HKU Physics Department
Undergraduate Curriculum Reform Consultation Document

18 Oct 2017

Background:

After running the 4-year curriculum for more than five years, we have conducted a summative review on the curriculum. In fact, we spent half a day in our recent Feb 2017 departmental retreat to talk about the issue. The department Curriculum Development and Management Committee (CDMC) then took care of the follow up work. It hosted numerous meetings to discuss the matter and to formulate a draft proposal after taking into account the comments and suggestions from various bodies, including the previous external examiner, Prof. Daniel Stein, undergraduate and postgraduate students and student bodies including the HKU Physics Society and the feedback from course evaluations. The most recent Staff Meeting of the Department on 12 Oct 2017 adopted the reform proposal tabled by the CDMC. The Department would like to consult stakeholders including current undergraduates (including the BSc and BSc&BEd students), postgraduates, alumni and interested persons before submitting our finalized version to the Science Faculty for approval. You are welcome to submit your views to the Department (email: physdept@hku.hk with subject "Curriculum Reform Consultation") by 13 Nov 2017 (Mon). You are also welcome to attend one of our curriculum reform consultation meetings held on 27 Oct 2017 (Fri) from 5:30pm to 6:30pm and 30 Oct 2017 (Mon) from 6:30pm to 7:30pm both in Room 522, Chong Yuet Ming Physics Building to know more about the proposed reform and to express your opinions. You may also contact the chair of the CDMC, Prof. H. F. Chau (email: hfchau@hku.hk), for inquiry about this proposed reform.

Rationale behind the changes and the key proposed changes:

1. To ensure that students have the necessary skill sets in mathematics and computer before taking physics courses that require those skills. In doing so, we avoid the unnecessary overlap of background materials taught in individual physics and astronomy courses. It also makes rooms for more effective teaching of the core physics and/or astronomy subject materials. In fact, this pedagogical model of "learning the skill sets first" has already been adopted in physics departments of major universities including U of Chicago, Oxford, Stanford, and UCLA.
2. To strike a balance between using labs as a place to deepen understanding of physics concepts (verifying physics theories) and training physics lab skills, we propose to keep the introductory level (1st or 2nd year levels) labs in individual courses for deepening the understanding of physics concepts. At the same time, two new 3rd year level labs (Physics Laboratory, and Astronomy Laboratory) will be introduced to train students the necessary lab techniques. In particular, 3rd year level Classical Mechanics, Electromagnetism, Statistical Mechanics & Thermodynamics, Quantum Mechanics, and Observational Astronomy will no longer have lab component. They may have class demonstrations though. Actually, this is essentially the model adopted by U of Chicago.
3. Currently, a physics major has to take all the following four 3rd year level courses --- Classical Mechanics, Electromagnetism, Statistical Mechanics & Thermodynamics and Quantum Mechanics. To increase flexibility, we propose to allow a physics major to take four of the following six 3rd year level courses --- Classical Mechanics, Electromagnetism, Statistical Mechanics & Thermodynamics, Quantum Mechanics, Physics Laboratory, and Theoretical Physics.
4. To provide more focused course choices for those who wanted to dig deep into certain areas in physics and to give them a proper recognition of their great effort, we propose the following

four themes for physics major students --- Astrophysics, Computational Physics, Experimental Physics, and Theoretical Physics. Each theme requires a major to take at least three advanced level (3rd or 4th year levels) courses plus an internship or directed study, or final year project in the relevant physics area.

5. With the cancellation of the astronomy major, we propose to reconstruct and consolidate our astronomy minor. In particular, we propose to offer a new 2nd year level Modern Astronomy and a new 3rd year level Astronomy Laboratory. At the same time, because of our "teach the skill sets first" approach, several advanced level courses will be consolidated without affecting the subject materials we used to cover. In particular, we propose to combine the current Physical Universe and Principles in Astronomy into a new Astrophysics course, and to combine the current Stellar Physics and Special Topics In Astrophysics into a new Advanced Astrophysics course.
6. To provide more computational physics training to students, we propose to strengthen the computational skill component in the 2nd year level courses Methods In Physics I, and Methods In Physics II. In addition, we will introduce a new 3rd year level course Machine Learning In Physics and re-introduce the 4th year level course Data Analysis & Modeling In Physics. Machine Learning In Physics, and Data Analysis & Modeling In Physics will also be two of the elective courses for the Computational Physics Theme.

Timeline of implementation:

We propose to implement the change starting the first semester of the academic year 2018-2019 in four phases. With a few exceptions, all proposed changes in 1st year level courses will be implemented in 2018-2019, 2nd year level courses in 2019-2020 and so on. In order to do, we need to have all the new course syllabi and related materials ready for the approval of the Science Faculty by early 2018.

Proposed changes in detail:

Terminologies plus university and faculty requirements ---

Courses are divided into different levels. 1000 level courses build on knowledge of certain pre-university courses. 2000 level courses build on knowledge of certain 1000 level courses, and so on. 1000 and 2000 level courses are collectively known as introductory level courses. 3000 and 4000 level courses are collectively known as advanced level courses. High flyers may even take challenging 7000 (graduate) level courses, too.

Among other things, the University and Faculty requirements state that a student can fulfill a major by taking 16 courses from a list of core (compulsory) and elective courses. Surely, he/she can take more than 16 courses from the list by his/her own choice. Out of the 16 courses, 2 are faculty-wide 1000 level compulsory courses, and 1 is a capstone course (such as final year project) taken in their second semester of the third year of study the earliest. In addition, at least 8 of them (including the capstone course) have to be advanced level courses. As for the minor, the University and Faculty regulations demand that one should take at least 6 courses from a list of cores and elective courses out of which at least 3 have to be advanced level ones. Our proposed curriculum changes comply with these requirements. In addition, the Faculty does not allow certain major-minor combinations for pedagogical reason. In our case, one is not allowed to major in physics and minor in physics at the same time; but one can major in physics and minor in astronomy.

The following is a list of course abbreviations we use in this document.

AdvAp = Advanced Astrophysics (4000 level)
AEM = Advanced Electromagnetism (4000 level)

Ap = Astrophysics (3000 level)
AQM = Advanced Quantum Mechanics (4000 level)
AstroLab = Astronomy Lab (3000 level)
AtomNucl = Atomic & Nuclear Physics (3000 level)
CM = Classical Mechanics (3000 level)
CompPhys = Computational Physics (4000 level)
Cosmo = Cosmology (4000 level)
DAMP = Data Analysis & Modeling In Physics (4000 level)
DS = Directed Studies In Physics (3000 level)
EM = Electromagnetism (3000 level)
FundPhys = Fundamental Physics (1000 level)
FYP = Physics Project (4000 level)
GEM = Graduate Electromagnetism (7000 level)
GQM = Graduate Quantum Mechanics (7000 level)
GR = General Relativity (4000 level)
GSM = Graduate Statistical Mechanics (7000 level)
Intern = Physics Internship (4000 level)
ISM = Interstellar Medium (4000 level)
IEM = Introductory Electricity & Magnetism (2000 level)
IHT = Introductory Heat & Thermodynamics (2000 level)
IMech = Introductory Mechanics (2000 level)
IQP = Introductory Quantum Physics (2000 level)
Laser = Laser & Spectroscopy (3000 level)
ML = Machine Learning In Physics (3000 level)
ModAstro = Modern Astronomy (2000 level)
MP1 = Methods In Physics I (2000 level)
MP2 = Methods In Physics II (2000 level)
NU = Nature Of The Universe (1000 level)
OA = Observational Astronomy (3000 level)
PartPhys = Particle Physics (4000 level)
PhysLab = Physics Laboratory (3000 level)
PhysOpt = Physical Optics (3000 level)
PlanetSci = Planetary Science (4000 level)
PS = Problem Solving In Physics (1000 level)
QM = Quantum Mechanics (3000 level)
SolidState = Solid State Physics (4000 level)
SR = Introductory Relativity (2000 level)
StatMech = Statistical Mechanics & Thermodynamics (3000 level)
TheoPhys = Theoretical Physics (3000 level)

Current physics major curriculum –

All current courses plus major and minor curricula of the Department can be found in the website http://www.phys.hku.hk/students/course-information.

1000 level: The two faculty-wide science foundation courses
Fundamental Physics[4]
Problem Solving In Physics
2000 level: Introductory Mechanics

Introductory Electricity & Magnetism
Heat & Waves[2]
Modern Physics[6]
3000 level: Classical Mechanics
Electromagnetism
Statistical Mechanics & Thermodynamics
Quantum Mechanics
3000+ level: Any three 3000+ level physics courses
One capstone course in the form of Physics Internship, Directed Studies In Physics, or Physics Project

Proposed new physics major and course taking sequence --
1000 level: The two faculty-wide science foundation courses
Problem Solving In Physics (PS)[1,13]
2000 level: Introductory Mechanics (IMech)[1,2,3,7,8]
Introductory Electricity & Magnetism (IEM)[1,8]
Introductory Heat & Thermodynamics (IHT)[1,2,5,8]
Introductory Quantum Physics (IQP)[1,6,8]
Methods In Physics I (MP1)[1,10,13]
3000 level: Any four from the following six
Classical Mechanics (CM)[1,7,8]
Electromagnetism (EM)[1,2,8,10]
Statistical Mechanics & Thermodynamics (StatMech)[1,5,8]
Quantum Mechanics (QM)[1,8,10]
Physics Laboratory (PhysLab)[8]
Theoretical Physics (TheoPhys)[1]
3000+ level: Any three additional 3000+ level physics courses
A capstone experience course in the form of Physics Internship (Intern), Directed Studies In Physics (DS), or Physics Project (FYP)[14]

Highlights:

1. PS, and MP1 are skill set courses. IMech, IEM, IHT, IQP, and MP1 require PS as pre-requisite. CM, EM, StatMech, QM, and TheoPhys require MP1 as pre-requisite.
2. We propose to change the Heat And Wave course to IHT. The physics of waves will be absorbed in IMech (for material waves), EM (for EM waves and boundary condition matching for wave propagation from one medium to another), and another optional 3000 level course Physical Optics (PhysOpt), which is a re-designed new course based on the current Waves & Optics course.
3. We propose to drop fluid mechanics in IMech. Some fluid mechanics will be covered in the 1000 level selective course Weather, Climate & Climate Change.
4. Fundamental Physics (PhysFund) is no longer a required course for the major. It will be a required course for physics minor. It will continue to give an overview of mechanics, thermodynamics, electromagnetism and a little bit of modern physics to beginners.
5. IHT, and StatMech will be re-organized to cover most of the thermodynamics and statistical mechanics topics taught in the current Heat & Waves, Statistical Mechanics & Thermodynamics, and Advanced Statistical Mechanics courses. Consequently, the 4000 level Advanced Statistical Mechanics course will be phased out.
6. IQP is basically the same as the current Modern Physics course. The name change is just to make the course names more coherent and logical.

7. With more time to focus on the physics rather than the required skill, IMech, and CM will be re-organized to cover most of the topics originally taught in the current Introductory Mechanics, Classical Mechanics, and Advanced Classical Mechanics. Consequently, the 4000 level Advanced Classical Mechanics will be phased out.
8. PhysLab, the course to build up laboratory skills, requires any two of CM, EM, StatMech, and QM as co-requisite. Lab component will be taken out from CM, EM, StatMech, and QM. Lab component in FundPhys, IMech, IHT, IEM, and IQP will stay as the main goal of labs in the introductory level courses is for verification of theories taught in class.
9. The suggested logical course taking sequence is PS -> IMech, IEM, IHT, IQP, MP1 -> any four from (CM, EM, StatMech, QM) -> any three additional 3000+ level physics courses, one capstone course.
10. The 2000 level elective course Methods In Physics II (MP2) will cover additional skill set topics. Those planning to take EM, Advanced Electromagnetism (AEM), and Advanced Quantum Mechanics (AQM) will find this course useful. In addition, computer labs will be added to MP1 and MP2.
11. We propose to change the 3000 level elective course Waves & Optics to PhysOpt, which better reflects our currently teaching in the course. More advanced topics in waves such as diffraction will be covered in this course.
12. We plan to offer a new 3000 level elective course Machine Learning In Physics (ML) to talk about the latest usage of machine learning techniques in solving physics and astronomy problems. Similarly, we plan to re-offer the 4000 level elective course Data Analysis & Modeling In Physics (DAMP) to allow students to learn more up-to-date data analysis and computational modeling techniques used in solving physics problems.
13. Occasionally, students may acquire knowledge in PS before entering HKU. They may take Methods In Physics II (MP2) as replacement. Very occasionally, students may further acquire knowledge in MP1 before entering HKU. They may take Introductory Relativity (SR) as replacement.
14. See "Naming of capstone course" below for the reason why we propose such a change as one of the options.

Proposed Astrophysics Theme in Physics Major ---

One has to follow the physics major curriculum out of which at least three from the following 3000+ level astronomy/astrophysics elective courses (with at least one of them must be 4000+ level) have to be taken: the 3000 level Observational Astronomy (OA), Astrophysics (Ap)[15], and Astronomy Laboratory (AstroLab), as well as the 4000 level Advanced Astrophysics (AdvAp)[15], Cosmology (Cosmo), Planetary Science (PlanetSci), General Relativity (GR), and Interstellar Medium (ISM). In addition, the capstone course one has taken must be related to astrophysics. This theme Is to recognize the hard work of those who have taken enough number of astrophysics related advanced level courses.

An example of physics/astronomy courses taken by a physics major with astrophysics theme are: PS, IMech, IHT, IEM, IQP, MP1, CM, QM, EM, TheoPhys, OA, Ap, Cosmology, DS.

Highlight:

15. Ap is the consolidation of the two existing 3000 level courses Physical Universe and Principles In Astronomy. AdvAp is the consolidation of the two existing 4000 level courses Stellar Physics and Selected Topics In Astrophysics. These are possible partly because of our "teach the skill sets first" strategy.

Proposed Computational Physics Theme in Physics Major ---

One has to follow the physics major curriculum out of which at least three from the following 3000+ level computational physics related elective courses (with at least one of them must be 4000+ level) have to be taken: the 3000 level TheoPhys and ML as well as the 4000 level DAMP, and Computational Physics (CompPhys). In addition, the capstone course one has taken must be related to computational physics. This theme is to recognize the hard work of those who have taken enough number of computational physics related advanced level courses.

An example of physics courses taken by a physics major with computational physics theme are: PS, IMech, IHT, IEM, IQP, MP1, CM, StatMech, QM, TheoPhys, CompPhys, DAMP, AQM, DS.

Proposed Experimental Physics Theme in Physics Major ---

One has to follow the physics major curriculum out of which PhysLab plus at least two from the following 3000+ level experimental physics related elective courses (with at least one of them must be 4000+ level) have to be taken: the 3000 level AstroLab, Laser & Spectroscopy (Laser), PhysOpt, and Atomic & Nuclear Physics (AtomNucl)[16] as well as the 4000 level Particle Physics (PartPhys)[16], DAMP, and Solid State Physics (SolidState). In addition, the capstone course one has taken must be related to experimental physics. This theme is to recognize the hard work of those who have taken enough number of experimental physics related advanced level courses.

An example of physics courses taken by a physics major with experimental physics theme are: PS, IMech, IHT, IEM, IQP, MP1, CM, StatMech, QM, PhysLab, Laser, AtomNucl, PartPhys, DS.

Hightlight:

16. Course contents of AtomNucl, PartPhys will be changed to allow a more balanced coverage of both the experimental and theoretical aspects of the subjects.

Proposed Theoretical Physics Theme in Physics Major ---

One has to follow the physics major curriculum out of which at least four from the following 3000+ level theoretical physics related elective courses (with at least two of them must be 4000+ level) have to be taken: the 3000 level TheoPhys, CM, EM, StatMech, and QM, plus the 4000 level AEM, AQM, SolidState, and PartPhys, as well as the 7000 level Graduate Quantum Mechanics (GQM), Graduate Electromagnetism (GEM), and Graduate Statistics Mechanics (GSM). In addition, the capstone course one has taken must be related to theoretical physics. This theme is to recognize the hard work of those who have taken enough number of theoretical physics related advanced level courses.

An example of physics courses taken by a physics major with theoretical physics theme are: PS, IMech, IHT, IEM, IQP, MP1, CM, EM, StatMech, QM, TheoPhys, AEM, AQM, DS.

Naming Of Capstone Courses ---

We have two proposals. The first is to keep the names of the current capstone courses, namely, Intern, DS, and FYP. However, to better reflect what a student has done, an alternative proposal is to divide DS and FYP capstone courses into four mutually exclusive courses according to the theme, namely, Directed Studies In Astrophysics, Directed Studies In Computational Physics, and so on. The Intern course name will stay to allow flexibility. The advantage of this proposal is better recognition and reflection of what a student has done. The disadvantages are the creation of lots of “courses” in the course selection manual plus the extra administrative works. We would like to hear your opinions on this issue.

Current physics minor curriculum ---
1000 level: Fundamental Physics
2000 level: Introductory Mechanics
Modern Physics
3000+ level: Any four physics courses from this level

Proposed new physics minor curriculum ---
1000 level: FundPhys
1000-2000 levels: Any three from SP, MP1, MP2, IMech, IEM, IHT, IQP, and SR
3000+ level: Any three physics courses from this level

That is, our proposed change add flexibility to the curriculum.

Current astronomy minor curriculum ---
1000 level: Fundamental Physics
Nature Of The Universe
2000 level: Modern Physics
3000+ level: Any four physics courses from this level

Proposed new astronomy minor curriculum ---
1000 level: Nature Of The Universe (NU)
2000 level: Modern Astronomy (ModAstro)
1000-2000 levels: Any one from FundPhys, SR[18] and Planetary Geology[17]
3000 level: OA
3000+ level: Any two from AstroLab, Ap, AdvAp, GR, Cosmo, and ISM

In making these changes, we hope that more students from different Faculties can do this minor.
Highlights:

17. Planetary Geology is a course offered by the Earth Science Department.
18. SR is the same course as the current Introduction To Relativity. The proposed name change simply wants to make course titles more consistent in each level.
19. The goal of the astronomy minor is to allow students to have a reasonable exposure in astronomy, in particular, on the observational and astronomical aspects of the subject.

Highlights of some of the elective courses to be offered or consolidated ---
1000 level:

FundPhys --- it will becomes an overview course in physics for minor as well as for students who wanted to get a taste of physics or required an overview background in physics for their study in another area.

2000 level:

ModAstro --- It is a newly designed course for astronomy minor. It focuses on more up-to-date development in modern astronomy such as gravitational wave detection, cosmology and extra-solar planets.

MP2 --- It will provide the supplementary skill sets in programming and mathematics for courses like EM, QM and ML.

3000 level:

Ap --- It will be the course by consolidating materials in Physical Universe and Principles Of Astronomy, both of which will be phased out after the launch of Ap.

AstroLab and PhysLab --- These two new courses will focus on developing students the necessary lab skills.

PhysOpt --- It is the renamed course from the current Waves & Optics to better reflect what is currently taught. Moreover, it will incorporate some of the wave teachings such as a more detailed theory of diffraction of light here.

AtomNucl --- This course will change to provide a more balanced coverage of both the theoretical and experimental aspects of the subject.

ML --- A new course for introducing the usage of this cutting edge technique in physics and astronomy.

4000 level:

DAMP --- It will be re-launched to strengthen the computational physics and modeling skills of students.

Advanced Classical Mechanics and Advanced Statistical Mechanics --- They will be phased out. Most of the materials will be absorbed in CM and StatMech. We could do so because our "learn the skill sets first" approach minimizes repetitions. Indeed, IMech, CM, ACM, StatMech and Advanced Statistical Mechanics are the courses that we keep on receiving comments of having too much overlapping of materials.

AdvAp --- This new course is the result of consolidation of the Stellar Physics and Special Topics In Astrophysics courses, both of them will be phased out after the launch of AdvAp.

PartPhys --- This course will change to provide a more balanced coverage of both the theoretical and experimental aspects of the subject.

Graduate level:

The following graduate level courses are still available for bright undergraduates to take as electives: GQM, GEM and GSM.

We remark that the Physics Department also offer a few servicing, inter-faculty elective and common core courses. They are not listed here as they are not affected by this proposed curriculum reform.

Double counting ---

There are a few courses listed under the curricula of both major in physics and minor in astronomy. No double counting of these courses is allowed. In fact, we have enough elective courses at all levels for students to choose in order to fulfill the physics major plus astronomy minor.

An example of physics/astronomy courses taken by a physics major plus astronomy minor are: PS, NU, IMech, IHT, IEM, IQP, MP1, ModAstro, SR, CM, EM, StatMech, QM, OA, AstroLab, Ap, GR, AEM, Cosmo, Intern.

A student interested in astronomy and astrophysics can do a major in physics in the astrophysics theme plus a minor in astronomy. An example of courses he/she taken are: PS, NU, IMech, IHT, IEM, IQP, MP1, ModAstro, SR, CM, EM, QM, PhysLab, OA, AstroLab, Ap, AdvAp, GR, ISM, DS.

For very hard working students who wanted to do physics major with two themes, the same logic applies. So again, there is no double counting. There is a special arrangement for the capstone course though. It is unrealistic for a student to do two capstone courses, each for one theme. We, therefore, propose to

allow them to replace one of the capstone course in a theme by another regular course in the same theme or to use FYP, which is a year-long course weighted as two courses to fulfill capstone requirement of both themes.

An example of physics courses taken by a physics major with double themes in computational and theoretical physics are: PS, IMech, IHT, IEM, IQP, MP1, MP2, EM, StatMech, QM, TheoPhys, ML, CompPhys, DAMP, AQM, FYP in computational physics

Similarly, an example of physics courses taken by a physics major with double themes in astrophysics and experimental physics are: PS, IMech, IHT, IEM, IQP, MP1, CM, EM, QM, PhysLab, OA, AstroLab, Ap, PhysOpt, AdvAp, DAMP, DS in experimental physics. In any case, doing a double theme is very demanding indeed.

Prof H F Chau
Chair of the CDMC

And

Prof M H Xie
Head of Physics Department