# How to present problem set solutions

Most of your working time as an undergraduate is spent preparing solutions to problem sets. It therefore makes sense for us to spend some time helping you understand the best way to approach writing these solutions. This could be the most valuable thing you learn over your first few weeks at Oxford. Writing good solutions will hopefully quickly become second nature.

We understand that the type of solutions we ask for are very different from those you would have been asked to provide at school, and so we have prepared the following document to help you understand the differences (and the reasons for the differences – this is not just us being fussy).

Do read this document carefully, and do refer back to it occasionally.

## Overview

The principle aims of the problem sets and subsequent feedback are to give you an opportunity to:

(a) Practice preparing clear explanatory written solutions to problems (essential for your examinations and nearly all careers, especially anything technical or academic);
(b) Increase your understanding of the subject matter by solving and discussing the context of problems (essential for your examinations and many of your likely future careers, especially in a technical area related to physics); and
(c) Gauge the extent of your writing skills and understanding of the subject matter, relative to each other, and to the standards of the Tutors, College and University (essential to define aims (a) and (b) for you, and therefore help you achieve them).

You should therefore use this opportunity to:

(a) Prepare solutions that are well written, clearly presented, and fully explained (you cannot ignore practicing these skills and hope to 'turn them on' at a later date, e.g. in an exam, since they take a lot of practice and in an exam you will find that you only have time to write in the automatic way that you are fully used to);
(b) Analyse the subject of each problem in sufficient depth that not only is its solution clearly justified, but its role in the context of the wider subject area is clear (often the final solution is given or well-known, obtaining it is only a small part of understanding the subject, and it is the understanding of the wider subject area that will allow you to solve a different problem); and
(c) Make clear to your Tutor, in your solutions, your understanding of the topic, and highlight any difficulties in a cover sheet appended to your work. (Tutors spend a finite time reading and commenting on your work. Help them to help you; misleading them offers no advantage as formal assessment takes place outside of problem sets and tutorials.)

These aims differ quite significantly from those of answering A-level problems, which might have been to:

(a) Obtain the correct final solution without clearly presenting the full approach, method or intermediary steps (at University the length and complexity of the problems is such that the approach, method and intermediary steps, of which there may be many possibilities, are not at all obvious);
(b) Obtain the correct final solution without justifying or necessarily even understanding the method used (at University the diversity of problem types rule out memorising methods for each type of problem, instead you have to understand the core principles behind the methods and adapt them for each problem you come up against); and
(c) Convince some figure of authority, e.g. a teacher, that you are doing well, so that you get better reports (as stated above, at University this is disadvantageous to you outside formal assessment).

## Specifics

To achieve the aims above, here are a few specific examples of things we recommend you do.

(a) Good writing practice:
    i. A good general suggestion is to write as if explaining your solution to a struggling fellow student (or perhaps write for a future version of yourself who is revising the subject after forgetting about it for a few months), rather than leaving out details due to a lack of confidence or worry about patronising a Tutor.
    ii. You should, in words, clearly describe what you are doing at every step of your method even when not asked in the question to specifically explain the method (usually not many words are needed, clear short hand is fine). It should always be possible to read and understand the approach you are taking to solve the problem without looking at a single equation.
    iii. Additionally, presenting mathematical steps without words is often meaningless or incorrect. Words (sometimes very few) are needed to differentiate between assumptions, axioms, conditions and results, and to show which follow from or lead to the others. Use such words. For example, "$y=2x+1$, $x=0$, $y=1$, $x=1$, $y=3$" is contradictory as $x$ is set to both 0 and 1, which can't be true. What should be written, perhaps obvious in this case, is "if $y=2x+1$ then for $x=0$ we have $y=1$ and for $x=1$ we have $y=3$."
    iv. Clearly distinguish the solutions to the different parts of the question, e.g. by using the numbering in the question, section titles and/or horizontal lines.
    v. Clearly highlight the final or key intermediary solutions to a problem or part of a problem, e.g. by underlining or boxing.
    vi. Use the notation given in the problem.
    vii. Fully explain any notation you introduce that is not given in the problem.

viii. Whenever possible, draw a plot or diagram: it is by far the easiest way to introduce notation and explain your approach.
ix. When drawing a diagram, make it large and clear, and label it fully.
x. Do not use formulae without explaining what they are and, if not beyond the scope of the question or completely obvious, derive them (to avoid distracting from the main argument you could separate out such derivations, e.g., using a box or parentheses).
xi. Carefully read the question. Express solutions in the form the question states. Do exactly what is asked; there are big differences between the instructions 'show that', 'find', 'state', 'describe', 'derive', 'summarise', 'verify' and 'explain'. Such diversity in the desired detail of solutions is not usual at A level. Understanding the difference between these instructions/required levels of detail will be key in making sure you do no more or less than is necessary in an exam. Having said that, in a problem set for a tutorial (i.e. as opposed to an exam) it will usually be in your interest to do more than strictly asked by the question (e.g. derive the validity of a method when you use it for the first time). Please do this (again, to avoid distracting from the main argument you could separate out such extras, e.g., using a box or parentheses).
xii. Take care not to write nonsensical statements that aggravate the reader. Take the following example. Let u = 5m/s and t = 5 s, then the statement "u x t = 5 x 5 = 25 m" makes absolutely no sense as the dimensions on either side of an equality are different. It should be "u x t = 5m/s x 5 s = 25 m." As well as being unpleasant to read, carelessness like this can lead to errors in more difficult circumstances.

(b) Striving for full understanding:

i. Remember that solving problems is only a means of achieving the real goal, understanding the subject area, so adjust your motivation and writing to the latter.
ii. Your tutorial work will act as your main revision resource, it should therefore aim to capture as much of your understanding of the subject area as possible.
iii. Your tutorial work is an opportunity for you to get feedback about your understanding of the topic, but no feedback can be given about something you don't write.
iv. It follows from the previous two points that you should be as expansive as possible, don't try and avoid key concepts just because the problem does not explicitly tell you to do so, and certainly don't try and say as little as possible to avoid ever saying something incorrect – better for any incorrect assumptions to be dispelled quickly in the tutorial environment than left unchallenged until an exam.
v. Read around the subject, not just a page/paragraph containing the solution to a particular problem; understand the context of the problem, why it arises and the implications of its solution. It is very hard to recall anything later about a problem you treated in isolation.

(c) Getting the most useful feedback:

i. Hand in the solutions with all pages in order and attached together, so that nothing gets lost or confused.
ii. Attach a cover sheet highlighting the areas you find most difficult and would like the Tutor to focus on, together with any general questions you may have.
iii. In your solutions, highlight problematic sections and ask questions specific to that section.
iv. Avoid distracting the marker with easily avoidable errors by checking your answers using textbooks, computational tools such as Mathematica and Wolfram Alpha, and each other.
v. Check that any values obtained are roughly in the expected range, and remark if this is not the case.
vi. Check that any final algebraic expressions have the dimensions you expect.
vii. When substituting specific quantities into an algebraic expression and simplifying, be sure to carefully keep track of the units as discrepancies in the units are usually the first sign of an error.
viii. Never hand in a blank page as a solution to a problem or part of a problem. There is always a solution available to you in a book or from a fellow student. Reproduce this, highlighting the parts you don't fully understand to the Tutor so that they can be explained to you.
ix. Conversely, do not hand in work that you do not yourself understand without pointing out the passages that you have difficulty with, otherwise the Tutor may be <u>temporarily</u> fooled into thinking you understand it and miss out an opportunity to help you.
x. Talk about your work with the other students, they will help you spot many difficulties with your work and prevent you from becoming stuck on some problems, leaving a smaller number of difficulties to be focused on by the Tutor and spreading your time more evenly over the subject matter. You will learn a great deal from your fellow students.