

How to Read an Engineering Research Paper

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Reading research papers effectively is challenging. These papers are written in a very condensed style because of page limitations and the intended audience, which is assumed to already know the area well. Moreover, the reasons for writing the paper may be different than the reasons the paper has been assigned, meaning you have to work harder to find the content that you are interested in. Finally, your time is very limited, so you may not have time to read every word of the paper or read it several times to extract all the nuances. For all these reasons, reading a research paper can require a special approach.

To develop an effective reading style for research papers, it can help to know two things: what you should get out of the paper, and where that information is located in the paper. First, I'll describe how a typical research paper is put together.

Despite a paper's condensed form, it is likely repetitive. The introduction will state not only the motivations behind the work, but also outline the solution. Often this may be all the expert requires from the paper. The body of the paper states the authors' solution to the problem in detail, and should also describe a detailed evaluation of the solution in terms of arguments or an experiment. Finally, the paper will conclude with a recap, including a discussion of the primary contributions. A paper will also discuss related work to some degree. Because of the repetition in these papers at different levels of detail and from different perspectives, it may be desirable, to read the paper "out of order" or to skip certain sections. More on this below.

The questions you want to have answered by reading a paper are the following:

1. **What are motivations for this work?** For a research paper, there is an expectation that a problem has been solved that no one else has published in the literature. This problem intrinsically has two parts. The first is often unstated, what I call the **people problem**. The people problem is the benefits that are desired in the world at large; for example some issue of quality of life, such as saved time or increased safety. The second part is the **technical problem**, which is why the people problem does not have a trivial solution; that is, why a new technological or engineering solution may be required. Implicitly there is implication that previous solutions to the problem are inadequate. Occasionally an author will fail to state either point, making your job much more difficult.
2. **What is the proposed solution?** This is also called the **hypothesis** or **idea**. There should also be an argument about why the solution solves the problem better than previous solutions. There should also be a discussion about how the solution is achieved (designed and implemented) or is at least achievable.
3. **What is the evaluation of the proposed solution?** An idea alone is usually not adequate for publication of a research paper. What argument and/or experiment is made to make a case for the value of the ideas? What benefits or problems are identified? Are they convincing?
4. **What are the contributions?** The contributions in a paper may be many and varied. Ideas, software, experimental techniques, and area survey are a few key possibilities.

5. What are future directions for this research? Not only what future directions do the authors identify, but what ideas did you come up with while reading the paper?

As you read or skim a paper, you should actively attempt to answer the above questions. Presumably, the introduction should provide motivation. The introduction and conclusion may discuss the solutions and evaluation at a high level. Future work is likely in the concluding part of the paper. The details of the solution and the evaluation should be in the body of the paper. You may find it productive to try to answer each question in turn, writing your answer down. I recommend that you keep a notebook on all the papers you read. You should use my [standard one-page form](#) that you can fill out for each paper. In practice, you are not done reading a paper until you can answer all the questions. I will be asking you these questions in class.

Also, you should be aware of the context of the paper in relation to the other papers in the class. Often a paper will represent a generalization, new direction, or contradiction to earlier papers.

If you find that filling out this form doesn't work for you, you can try writing a 250 word abstract of the paper--not rewriting the abstract at the front of the paper, but *your* abstract, capturing the above five issues from your perspective. I often find it useful to write an abstract because it develops the logical connections between the above five issues.

If you are somewhat lost on a particular paper, and sometimes if you are not, it can pay to write down *questions* you have about the paper. Perhaps the paper was vague on key issues, or ignored issues that you think are important. If you come to class with such questions, you are prepared to counter or preempt my own questions.

Reading a book is somewhat different. Although you want to answer the above questions for a book, it may not do the book justice given the amount of detail in each chapter. You may want to fill out the above questions on a chapter-by-chapter basis, and then produce a summary form for the entire book when you have finished reading it. However, each chapter will have a particular slant that may make certain questions irrelevant. Also, a book is often not oriented towards explaining the solution to a research problem. However, engineering books are invariably oriented towards problem solving of one kind or another.

I have a habit of writing on papers directly, less with books simply because they cost so much. A well-annotated paper is worth its weight in gold, as it not only contains the content of the paper, but your assessment of its value to you.