READING LIST FOR APPLIED SUPERCONDUCTIVITY

Undergraduate Texts:

If you are fabricating some high temperature superconductors for a short experimental project some basic texts that are useful include:

H M Rosenberg – *The Solid State*.
http://www.amazon.co.uk/Solid-State-Introduction-Materials-Engineering/dp/0198518706/ref=sr_1_1/202-0210760-8966217?ie=UTF8&s=books&qid=1183800926&sr=1-1
This is gives a very basic introduction to the phenomena of superconductivity.

Gerald Burns – *High Temperature superconductivity*
http://www.amazon.co.uk/High-Temperature-Superconductivity-Introduction-Gerald-Burns/dp/0121460908/ref=sr_1_8?s=books&ie=UTF8&qid=1423828349&sr=1-8&keywords=gerald+burns

K Osamura - *Composite Superconductors*
http://www.amazon.co.uk/gp/product/0824791177/ref=ox_sc_act_title_1?ie=UTF8&psc=1&smid=A18W6Y26ZLGDD2

Students joining the Superconductivity Group about to embark on a PhD.

If you are a fusion CDT student: Don't forget that your overwhelming priority in your first year is to try to get the best mark you can in each piece of work for the CDT. I am very happy for you not to start any of the reading below until the end of your CDT courses. The courses are full-time, so you cannot start your research. The other priorities for new members of the group are: completing your first-year report in July and passing your English language exam (if necessary).

It is quite usual that although the students who join our group have a strong interest in superconductivity, they have not studied it in any detail in their first degree. This is not a problem.

Remember, you are well resourced during your PhD. If you want to have your own personal copy of a text-book, I am very happy for the group to buy you a copy (for the duration of your PhD). Of course you don't pay for it from your personal stipend (i.e. from your beer or coffee monies). Please ask Dr. Raine how best to order it (electronically) from the research funds earmarked for you. When the book arrives simply write "Superconductivity Group" and the date on the inside of the front cover – store it on the group book shelf in the office when you are not using it.

In a high magnetic field group like ours, you need to be able to write down Maxwell's equations in differential and integral form (eg. Ampere's law) from memory. If you can't, please brush-up your EM, by looking at: Electromagnetism – Grant and Phillips – Wiley.

To give you some very (crude) broad brush statements: If you are studying for a PhD, you need to be very clear that getting your 'new data' be that computational or experimental for a publication is your primary (technical) responsibility. In a group like ours, in the first 2 years, this is predominantly issues of followship, being organized and perspiration. I cannot emphasize how much more important 'new data' is than reading the literature in the first year. Please prioritise the 'new data' aspect of the milestones discussed with DPH in personal meetings. 'New data' is the core of new research. You should be pulling together a new body of data by the end of your 2nd year and hopefully producing a conference paper by then (some manage it by the end of their first year!!). By the end of your 2nd year, it is clearly better if you understand what we can call the 'core literature'. Although, the reality is that we can finesse/support your understanding of the core literature in helping you to write your first conference paper if you have some substantial 'new data', it will have been difficult for you to have moved quickly and smartly enough to get the data (sine qua non) for the paper, if you haven't understood the 'core literature'.

Old School approach: In most research groups, researchers will regularly be asked to produce a compilation or talk on a relevant topic. If it is a written compilation (some are available on the group archive), the experimental ones (generally a compilation of your experimental results) are quite different to the theoretical/computational ones (line-by-line derivations of some proofs), and with most things in research, your first port of call should be to copy the format and approach that the best students in the group produced previously. When I was in the USA, my boss never asked me to read specific text-books, review articles or archival papers – it was assumed I would choose the best materials for me, and keep reading them until I was in a position to understand (and unpick) the newest papers I was asked to review.

New School approach: PG students have asked me about how best to address the literature. The short answer is to do whatever worked for you, when you set about reading/understanding the 5 most important text-books for your undergraduate course. If you want something more structured:
Read the text-books below (I suggest: 1 chapter every two weeks - Don't worry about catching up if you miss a week). Unfortunately, a superficial reading won't hack it (and there are no exams). I recommend: As you read each chapter, copy out every equation given, and keep the electronic copy of the equations for your records. If you are really 'nails', complete the questions at the end of each chapter – I am not sure it is really required. When you finish each chapter, write a few more notes – numbers and equations are best. This general approach will also work for reading journal papers throughout your PhD – build an electronic library of the papers you have read, with your own annotations on the .pdfs. If you find any of the chapters/papers are getting tough – find some other text books/review articles, and go 'old-school' for a few weeks:

i) C P Poole, H A Farach and R J Creswick, *Superconductivity* (Academic Press Inc, San Diego, California, 1995 (~ £40)
http://www.amazon.co.uk/Superconductivity-Charles-P-Poole/dp/012561456X/ref=sr_1_3/202-0210760-8966217?ie=UTF8&s=books&qid=1183800021&sr=1-3
All chapters

Poole is a very good textbook with a well-chosen good broad overview. Nevertheless, please do remember that like all textbooks: not all of Poole is written well; some of it is simply wrong; and not all of it is (very) relevant for your PhD.

ii) Tilley and Tilley - Superfluidity and Superconductivity (~ £43).
http://www.amazon.co.uk/Superfluidity-Superconductivity-Graduate-Student-Physics/dp/0750300337/ref=sr_1_3/202-0210760-8966217?ie=UTF8&s=books&qid=1183800344&sr=1-3
Chapters: 1, 2, 4, 5, 8, 10 and 11 (Line-by-line Chapter 8)

The most important text-books that I recommend next are quite old. However, Wilson's book is a light read:

iii) M N Wilson, *Superconducting Magnets* (Oxford University Press, 1986) (~ £24)
http://www.amazon.co.uk/Superconducting-Magnets-Monographs-Cryogenics-Martin/dp/0198548109/ref=sr_1_1/202-0210760-8966217?ie=UTF8&s=books&qid=1183800498&sr=1-1
Chapters: 1, 2, 10, 11, 12, 13. (Particularly Chapter 12)

iv) M Tinkham, *Introduction to Superconductivity* (McGraw-Hill Book Co., Singapore, 1996). All chapters.

Experimentalists should note that we also have a copy of the excellent textbook for reference:

Experimental techniques for low-temperature measurements – J W Ekin (~£40).
http://www.amazon.co.uk/gp/offer-listing/0198570546/ref=sr_1_olp_1/202-0210760-8966217?ie=UTF8&s=books&qid=1183801912&sr=1-1

Before the end of your 2nd year, you should have read chapters 1,3, 4, 5, 9 and 10.

There are some research papers you should try to read in parallel.

Characterisation of the Transport Critical Current Density for Conductor Applications Mark J. Raine, Simon A. Keys and Damian P. Hampshire 2021. (Ask Dr. Raine for a copy/link).

P.O. Branch, Y. Tsui, K. Osamura and D. P. Hampshire. Weakly-Emergent Strain-Dependent Properties of High Field Superconductors. Nature Scientific Reports 9:13998 (2019).

Andrew P Smith, Mark J Raine, Elizabeth Surrey, Satoshi Awaji, Tatsunori Okada and Damian P Hampshire 3-D Properties in (RE)BCO Tapes Measured in Fields up to 35T., IEEE Transactions on Applied Superconductivity., 29 (5) p. 6601005 (2019).

Alexander Blair and Damian P Hampshire Modeling the critical current of polycrystalline superconducting films in high magnetic fields., IEEE Transactions on Applied Superconductivity., 29 (5). p. 8001705 (2019)

G. J. Carty and D. P. Hampshire – The critical current density of an SNS Josephson-junction in high magnetic fields – SuST 26 065007 (2013)

D. M. J. Taylor and Damian P. Hampshire - The scaling law for the strain-dependence of the critical current density in Nb_3Sn superconducting wires - *Supercond. Sci. Tech* 18 (2005) S241-S252

H J Niu and D P Hampshire - Disordered Nanocrystalline Superconducting $PbMo_6S_8$ with a Very Large Upper Critical Field. *Phys. Rev. Lett* 91 027002 (2003)

You will find after you have completed the four recommended text-books, that subsequent text-books are very much easier/quicker. There are some other good texts and reviews that are focused on the Physics of applied superconductivity:

J Annett – Superconductivity, superfluids and condensates
http://www.amazon.co.uk/Superconductivity-Superfluids-Condensates-Oxford-Physics/dp/0198507569/ref=sr_1_2?s=books&ie=UTF8&qid=1423828497&sr=1-2&keywords=james+annett

If you joining us with an interest in a joint Engineering-Physics PhD in a collaboration with our group, then take advice about focused reading but after you have finished the recommended text books, you may consider during your 2nd year (Apologies re links here):
AC and DC power transmission-Caracino Pirelli.pdf
Applied properties of s-c materials -Masur Amer Supercon.pdf
Current leads - Ryan OI.pdf
Electromagnets - Jones Oxf.pdf
Energy storage - Blaugher NREL CO.pdf
Fault-current limiters - Giese Argonne+Naperville.pdf
Intro processing - Murakami+Flukiger.pdf
MgB2 - Buzea Canada+Tohoku.pdf
Phase diagrams - Shercliffe+Ashby Camb.pdf
Processing LTC conductors - Nb3Sn - Miyazaki Kobe Steel.pdf
Refrigeration methods - Radebaugh NIST.pdf
Transformers - McConnell ORNL.pdf
YBCO - K-B+Murakami ISTEC.pdf

Do remember that the British Ph.D is short – typically ~ 3 ½ - 4 years. Our aim is to successfully build a world-class research team that produces publications at the cutting-edge of science. After you finished your courses, an experimentalist should try to spend at least half their time doing experiments in the laboratory (The reading is much lower priority than getting your experiments underway. Experience shows that your reading is far better focused and retained when you have to analyse your data for publication).

There are some other excellent texts and reviews that can also be very useful with specific topics:

Excellent Physics texts:

J D Jackson, *Classical Electrodynamics* (John Wiley and Sons, New York, 1999)
G Woan, (CUP, Cambridge, 2003)
N W Ashcroft and N D Mermin *Solid State Physics*
H Bruus and K Flensberg *Many-body Quantum theory in Condensed Matter Physics*

Excellent reviews and lectures:

M R Beasley *Notes on Ginzburg-Landau Theory Summer School* 2009
Eltsov Lectures https://mycourses.aalto.fi/mod/resource/view.php?id=677688

Excellent general books

C P Poole, *Handbook of superconductivity* (Academic press, 2000)
J B Ketterson and S N Song, *Superconductivity* (Cambridge University Press, 1999)

J R Waldram, *Superconductivity of Metals and Cuprates* (IOP Publishing Ltd., London, 1996)

Excellent books for G-L theory and pinning

P G De Gennes, *Superconductivity of Metals and Alloys* (Addison Wesley Publishing Company, Redwood City, California, 1989)

Matsushita *Flux Pinning in Superconductors*

Excellent books for Josephson Junctions

Barone and Paterno *Physics and Applications of the Josephson Effect.*

Van Duzer and Turner *Principles of Superconductive Devices and Circuits.*

Excellent reference books:

D Cardwell and D Ginley, *Handbook of Superconducting Materials* (IOP, Bristol, 2003)

B Seeber, *Handbook of Applied Superconductivity* (Institute of Physics, Bristol, 1998)

E M Landau, I M Lifshitz and L P Pitaevskii, *Electrodynamics of Continuous Media* (Butterworth Heinneman, 1960)

E Landau, E Lifshitz and L Pitaevskii, *Electrodynamics of Continuous Media* (Butterworth Heinneman, 2002)

A B Pippard The elements of Classical Thermodynamics (CUP, Cambridge, 1964)

Review of the literature for your thesis, or first long journal paper (3rd and 4th Year).

Writing a review of the (infinitely expanding) literature was a very daunting prospect for all of us the first time through. It is a critical hard-earned research skill. Don't worry! It is much more perspiration than inspiration. Perfectionists have real problems producing the first draft because we need to review the literature properly (but it must be focused not exhaustive). Unfortunately, it is not sensible to start writing this review until you know what your new work will be (that you will publish/write into your thesis). This is because, you must clearly describe the underpinning work that precedes your work – and then show that your work is different to what went before. Usually, you have to understand this underpinning literature in far more detail than you (could possibly) understand the rest of the core literature (and producing the review may include me asking you for a line-by-line understanding/deconstruction of it). This underpinning work can also change quite quickly…..

If you find yourself overwhelmed by the huge amount of literature out there – by numbers you can: have a discussion with DPH about where your new contribution is most likely to be, identify the most recent reviews in the literature in your area; use the text books and the reviews from the literature to produce a short, heavily-referenced review (eg 40 references) no more than 7 pages long (the most valuable references in order are: text-books, review articles and then papers – to avoid internal self-referencing errors only quote the group papers when you have no other choice [i.e. we were first to do the work]); then, identify the most important say 8 - 16 recent papers that underpin your work and add them to your review. Your first draft is then done and you have to abandon it to DPH. Blair has an excellent review: Pgs 80 – 95 in his thesis (supplemented by the tables in his recent paper…).

Professor Hampshire
17th August 2021