**PH30024/40024 – Suggestions on Structure**

Jack Binysh, Oct. 2022

This document is a set of rough ideas for your own reports. To be clear, the ideas in this document are suggestions – use the official mark scheme/guidelines for hard rules. E.g. I suggest a distribution of content for your report in the “Structure” section below, but this is simply a rough guideline, not a hard constraint.

**General points:**

* <3000 words, or ~ 8 pages.

* From the guidelines: “Find a section of the topic that particularly interests you, read around it, and use your report to explain the research in that area, comparing and contrasting different approaches. You are likely to get low marks if you simply repeat the lecture material or provide just a broad overview of the field.” i.e. the suggested approach is to compare and contrast a cluster of recent research (i.e. a few recent papers).
* **Figures**: Feel free to take figures from source papers – make sure you cite the source paper in the figure caption. Even better, consider assembling your own composite figures from several source papers, which will complement the compare/contrast approach taken in your report.

**Structure:**

Below I give a suggested structure for the report, illustrated with some examples relevant to Liquid Crystal Elastomers (one of the topics from the research seminar in 2022).

**Abstract (YOU NEED THIS)** (150 words)

* A stand-alone summary of what the report is about, and its main conclusions.

**TIP**: Read the abstracts of the papers you have chosen: this is the right tone for your own abstract.

**Introduction (1-2 pages)**

* What research field is your report about?
* What is the overall goal of the research field that you have chosen?
* What is the challenge in the field that you have chosen to address in your report?
  + E.g. “Liquid crystal elastomers have recently emerged as a promising technology for designed shape-programmable materials: materials which change shape on command, and can be used for mechanical actuation tasks. Their proposed applications include xyz… However, the field currently faces challenges to realising this goal, in particular the first-principles prediction of exact shapes remains unexplored…”
* What are you going to do in the report?
  + E.g. “This report will compare three recent strategies for programming arbitrary shape change into LC elastomers… After a some brief background on the fundamentals of LC elastomers in Sec.B , I will discuss each methodology in turn in Sec. C, before comparing and contrasting approaches, and offering conclusions in Sec. D.”

**TIP:** Often the introduction of a paper will spell out the author’s view of their own field, and the overarching purpose of the research (albeit briefly). Read the paper introductions critically!

**TIP:** You can imagine that you are writing a “mini-review paper” of a few recent technical papers. So, although **we do not want you to use review papers as your main source material**, you could look at one for inspiration in terms of structure: a review paper will explain the importance of the research it discusses etc. It will also often contain figures which are an amalgamation of figures from original papers – you might consider doing this yourselves!

**Background (1-2 pages)**

* What is the essential physics background knowledge a fellow MPhys (or 3rd year) student needs to know to understand your report? There could be several different things you need to explain; each can have a subsection of its own.
  + E.g. What is a Liquid Crystal elastomer? What is their fundamental mechanism – how do they shrink/expand? What are the basic bits of Liquid Crystal elastomer physics I need some understanding of before I can read the rest of the report?

**TIP:** When you introduce a technical term, think about whether you have given your reader some feel for what it means. Here’s an example from my own writing, from https://doi.org/10.1038/d41586-022-01840-7

*“For an example of this simplification procedure in action, take active nematics, a class of material composed of elongated particles that actively pull or push on each other. Passive nematics form the basis of liquid-crystal displays, and the well-established theories describing these systems have been adapted to describe the intriguing behaviours that arise in their active counterparts.”*

In the above paragraph, by giving a rough definition of what an “active nematic” is, you give the reader some handle on what is to follow. You might ask what I mean by “pull or push on each other” – fair enough! But you at least have some mental picture of what I’m talking about now. Consider how the paragraph above would read without the brief explanation.

**TIP:** For a good example of clear writing for a scientifically literate audience, look at *https://www.quantamagazine.org/* . Find an article in there, on a subject matter you know a bit about, and read it *critically* – i.e. look at when they define terms, how much explanation they give their readers etc.

**Current Research (3-4 pages)**

* What are the crucial advances in each paper you have chosen, and how do these advances address the overall goals of this research field, as discussed in your introduction?
* What are the methodologies the papers use – i.e. how do they come to their conclusions? Analytic techniques, simulation methods, experimental methods?
  + **Paper 1:** E.g.Paper 1 proposes a set of Partial differential equations to modelling the folding process, here are the equations and what they mean, here’s how their approach works, here are some figures from Paper 1 with a discussion of what they mean in the figure caption.
  + **Paper2:** E.g. By contrast, Paper 2 offers a computational approach, using Finite Element Methods to model the expansion of the LC elastomer, it works like this…
* Looking at your collection of papers overall, how do they compare and contrast? Is one paper more successful than another? Are they trying to achieve different goals within the same overall direction of research?

**Conclusions/Future Directions (~1/2 page)**

* Now that we have discussed the current research, what are they key messages that I (the reader) should take away? If I remember one thing about your report in a week’s time, what should it be?
* Circle back to your introduction – have we addressed the questions and challenges raised there? (i.e. does the report you have written have a cohesive structure?)
* What has the research you have read about “opened the door” to, in terms of future research directions?

**TIP:** Papers themselves will have conclusion paragraphs at the end of the main text of the paper. Here, the authors will discuss their opinions of future research directions, and summarize how their work addresses the challenges likely raised in their intro. You will likely read 2 or 3 of these (or more!). Read these *critically*. What is *your* opinion?

**References (YOU NEED THIS)**

**TIP:** When you are reading papers, pay attention to how they cite papers – this will clue you in to how you want to do it.

**TIP:** Just for an example, here are some references from a report I’m writing currently:

*In the main text:*

“However, their appearance in minimal physical systems is particularly striking, precisely because they are typically forbidden by conservation laws: non-reciprocity is a hallmark of non-equilibrium, non-Hermitian physical systems. Indeed, recent work shows that odd interactions yield linear phenomena *forbidden in passive materials*, such as unidirectional wave amplification1, and mechanical waves in overdamped media2 .” ….

*In the references:*

1: M. Brandenbourger, X. Locsin, E. Lerner, C. Coulais, *Nat. Commun.* **2019**, *10*, 4608.

2: C. Scheibner, A. Souslov, D. Banerjee, P. Surówka, W. T. M. Irvine, V. Vitelli, *Nat. Phys.* **2020**, *16*, 475–480.

.