# Report of the Curriculum Committee

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# 1 IID General Relativity

We received a proposal from Dr Siklos, the current lecturer, to modify the schedules.

It was suggested that Israel's theorem should be listed with a star because of the level of technicality of its statement. Although in practice it is unlikely that exam questions will be set on this topic, we agreed that it would send a confusing message to students if too many items in the last section of the course were listed with stars. Therefore, we do not recommend a change.

There was a suggestion to change the number of lectures allocated to the different sections of the course. However, this suggestion has been incorporated already into this year's version of the schedules. In particular, no further change is recommended here.

Finally, it was noted that Birkhoff's theorem provides a good example of how Einstein's equations are solved, and we agree that it should continue to be lectured. However, its proof is rather long. In particular, there is agreement that it would be very difficult to set reasonable exam questions on the proof. Therefore, we **recommend** that the fourth paragraph of the schedule be changed to 'Birkhoff's theorem *with proof*'.

# 2 IB Linear Algebra

We received several suggestions from Dr Wadsley, the current lecturer, to modify the schedules.

There was a proposal to change the order of the material, moving the lectures on dual spaces before the lectures on determinant and trace. While we could see the conceptional merit to reordering the lectures in this way, we also could find a counter-argument in favour of the current ordering – to explore linear maps systematically before introducing bilinear maps inherent in the notion of dual space. Since lecturers have the freedom to order the material to suit their tastes, we do not recommend a change.

It was suggested to remove the phrase 'over $\mathbb{R}$ or $\mathbb{C}$' from the first paragraph of the schedule. Since the term 'field' is not defined in any IA course, this suggestion would necessitate adding it, for instance, to Numbers & Sets. Upon consultation with Prof Thomason, we agree that fields do not fit in naturally to any existing IA schedules. Furthermore, while we certainly appreciate the mathematical reasons why one want to define vector spaces over general fields, we agree that the gain in mathematical elegance is outweighed by the likely

possibility of alienating students uncomfortable with too much abstraction. Furthermore, vector spaces over $\mathbb{R}$ and $\mathbb{C}$ feature in many branches of both pure and applied mathematics, so they are worth studying for their own sake. Indeed, those students who are more comfortable with abstraction will see that such vector spaces are special cases of a more general structure, and we encourage the lecturer to simply remind the class in an informal way that many results have analogues over any fields, not just $\mathbb{R}$ and $\mathbb{C}$. In particular, we do not recommend making this proposed change.

It was noted that the definition of the determinant as a particular multilinear form appears before the definition of bilinear forms. However, since the schedule does not include a systematic study of multilinear forms, we agree that this apparent anomaly is harmless and do not recommend a change.

Finally, since quotient groups are covered in IA, we agree that adding 'quotient spaces' to the first paragraph is a sensible suggestion. It is an important concept in Linear Algebra, not requiring a great deal of extra time to lecture, and would tie in well with quotient modules in the Group, Rings & Modules course. We therefore **recommend** that 'subspaces' should be amended to 'subspaces and quotient spaces' in the first paragraph of the schedule.

# 3   IIC Statistical Modelling

A thoroughly revised schedule was received by Dr Shah, the current lecturer. The changes reflect the way the course has been lectured recently, and in particular, accounts for the changes to IB Statistics implemented a few years ago.

The revised schedule now also includes 'the delta method'. There was minor concern that this wording might imply that the proof of the delta method is to be lectured and and would be examinable, which is not the intention. However, since the delta method is under the heading 'Overview of basic inferential technique', and the other topics in this section would be review from IB Statistics with the statements recalled without proof, we agreed that the wording of the delta method is not confusing.

We noted that 'Posterior distributions and credible intervals' was omitted from the proposed schedule. We agreed that this topic is important, and should not be omitted from the schedule.

Finally, three more books have been added.

We have consulted Dr Shah, who has produced a new proposed schedule incorporating our suggestions, which is attached to this report. We **recommend** that it be adopted.

The Committee noted that the take up of Statistical Modelling short questions over the past five years is around 6.1%, compared to the overall average of 12.3%, and for long questions 9.5% compared to 15.5%. Since this course is a Part IIC course, and therefore carrying the additional educational burden of providing straight-forward exam questions for diligent students who have learned the bookwork, we are concerned with these relatively low

take up numbers. The course has a large R language component, and we noted that the exam questions based around R code seem to be off-putting to many students. Nevertheless, coding is an important 'transferable skill' - a view endorsed by the Faculty through the CATAM projects in Parts IB and II - so the unpopularity of the coding questions is disappointing. No specific recommendation came of this dicussion, but we encourage interested parties to propose ideas to strengthen this course.

# 4    IID Analysis of Functions

The Curriculum Committee submitted a policy paper during Michaelmas Term 2014 recommending the removal of Part II Partial Differential Equations and the development of a replacement 16 lecture D course on analysis. The Faculty Board accepted the recommendation, and PDEs has been removed from the 2015-16 lecture list, and a Working Party was created to draft to the replacement.

The Working Party produced a draft schedule for discussion during the Curriculum Committee meeting. We were in agreement that the general shape of the course seems appropriate. However, we noted that there is perhaps too much overlap with Part II Probability & Measure in the section on Fourier analysis. Indeed, the student members of the Committee report that Probability & Measure is very popular with those Part II students interested in this area of analysis, so the overlap could be shortened into a review section if Probability & Measure is listed as an essential prerequisite course.

Furthermore, the student members believe that the popularity of the course would be enhanced if it were to include a few applications of the analysis of functions to partial differential equations. It seems possible that these applications, for instance in proving the existence of weak solutions to Poisson's equation, could be added to the final section, provided the section on Fourier analysis is shortened as recommended above.

The Committee has asked the Working Party to consider our recommendations and revise the schedule accordingly. The new proposed schedule should be ready for circulation in time for the Departments staff meetings at the beginning of the Lent term.

# 5    IIC Cosmology

The Committee noted that the take up of Cosmology short questions over the past five years is around 3.9%, compared to the overall average of 12.3%, and for long questions 5.5% compared to 15.5%. We noted that these take up figures are significantly lower than the other Part IIC courses, including Statistical Modelling discussed above. Again, given the special role of C courses, these figures are troubling. (For perspective, the uptake for IID Partial Differential Equations was 2.3% in the last five years of its existence.)

The Committee has asked various interested parties to suggest changes to the Cosmology

schedule. An important aspect of the unpopularity of the course is that it requires a great deal of physical insight which might beyond the range of the typical mathematics student. We note that much of the mathematics of the subject of cosmology already appears in Part IID General Relativity, and hence if the Cosmology schedules were to be revised, excessive overlap with General Relativity should be avoided.

A more drastic proposal, in light of its low exam uptake figures, would be to remove the Cosmology course. However, since this Committee believes that there should be reasonable number of C courses on offer to Part II students, the removal of Cosmology would only be feasible if a replacement C course was available.

Prof Shellard has informed the Committee that the cosmology group will produce a considered proposal soon.

# 6    Part II-C Courses

The Committee notes that the Faculty Board has asked the Working Party on C Courses to find an Applied C course to replace Dynamical Systems (which was reclassified as a D course in 2014).

The Working Party reports that after a broad consultation with the DAMTP staff, two proposals for new C courses have emerged: (1) to reformat the 16 lecture D Integrable Systems into a 24 lecture C course and (2) to create a new C course on Quantum Information Theory. Full schedules for both proposed courses will be drafted in time for the Lent term departmental meetings, with the goal of choosing between the two and having a new course in place for the 2016-17 academic year.

The Committee welcomes this news. While there is some enthusiasm for both proposed courses, we favour the Integrable Systems proposal. First, the logistics in terms of extra lecturing, supervising and examining are simpler for proposal (1) than proposal (2). Second, adding another quantum course to the Tripos (to join IB Quantum Mechanics, II Principles of Quantum Mechanics and II Applications of Quantum Mechanics) would require careful scrutiny to ensure minimal overlap, and might unbalance Part II. Some alternative, as yet unexplored, options for including new material on QIT might be (i) as a possible replacement for Cosmology or (ii) inclusion in one of the existing quantum courses such as AQM.

Does the Board wish to provide a steer at this stage, or should the Committee continue pursuing draft C course Schedules for Cosmology (revised), Integrable Systems (reformatted) and Quantum Information Theory (new)?