Imperial College London

Optional Module Guide

Year 2018-2019

Department of AERONAUTICS

Please Note:

The following document was made by students for students. It is meant as a less formal introduction of the courses to make choices for 3rd and 4th year modules easier. Do not take everything that is written as a given, as courses could be reviewed and approaches taken changed. Please email vl516@ic.ac.uk if you would like any modifications to be made or if you would like this document to be taken down.

Picking your modules: Tips and things to look out for

Here are a few recommendations which would be worth keeping in mind when reading the module descriptions below.

- Pick things that you are interested in. Do NOT get lost in making predictions on which module sounds easiest, in the end it will be a burden to study for if you're not enjoying it and it certainly will not help in increasing your overall grade.
- Plan your year. Pay close attention at the deliverables and deadlines on every module. If possible, balance the workload throughout the year, taking core modules into account. You do not want to end up with 11 deadlines at the end of the 2nd term.
- On a similar note, remember as of next year, spring term modules are open to 4th years as well. Make sure to take this into account in your choices, and be aware that some modules don't run every year (all this information will be available to you in the module selection sheet).
- Your third year summer is quite important internship-wise and "year in industry"-wise. Think about it when picking your modules.
- Ask higher years questions if you're unsure! We've been through this and can certainly be of some help to tell you what we've been through.

1 Spacecraft Systems

1.1 Content

This module covers end-to-end design of the systems required to operate a space mission; this includes not only the design considerations for the spacecraft itself, but also the ground systems, launch vehicles, orbit design and timelines of the mission. The design process for spacecraft (compared to say, the aircraft design process you will learn in AVD) is also discussed. The level of detail varies between topics, but is designed to give you a very good (if general) overview. You will also apply your knowledge to a (un-evalutated) case study as a class. The content is split about 60/40 descriptive and math based. The module is largely based on the 'bible' of space missions, Space Mission Analysis and Design (SMAD). A key point of this module was the large number of excellent guest lecturers from companies such as SSTL, Arianespace, Nammo, etc.

1.2 Interest and Take-Away Message

Great for people interested in the real engineering process of spacecraft design, and mandatory for Spacecraft Engineering stream. As mentioned, this gives you a very broad overview of the unique considerations of designing for space operations, as well as a great sense of the history of spacecraft and the current state of the industry. The guest lecturers were particularly excellent, and are a highlight of the course. If you see yourself working in the space industry, this is a must.

1.3 Work Load and Assessment

Single evaluation: Summer term exam. No extra work during term. This module is very new so you will have only one past paper, and a sample paper, as well as tutorial questions to prepare with. A majority of the content is descriptive, and appears to not be heavily evaluated, with the vast majority of the questions focused on orbital mechanics and propulsion mechanics. However, as this module is brand new, this may change, so be sure to read the exam report.

2 Advanced Manufacturing

2.1 Content

This module is all about manufacturing composite materials. This includes traditional carbon fibre composites, as well as ceramic composites etc. The approach is relatively standard, you are given a copy of the lecture slides - not fill in notes. So be aware that you have to stay awake and actually make an active effort to take notes. The course is in the first term (so it's pretty tactical to get it done before second term).

2.2 Interest and Take-Away Message

I enjoyed the course in general, it's pretty standard stuff. It was actually interesting despite what the course title suggests. I feel manufacturing is super neglected by engineering students, and given everything you design requires manufacturing this makes me sad - take home point, the content is useful. It's not like second year manufacturing, it's a little more focused on actual numbers. Be prepared to whip out some incompressible fluids, for fibres through resin etc.

2.3 Work Load and Assessment

All in one January exam. Unfortunately you will only have three past papers. If I'm being honest my mark in this module was lower than expected, but I know people that got respectable marks in it. Conceptually there is nothing too difficult in the exam, but be prepared to commit stuff to memory (which I know aero's hate).

3 Computational Fluid Dynamics

3.1 Content

In terms of content, the official information on DSS is quite exhaustive and I recommend having a look there. In simple words, the module is split into two parts. The first one was covered by Professor Spencer Sherwin. It mostly repeats the material of the Professor Doorly's part of Second Year Numerical Analysis which is (in case it changed): basic discretization schemes and mathematical analysis of their stability and accuracy. It is fairly straightforward but it progresses quickly. There is a set of notes and during the lectures they are slowly filled. The second part, lectured by Dr George Papadakis is a bit more demanding and introduces new concepts. The teaching is based on slides and the notes are basically printout of the slides. Nonetheless, the notes are quite well made, aesthetically pleasing and easy to learn from. During the lectures, Dr Papadakis goes through the slides and sometimes stops to write on the whiteboard and explain some concept in more detail. Furthermore, both parts are reinforced by tutorials which are ok (everything what you would expect from a good tutorial sheet).

3.2 Interest and Take-Away Message

I enjoyed the course very much. The material is mainly conceptual so there are few things that you have to learn by heart. The pace is very good so with little extra work at home with tutorials it is manageable. For me personally it was the least stressful course of the year. Furthermore, the material presented bears some connections to other modules like Aircraft Aerodynamics. I was also able to use some of the things learned in CFD while doing the High Performance Computing assignment. The lecturers are very approachable and ready to help if you have problem with specific topic. Long story short: one of the best modules in the whole course and I highly recommend it for anyone seeing his/her future career in CFD.

3.3 Work Load and Assessment

The course is assessed by two courseworks - one for each part of the module (first by the end of November and second in February? - surely after the exam so be careful). The courseworks are relatively easy and each require about 2-3 hours of thinking/problem solving/coding in Matlab + time spent on report writing. It is a bit harder to fit the marking scheme so I would recommend asking questions on BB if unsure what the lecturer wants see in the answers. The exam is ok and I would say that it should be possible for anyone to get over 70% as long as enough time is spent on practicing exercises from the tutorials and the past papers.

4 High Performance Computing

4.1 Content

In terms of content, the official information on DSS is quite exhaustive and I recommend having a look there. Bottom line, the course structure is very simple. There is a GREAT set of notes outlining everything and a bit more that you need to learn in C++. Lectures are just computer sessions where in the first hour lecturers are explaining each topic, giving examples and the second one is for asking questions. You can do everything at your own pace - that is if it is faster than what is going on in lectures. Do not underestimate the speed of learning. It seems slow at first but then it gets from chapter 5 to 16 surprisingly quickly.

4.2 Interest and Take-Away Message

I enjoyed the course very much. I strongly believe it is one of the most useful optional modules. It is a great deal of work but if you are interested in computational aspect of engineering and enjoyed computing courses in years 1 and 2 then this module is not the one you should NOT miss. The work load is high so be sure to choose other options wisely - having yet another coursework in addition to HPC, AVD, L3 and labs might not be a good idea. Long story short: one of the best modules in the whole course and I highly recommend.

4.3 Work Load and Assessment

The course is assessed by two short in-class tests and one big coursework. The tests are.. ok. It is simple coding with very limited time. Nevertheless, if you prepare you will score a very good mark which contributes to 25% of the module mark (or something like that - check in DSS). The coursework is enjoyable and takes a good amount of time. The last year review quoted 100 hours - I guess that is quite accurate to get everything finished but it is not as bad as it sounds. Furthermore, it is programming a conceptually simple algorithm i.e. you plan what it should do and how (10% of time) and then you code it (80% of the time) which is like driving a car (takes time, is simple but also requires attention and thus is not boring). The last 10% goes to report writing. Plan your time well and it will be ok.

5 Biomechanics (IDX)

5.1 Content

The course is split in two fundamental sections: mechanics and fluids. The mechanics section looks at the kinematics and dynamics of the human body, as well as some fracture mechanics applied to bones at the end. The standard questions you would be asked to solve use a table with idealised anthropomorphic data, but sometimes there are more qualitative questions to be wary about. The fluids section is a piece of cake given our background, until they decide to turn everything into circuits using lumped modelling. Essentially, they make fluid dynamics in the human body analogous to circuits, so that tools like Kirchhoff's Law are applicable. Other than this, the course is a blood application of Year 1 Aerodynamics with some added permeability problems at the end.

As far as the maths go, you would be looking at Year 1 stuff, particularly matrix inversion and coordinate transformation. There is a little bit of a learning curve to get used to some of their conventions (which can be inconsistent at times, and so a little frustrating to study). Finally, their terminology in the first section, which looks at the definition of movements within the human body (anterior-posterior, proximal-distal, medial-lateral) can be a little tricky to get used to.

5.2 Interest and Take-Away Message

I am a little torn about this module. On the one hand, if you want to do something different from Aeronautics, but still enjoy the physics side of things, this module is ideal in the sense that you look at a different application of the techniques you have been learning so far and, if done in Year 3, might interest you in a medical/bioengineering focused FYP. On the other hand, it can be a little demotivating given that you are not learning anything new from a skills standpoint, but rather applying your previous knowledge to a different field.

This is one of those modules that will be interesting to you if you fully commit to it. If your motivation is just to pass another exam, the lectures will become very monotonous and you will focus solely on methods you already know, instead of the less likely to be examined pure bioengineering content, such as the application of biomechanics in research. Moreover, as you lose motivation to engage with the module, and quite frankly attend the lectures, you will become more prone to mistakes and end up with a lower grade than you would anticipate (like me).

5.3 Work Load and Assessment

This module is taught in the IDX slot from 9am to noon on Fridays. This information is particularly relevant because it does not change, and missing a day implies missing a whole week. There are 4 pieces of coursework to submit, two reports (10% each) and two problem sheets (5% each); the coursework is quite easy and intuitive, with a good opportunity for high grades, but it requires you stay on top of the lectures, as the reports look at computational applications of the content discussed in class (using MATLAB).

BE CAREFUL WITH THE EXAM. There are no actual pass papers provided, just a couple of test papers that structurally resemble the exam, but are quite easy in comparison. The exam is not as straightforward as the problems on the sheets (which also serve as tutorials), but dig deeper into the more qualitative content. If you treat this exam as you would any department-run module, you should have no issues, but the simplicity of the methods can be deceiving. From a grades standpoint, it is well designed, since passing is pretty much assured (if you turn in your coursework), but once you pass 70% it becomes exponentially harder.

6 Separated Flows and Fluid-Structure Interaction (IDX)

6.1 Content

Taught in term 2 and typically in 2 hour blocks, twice a week. The first half deals with separation of flow and more importantly, several ideas and theories that have been proposed in this regard. Looks in much more depth at boundary layer phenomena and how different approaches (and their limitations) affect the prediction of these separation phenomena. The second part, fluid structure interaction deals with the interaction of SEPARATED flows and structures (rather than just attached flow-structure interaction, which is more covered by aeroelasticity). Looks at three main concepts of interaction and being able to identify these (galloping, vortex-induced-vibrations and buffeting). This has interesting applications such as flow around skyscrapers in cities. Again, this part also has several in-depth concepts and phenomena that compared and even linked to more fundamental ideas such as a simple mass-spring damper. Full completed notes are provided but lectures are based on the visualiser rather than following the notes.

6.2 Interest and Take-Away Message

Overall, a theoretical module which is relatively concise but has very in-depth concepts that take some time to learn. It was a lot more mathematical than expected but that is not to say it is not interesting; if you are interested in turbulence modelling and design of products that are less typical aeronautical applications (than aircraft or race cars), this module provides an interesting view on that.

6.3 Work Load and Assessment

There is no coursework but only a 2hr exam in term 3. Notes are quite wordy so going through and making your own revision notes is beneficial. This module is also taught with MSc students so timetabling may not be ideal. Not many tutorials but there are plenty of past papers, though it is likely that every exam will be quite different due to the theoretical nature of the module. There is a qualitative and quantitative aspect to this module.

7 Mathematics

7.1 Content

This is a second term module with 3 hours of lectures and 1 hour of tutorials a week. You are provided with fill-the-gaps notes which you can fill in from the whiteboard notes Dr Phil Ramsden makes. Sadly he does not use the visualiser meaning if you miss a lecture it is hard to catch up, but this is an issue that has been raised with him this year and may hopefully change in future years.

The module begins with a brief foray into calculus of variations which is about functions which map functions to real numbers and seeking the functions which maximises or minimises this real number. This is different to what we met in school and in first year where we had a function that mapped real numbers to real numbers, and we sought the real number x such that f(x) was a maximum or a minimum.

The module then recaps complex number theory before delving in detail into plotting complex functions and finding their integrals and derivatives. Complex variables series are then studied and their results used to apply Laplace transforms and conformal mappings to aerodynamic applications.

7.2 Interest and Take-Away Message

This course is an extension on pure mathematics that we have studied before. If you find that you enjoy learning engineering theory and applying fairly difficult maths to solve these applied problems, but you do not take interest in solving maths questions for the sake of it, then this course may not be for you. By the end of the module there is somewhat more application, specifically to conformal transformations in aerodynamics, but it is still very algebra heavy.

7.3 Work Load and Assessment

This is a no-coursework module with a single exam in the summer term. The workload is small during the term with only a single tutorial sheet to complete a week.

8 Spacecraft Structures

8.1 Content

This course is divided into 2 parts, $\frac{1}{3}$ being taught by Dr. Lee and the remainder by Dr. Santer. Dr. Lee's part is an overview of the space environment interactions (that is Radiation, Neutral, Plasma and Particulate environments), and is relatively easy to grasp. Each lecture you are given a set of slides with most of the information needed on the topic. Dr. Santer's part of the course is divided up into 2, Vibrations Analysis (of rockets) and Deployable Structures (and this is the only undergraduate course in Europe that covers this topic). This course is derivation heavy, you are given a booklet of about 60 pages with most of the maths that Dr. Santer will go through in the course. It's really useful, but you also need to take notes during the lectures, mostly following the slides Dr. Santer creates with his Ipad. The first sub-part part focuses on designing against the vibrations felt by spacecraft during launch, looking at methods used in industry and could be said to be building on to 2nd year Structural Dynamics. The second sub-part about deployable structures looks at ways of analysing the stress in membranes. It also focuses on the mechanisms typically used in spacecrafts.

8.2 Interest and Take-Away Message

I personally really enjoyed this course, it was a nice shift from the aircraft oriented structures we'd done so far.. The Space Interactions part of the module, being very basic chemistry, is relatively different to things done before in the degree, and brings a new perspective of design (space is essentially danger). The Vibrations section is a lot of maths but also (for me at least) a lot of fun, and Dr. Santer makes sure to always justify his derivations with an application in the spacecraft structure design process (like showing launcher manuals, talking about his research in the field, his industry experience or even a short lab session about vibration testing of spacecraft!). The deployables part of the module is less maths and more mechanics and geometry (if that's different?), but still plenty of examples, supporting documents which relate to recent or future missions. I think a large part of what makes this module so interesting is the fact that it really gives you the mathematical tools that industry uses today.

8.3 Work Load and Assessment

Workload for this module is moderate. One 2h exam in January. Three parts, three questions in the the exam, three tutorials, it's all pretty straight forward. There is however a lot of content, so it might be harder to cover everything in the break depending on your number of exams. During the term, as long as you read through the notes and slides after lectures, you should be able to understand what goes on.

9 Advanced Mechanics of Flight

9.1 Content

First half by Robert Hewson - orbital mechanics and motion of satellites. Not like 2nd year. Similar to first year but a large extension on the theory already covered by Dr. Santer in the 1st year mechanics course. We look at different types of orbital transfer, not just Hohmann so that makes things a bit more complicated but also more interesting. We also briefly look at orbital elements, (Orbits in 3D with using i_x, i_y and i_z vector components. we also look at orbital timing, so how long it takes from a satellite to get from point A in an orbit to point B. The course has a fair few derivations in it but these are mainly geometric properties of conic sections and nothing more than that to be honest. Second half by Rafael Palacios - bit more similar to 2nd year flight mechanics but looks more closely at aircraft control and aeroelastic flutter. Wings/fuselage are modelled as flexible and this increases complexity slightly. Again, more interesting with a few more things to consider.

9.2 Interest and Take-Away Message

If you found Santer's orbital mechanics part of first year interesting, you'll really like the first half of this module (it's the main reason I took it, without worrying about the other atmospheric flight conditions part of the course). It makes a nice change to classic mechanics. I think the coursework is pretty fun too; it is related to the atmospheric flight conditions half of the course, and involves the longitudinal governing equations of a light aircraft, plotting eigenvalues, and how they change with respect to a change in atmospheric conditions.

9.3 Work Load and Assessment

Examination - 70% of total marks. 2/3 of the exam is on orbital mechanics (Hewson) and 1/3 of the exam is on Atmospheric Flight conditions (Palacios).

Coursework - 30% of total marks. MATLAB assignment is purely on eigenvalue analysis and stability, with a little bit on LQR control (something you study early in the second term in control systems with Dr. Kerrigan). It's all a good laugh and would recommend for sure. It is easy to get a good 80+ in the coursework which really takes the pressure off the exam for a decent grade overall. Enjoy.

10 Materials in Action

10.1 Content

This module is divided into three parts taught by Prof Emile Greenhalgh, Dr Vito Tagarielli and Dr Zahra Sharif Khodaei. Emile focuses on procedures for materials selection as well as advanced and new material developments. His first part is a bit of a revision of 2nd year materials. In the second part he teaches two topics about advanced composites and new materials, which is probably the most interesting part of his section, since this is his field of research. Overall Emile's part is qualitative and quantitative. Vito's part is about designing with sandwich structures and is very quantitative. It is easy to grasp and it requires good understanding of engineer's beam theory. Zahra's part is the shortest and is about inspection and health monitoring of aerospace materials. Her section is very qualitative and focuses solely on structural health monitoring. There are no calculations or equations to be memorised in her part.

10.2 Interest and Take-Away Message

The most interesting part of Emile's section was about composite materials and I recommend it to anyone interested in composites. The first part of his section was not as interesting and a bit slow paced. It is also quite hard to revise, since you can only rely on his slides or on a very bulky textbook from the library. Vito's part was enjoyable and the calculations involved were easy to grasp. It provides a good quantitative analysis of lightweight sandwich structures. Zahra's part is very interesting in my opinion. Her part is very theoretical, but that's probably because structural health monitoring is still a growing field of research. Overall I recommend this module to students interested in advanced aerospace materials.

10.3 Work Load and Assessment

There is no coursework to be completed during the term, 100% of the module mark comes from the final exam. The exam consists of 3 questions, one for each lecturer. Emile's and Vito's part are worth the same, but Zahra's part is worth much less since she only teaches 3 lectures.

11 Finance and financial management (BPES)

11.1 Content

This module includes basic knowledge about financial markets. There are eight topics: Introduction (the components of financial markets), Time value of money (discount future cash flows into today's values), Portfolio selection (combine risky and riskless assets), Capital Asset Pricing Model (discount for riskiness of asset), Risk pricing and arbitrage (pricing of risk, definition of arbitrage, bid ask prices), Equity valuation (Divident discount model), Fixed income valuation (bond pricing and duration), Options (different types of option contracts, pricing and option strategies). Generally, it contents study of equity, fixed income and derivatives markets, and how to evaluate them. It also introduces portfolio selections between different assets

11.2 Interest and Take-Away Message

This module is very useful for those who want to get in finance industry. It is about understand different financial products and various pricing equations. There are some basic math involved. People who enjoy A-level Economics and Accounting may find it interesting.

11.3 Work Load and Assessment

The assessment is divided into two parts: 30% coursework and 70% exam. For the coursework, a trading game with poker cards is performed by group of 4/5 people and a 5/6 pages group report is assessed. The exam is multiple choice questions without negative marking, most questions are purely calculations and others are about understanding of the theories.

12 Optimization

12.1 Content

This option is based on optimization techniques applied on functions and how to implement them. The module was taught in the first term. A set of very-well written notes is distributed at the beginning of the year. There are no slides but the lecturer follows roughly the same evolution that you can find in the notes.

12.2 Interest and Take-Away Message

If you like fast-paced very maths oriented lectures then you will enjoy this module (I know I did). The lecturer is very good and can actually help you with optimization issues that you will have in other modules (such as the applications exercise for example). Indeed this module can reveal itself as being quite useful if you actually learn how to play with the optimization techniques that you will be taught. It can be a good combo with HPC or Maths.

12.3 Work Load and Assessment

There was no coursework. The workload is actually quite okay as the notes are very well written (half of it being solely dedicated to exercises and solutions). The concepts are quite straightforward. However it should be noted that the exam is in May, which could be an issue depending on how many other exams you will have at this time of the year.

13 Aircraft Systems Engineering and Aerial Vehicle Technologies

13.1 Content

This module consists of two parts. The first one focuses on theoretical design of systems (e.g. fuel, avionics but also generic systems) where content is predominantly descriptive, i.e. deprived of almost any calculations. This part gives insight into how to adopt a system's approach when designing anything, i.e. take a more holistic approach and link interactions between components. The content is quite interesting, yet may seem very general at times. It is assessed with an exam and coursework, the latter of which takes about 20 hours to complete. The second part of the module focuses on Unmanned Aerial Vehicle (e.g. drones) and flapping wing vehicles (bird-like drones). Various aspects are included: vehicles' applications, ethics, overall design, aerodynamics, electronics, flight dynamics, etc., all of which are not in depth, but rather good insights backed with theoretical formulae and case studies. This part is assessed with an exam only.

13.2 Interest and Take-Away Message

Overall interesting; gives good introduction into UAVs. Can recommend this module to those wishing to expand knowledge about Unmanned Aerial Vehicles or those interested in systems.

13.3 Work Load and Assessment

See above.

14 Advanced Propulsion

14.1 Content

This module is a progression through the different limits of an engine as you increase Mach Number, that is as you go faster and faster, which part of your engine is going to be limiting and how can you remedy this. It focuses on the evolution of engines in the last 120 years, with a lot of anecdotes and historical facts about the industry from the lecturer. The approach taken is slightly different than in other modules in terms of how derivations are done, and in general the idea is maths are just a tool for you to do fun aerodynamics and thermodynamics with (which you should expect as a part of the course, although derivations aren't the main focus of all the lectures). Starting from a typical turbojet, the question becomes how can we make this faster, more efficient and also remain alive when piloting it. For this course you are given a set of slides at the start of each lecture, which you will need to annotate to get the most out of it.

14.2 Interest and Take-Away Message

I really enjoyed that module. It's a 3 hour block (which for us was on Friday mornings) with 2 hours of lectures and then a tutorial, which seems like a lot but actually runs very smoothly thanks to the excellent external lecturer. I thought the idea of breaking up lectures into a range of Mach Numbers makes things really intuitive, and gives you a better understanding of the performances of different engines, and the supporting videos/documents (shown in lectures) and slides were excellent. The lecturer is great and genuinely wants you to enjoy his module and learn as much as possible, he takes the time to come talk to everyone in the tutorials to help you through problem sheets, and has given every single group written and oral feedback on the coursework handed in just a week earlier! (more on this in the next section). If you liked Propulsion in 2nd Year and want to learn more about engines, rockets and other flying things, consider this module!

14.3 Work Load and Assessment

Assessment of this module is broken up into an exam in the summer term and a piece of coursework worth 25% of the module during the spring term, which is when this module is run. The coursework is a computing based exercise in groups with a small report where you are required to design a numerical ramjet, and shouldn't take more than a couple of hours if you split the tasks properly. During the term, workload for this module is quite light, and attending lectures and tutorials will enable you to grasp most of the key concepts.