hoops trying to get them to look excited, because odds are that they're simply thinking hard and not bored at all. When you're sitting in one of your grad classes and concentrating hard, pause for a moment and note what expression you have on your face. You're probably not sitting there with a big grin.
- **Perhaps the most difficult thing about teaching** is figuring out the level at which you should teach. If you could read your students' minds and know exactly what they know and don't know, then teaching would be easy. And to make things even more difficult, the "I'm totally lost" and the "I already know all of this" looks are pretty much the same. So the only way to know if you're teaching at the correct level is to get the students to talk and give you feedback. So do whatever you have to do to get them to talk.

Office hours

- **TF's generally have two or three hours** of office hours per week, but this is up to the professor.
- **The amount of help you give a student** in office hours should generally be proportional to the amount of effort they've put in. If they're trying really hard, there's nothing wrong with working through an entire problem with them. But if they're simply trying to squeeze out an answer, you can give out minimal info; just answer questions with other questions.
- **If your office hours are busy,** it's difficult to insure that your time is split equally among the students, but do your best. Be wary of students who talk loudly and dominate things. Keep an eye out for the student who is quietly thinking hard.
- **Occasionally a student may request a separate meeting** to go over things. These extra office hours will inevitably come up, especially before exams, so try to budget some time for them. But be careful not to let a given student monopolize your time.
- **Sometimes students stay in your office** long after office hours have ended. If you're having fun, then that's great. But if you have work that you need to be doing, feel free to firmly draw the line. We'd rather have you be excited and enthusiastic about your office hours, as opposed to dreading them because you know that students will stay for an hour afterwards.

Emails

- **These can take a little while** sometimes, so work them into your budget of time. Try to get back to students as quickly as you can, but make it clear at the beginning of the semester that there will generally be some turnaround time. Your students should not expect you to be sitting at your computer at all hours (even if you are!)

- **Although most students use email properly,** some students have a habit of sending a large number of very long emails when they could simply ask questions during office hours. Send an answer back, but suggest that they come to office hours where you can explain things more clearly and thoroughly.
- **Send emails to your students every now and then** with clarifications, helpful hints on the homeworks, etc. When they receive emails from you, they know you care. If you haven't emailed them in a while, try to think of some reason. There's bound to be something.

Homework grading

- **This is certainly the least inspiring TF task,** but alas, it has to be done. To take some of the sting out of the grading, it might be useful to set aside a fixed block of time for it every week once you've figured out how much time it takes.
- **Try to write a few comments** on their homeworks, but don't go overboard. If the explanation of their error is too long to write, then refer them to the solutions. In the case of a poor understanding of a problem, write "see me" or something to that effect. Note: when you take off points, always give some indication of why.
- **A couple personalized notes** on their homeworks will show your students that you care. Even just writing their name ("Cindy, don't forget that the velocity has a direction, too.") shows that you're going out of your way to help them.
- **Work out a good grading system.** Making the grading more systematic makes it both quicker and more uniform. Decide on some general rules for mistakes that will occur often (missing units, algebraic mistakes, copying an equation wrong etc.). How much, if anything, you take off will depend on the course level. It's usually best to grade one question for all the students at a time (rather than all the questions for one student at a time) because it makes the grading more consistent. Looking through a few answers before diving in will give you an idea of how to grade a problem.

Homework solutions

- **The procedure of writing up homework solutions varies** from class to class. Sometimes the Head TF writes them. Sometimes they rotate weekly among the TF's. If you are the only TF in a class, then I guess it's you. But since you have to work through the problems anyway to prepare for section, this shouldn't be an unbearable burden. But definitely ask the professor if he/she has solutions from previous years, so you can check your work.

Lectures

- **It's an FAS rule that section TF's must attend lecture.** But rules aside, it's simply a good idea. If there are any confusing things from lecture, you'll be aware of them, and you can clear them up in section.

- **It's good for your students to see you there.** If they see that you're involved in the class, then they'll be more likely to be involved, too.
- **Hang around for a minute after lecture,** in case your students need to see you for anything.
- **Personally, I have no qualms about my TF's sitting up back** and listening out of one ear while they grade, or work on section preparation, or study for their own classes, etc. You can use the lecture time quite efficiently, while still observing what's going on. But check with your professor about this.

TF meetings

- **All courses should have weekly TF meetings.** These can be extremely informal, and you might even be able to get a free lunch out of them. They will insure that you and the professor are on the same wavelength, and that certain students aren't falling through the cracks, etc.

Webpage

- **Someone must keep the website up to date.** The webmaster varies from course to course. It may be you, the professor, the Head TF, or a staff member. The most important bits of content on the site are the homework sets and the solutions.

Time management

- **Make general policies clear from the beginning of the term,** for example, the grading and emailing policies. It's easy to do at the start, but it becomes increasingly difficult to change things as the term progresses.
- **Setting aside fixed blocks of time** every week for preparation and grading can help prevent teaching from taking over your entire schedule.
- **Make sure you have worked out the division of labor with your professor.** For example, who manages the webpage, and who can do grade changes or give extensions? This will prevent confusion for everyone later in the term.

Having written all of this, let me now say the following. There are various things you are required to do, but how you go about doing them is up to you. I think that the tips above should be helpful, but you will quickly learn what system works best for you. Don't stress over memorizing a zillion do's and don't's. It's better to just be yourself, and stick to the one motto that will take care of virtually everything: Be nice, and try to help your students learn!

– David Morin (with help from Morten Ernebjerg)

* = Ask students

43 June 2080

This is for a section for 11b (E & M for non-majors). The students have just learned about Gauss' law and dipoles. In previous problem sets, some students have had problems drawing good graphs.

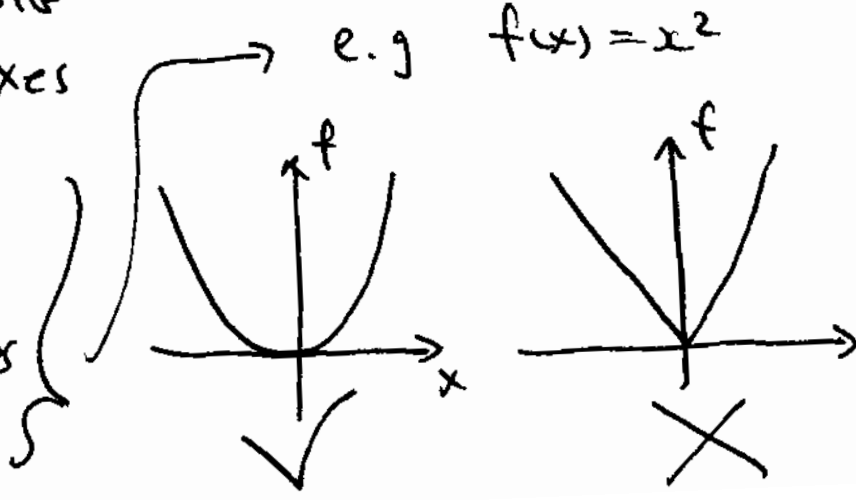
The Fine Art of Graphing

* What are the essential features of a graph?

- Intercepts w. axes
- Points of divergence ($f(x) \to \pm\infty$)
- Behaviour as $x \to \pm\infty$ (asymptotes)
- Maxima & minima

Tips for graphing

- Make graphs BIG
- Always label axes
- Draw graphs as smooth curves unless they really have cusps or breaks



(2)

* EXERCISE

Identify the main features of the function below and use them to graph it (no calculators!)

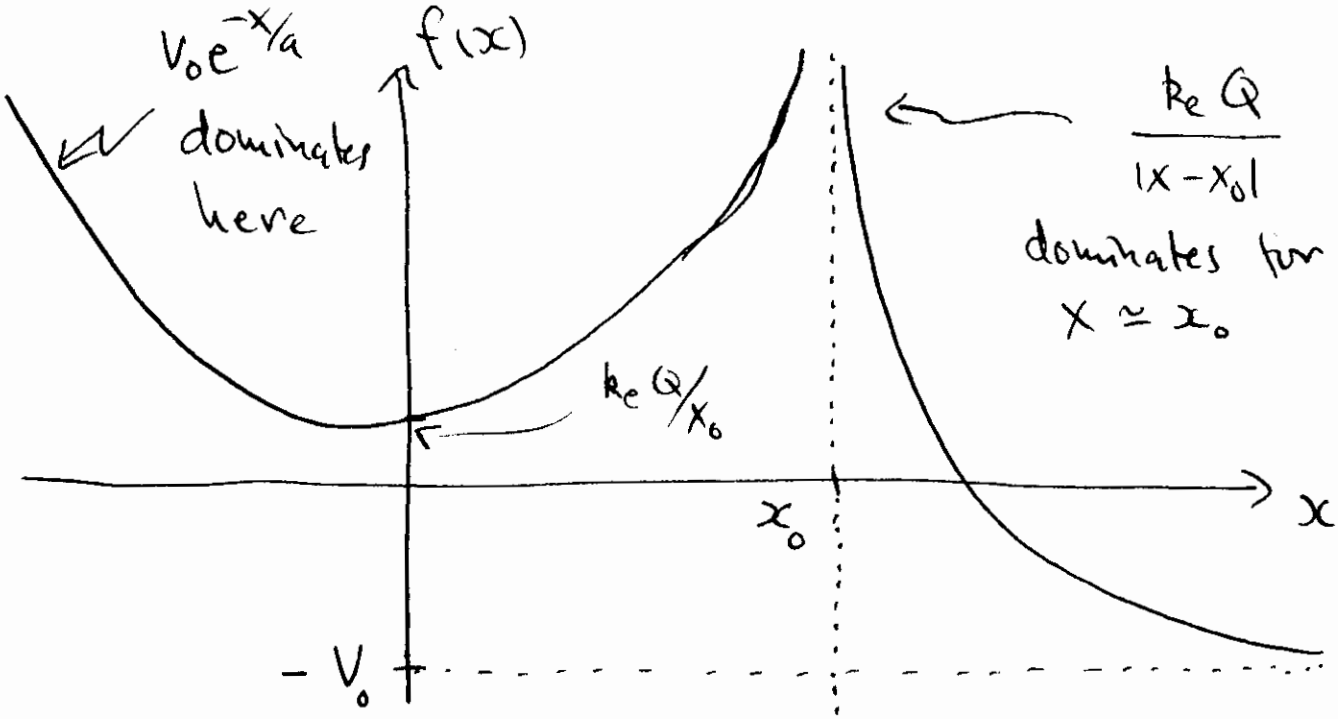
$$f(x) = \frac{keQ}{|x - x_0|} + V_0 \left(e^{-x/a} - 1\right) \quad Q, V_0, x_0 > 0$$

*Features:

- As $x \to x_0$, $f(x) \to +\infty$
- As $x \to +\infty$, $f(x) \to -V_0$
- As $x \to -\infty$, $f(x) \to +\infty$ (due to $e^{-x/a}$)
- $f(x=0) = keQ/x_0$
- Must have x-intercept in the interval $x_0 < x < \infty$
- Must have minimum in the interval $-\infty < x < x_0$

(graph overleaf)

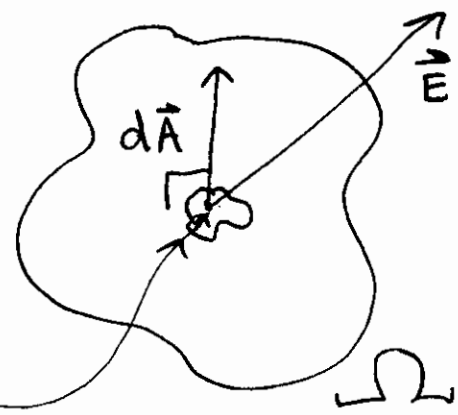
③



QUICK REVIEW

Most important new concept: Electric flux, Φ

$$\Phi = \int_{\text{surface } S} \vec{E} \cdot d\vec{A}$$



$d\vec{A} = dA\ \hat{n}$ ← unit vector perpendicular to surface

dA ← area element

NOTE:

- This is a definition, not a law
- Applies to both closed and open surfaces

Analogy: If you think of the fieldlines as giving a flow of water, Φ is a measure of how much water flows through the surface.

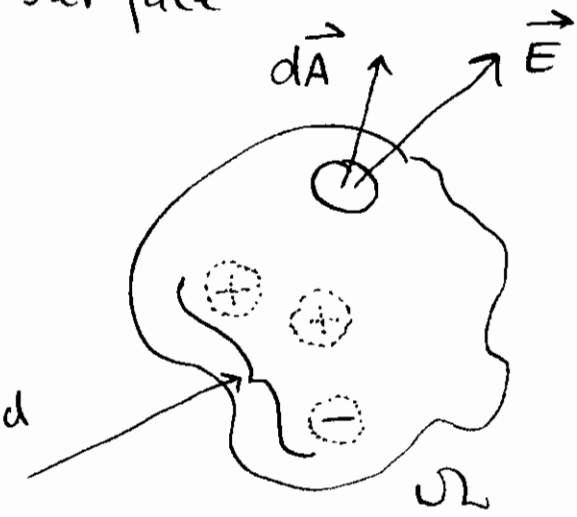
Gauss' law relates the flux through a closed surface and the total amount of charge inside the surface

$$\oint \vec{E} \cdot d\vec{A} = \frac{1}{\epsilon_0} Q_e$$

indicates closed surface

closed surface Ω

Q_e: total enclosed charge



Note:

- $d\vec{A}$ must point outwards
- The law is independent of the shape of the surface (with Q_e fixed)
- It is also independent of the distribution of charge.

Analogy: In the "water-flow" picture, Gauss' law says that the amount of water flowing through a closed surface is determined by the number and sizes of sources and sinks inside it.

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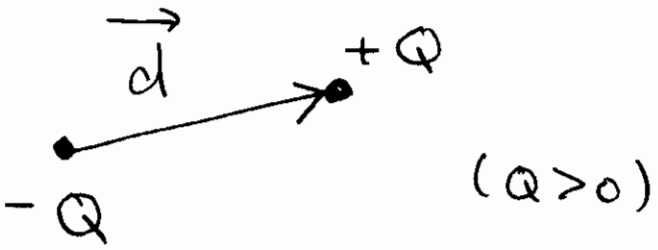
A dipole is an assembly of two charges of equal magnitudes but opposite sign (or anything equivalent).

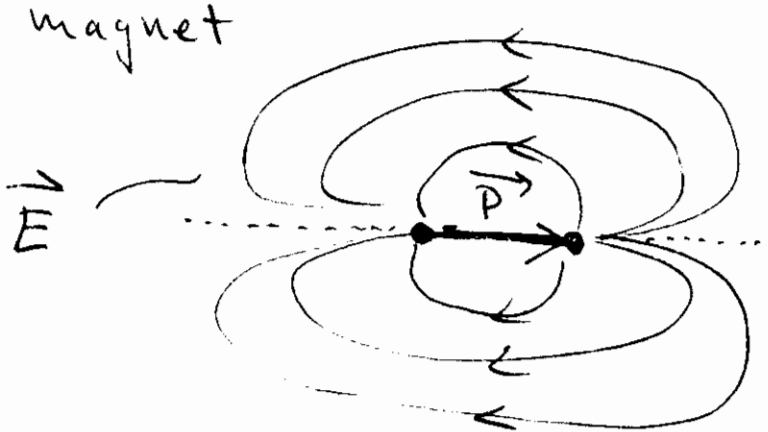


Dipole moment:

$$\vec{P} = Q\vec{d}$$

↑ not $2Q$

Analogy: A bit like an electric bar magnet



$$\vec{E}_{dipole} = \vec{E}_{+Q} + \vec{E}_{-Q}$$

(6)

A distance x ($\gg d = |\vec{d}|$) away along the $+x$ of a dipole we found

$$E \simeq \frac{4k_e Q d}{x^2} = \frac{4k_e |\vec{p}|}{x^3}$$

Note:

- Given in terms of $\vec{p}$ (rather than Q and $\vec{d}$ separately) $\longrightarrow$ $\vec{p}$ is a useful quantity
- Falls off faster than E for a single charge - makes sense? (yes, charges nearly ~~dance~~ cancel)

*

EXERCISES:

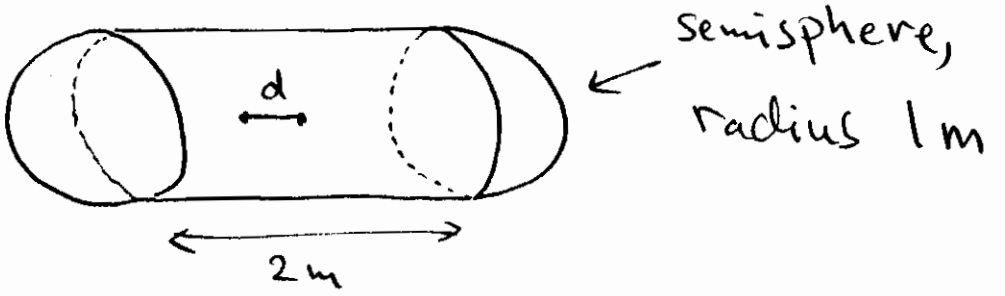
(1) Flux of a dipole

Consider a dipole with

$$d = 1\,\text{cm} \qquad Q = 1\,\mu\text{C} = 1\times10^{-6}\,\text{C}$$

7)

(a) Let the dipole be enclosed in the surface shown below



What is Φ over this surface?

(b) Consider now <u>all</u> possible closed surfaces. How many different values for Φ can we get and what are they?

— 11 —

(a) Gauss' law says

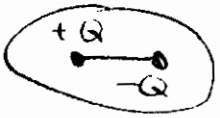
$$\Phi_c = \oint \vec{E} \cdot d\vec{A} = \frac{1}{\epsilon_0} Q_e = \frac{1}{\epsilon_0}(+Q - Q) = 0 \quad \Phi$$

The shape & dimensions are ~~irrelevant~~ irrelevant!

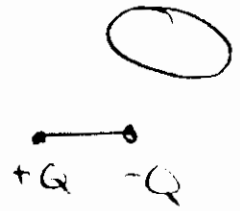
(b) Gauss' law says the possible values of Φ are ~~the~~ given by the different possible enclosed charges.

So we have 3 options

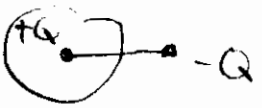
(i) $Q_e = 0$
$= \oint_c$



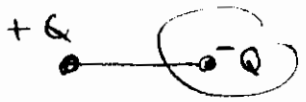
or



(ii) $\oint_c = +Q/\epsilon_0$



(ii) $\oint_c = -Q/\epsilon_0$



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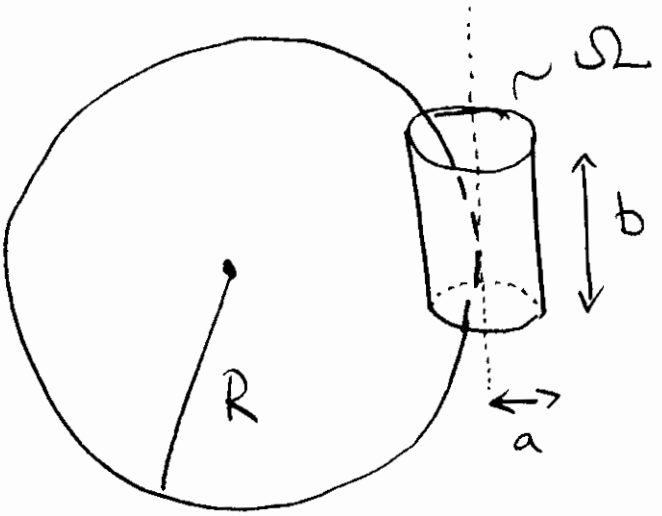
(2) Ring of charge

Consider a charge Q evenly spread over a ring of radius R. Find $\oint_c$ over $\mathcal{S}$ (including endcaps) in two ways (assume $R \gg a, b$)



(a) From Gauss' law

(b) By calculation directly from $\vec{E}$

(9)

(a) Since $R \gg a, b$ we can approximate the part of the ring inside the cylinder by a straight line. So

$$Q_e = Q\left(\frac{a}{2\pi R}\right)$$

fraction of rings inside cylinder

So

$$\Phi_c = \frac{Q_e}{\epsilon_0} = \frac{Q a}{2\pi\epsilon_0 R}$$

(b) Using the same approximation, $\vec{E}$ is like the field from a straight wire

$$\vec{E} = \frac{\lambda}{2\pi\epsilon_0 r}\hat{r} \qquad \lambda = \frac{Q}{2\pi R}$$

Notice that since $\vec{E}$ is perpendicular to the wire, the endcaps do not contribute to Φ_c since

$$\vec{E}\cdot d\vec{A} = 0 \quad \text{on endcaps } (\vec{E}, d\vec{A} \text{ at } 90^\circ)$$

So

$$\Phi_c = \oint_{\text{cylinder}} \vec{E}\cdot d\vec{A} = \int_{\substack{\text{cylinder,}\\ \text{no endcaps}}} \vec{E}\cdot d\vec{A}$$

(10)

$$= \int \left(\frac{\lambda}{2\pi\epsilon_0 r}\hat{r}\right)(\hat{r}\, dA)$$

$$= \frac{\lambda}{2\pi\epsilon_0 b} \times \underbrace{(2\pi a b)}_{\text{cylinder (- endcaps) area}}$$

$$= \frac{Q}{2\pi R} \times \frac{q}{\epsilon_0} \qquad \text{as before}$$

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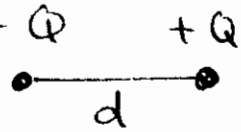
(3) Dipole in a field

We put the dipole 

in a potential $V(x) = B/x$. Find the total force on the dipole assuming $|x| \gg d$. (x = coordinat along dipole axis)

— // —

We can just sum the forces on each of the charges (along the x-direction)

$$F = F_{+Q} + F_{-Q} = -Q\left.\frac{dV}{dx}\right|_{x+d} - (-Q)\left.\frac{dV}{dx}\right|_{x}$$

$$= \frac{QB}{(x+d)^2} - \frac{QB}{x^2}$$

But $$\frac{QB}{(x+d)^2} = \frac{QB}{x^2}\left(\frac{1}{(1+d/x)^2}\right) \simeq \frac{QB}{x^2}\left(1 - \frac{2d}{x}\right)$$ since $d \ll |x|$

(11) So

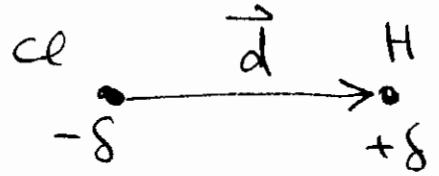
$$F_{tot} \simeq -\frac{2BQd}{x^3} = -\frac{2B|\vec{p}|}{x^3}$$

$\vec{p}$ appear naturally

(4) Microwaving

(The phenomenon here, applied to H_2O, is what make microwave ovens work)

A molecule of hydrochloric acid is a dipole since the Cl atoms pulls the electrons more strongly



We now apply an $\vec{E}$-field

$$\vec{E}(t) = \vec{E}_0 \cos(\omega t) \qquad \vec{E}_0 \propto \vec{d}$$

(a) What are the forces on the charges and the molecule overall?

(b) How will the molecule move?

(2)

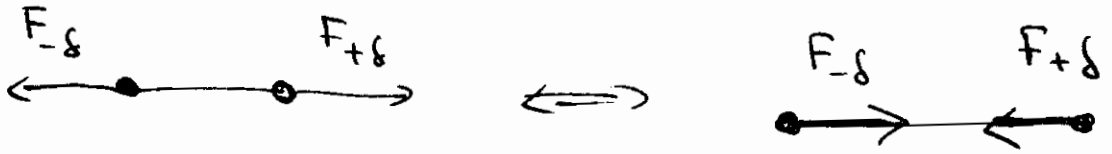
(a) We have

$$F_{+\delta} = +\delta E = \delta E_0 \cos(\omega t)$$

$$F_{-\delta} = -\delta E = -\delta E_0 \cos(\omega t)$$

$$F_{tot} = +\delta E - \delta E = 0$$

(b) We see that the two charges are always being pulled in opposite directions.



So the molecule will oscillate

(⇒ molecular motion ~ heat !)

First day of class

These are a few simpleminded tips for your first hour on stage. The first section sets the tone for the rest of the semester so it's worth getting off to a good start.

- Prepare well. It's worth spending extra time on planning and writing out your first section. In physics, you typically have plenty of material to cover already in the first section so you dive right into the material. Being well prepare also gives extra confidence.
- Give the students all your relevant data — e-mail, office no. and office phone no. and office hours. Throwing in a few words about where you're from and what you do is also a good way to break the ice.
- Get everyone's e-mail so you can set up a mailing list.
- Do a round letting every students say their name, major and perhaps reason for being in this class. Letting people say a bit more than just their name allows your students to get to know the people next to them and gives you useful information about the academic background of your audience.
- Make sure you are familiar with the organizational details of the course - office hours, grading, midterm, when homework is due etc. Students often ask about these things (even if it was announced in lecture...).
- Tell your students how you plan to structure the section so they know how things are going to run.
- Encourage questions from the beginning — it's much easier to get a good 'flow' if people interact from the beginning. Also encourage feedback. It will be useful for you and lets your students know you're open for suggestions.
- Consider arranging "Meet the TF"-sessions (see the TF Handbook).
- Accept that you're first section isn't going to be your greatest — and that that's fine. Your students are probably also nervous and there are still many months left of the semester.