Programme Specification for
MSc in Advanced Computational Methods in Aeronautics, Flow management and Fluid-Structure Interaction

This specification provides a concise summary of the main features of the programme and the learning outcomes that a typical student might reasonably be expected to achieve and demonstrate if he/she takes full advantage of the learning opportunities that are provided. This specification provides a source of information for students and prospective students seeking an understanding of the nature of the programme and may be used by the College for review purposes and sent to external examiners. More detailed information on the learning outcomes, content and teaching, learning and assessment methods can be found in the course handbook online at: https://workspace.imperial.ac.uk/aeronautics/Public/Postgraduate%20(MSc)%20Programmes/MSc%20Advanced%20Computational%20Methods%20Programme%20Handbook%202015-16.pdf The accuracy of the information contained in this document is reviewed by the College and may be checked by the Quality Assurance Agency.

1. Awarding Institution: Imperial College London
2. Teaching Institution: Imperial College London
3. External Accreditation by Professional / Statutory Body: The Royal Aeronautical Society
4. Name of Final Award (BEng / BSc / MEng, MSc, MRes etc.): MSc
5. Programme Title (e.g. Biochemistry with Management): MSc in Advanced Computational Methods in Aeronautics, Flow management and Fluid-Structure Interaction
6. Date of production / revision of this programme specification: October 2015
7. Name of Home Department: Aeronautics
8. Name of Home Faculty: Engineering
9. UCAS Code (or other coding system if relevant): H1U6 (Full-Time); H1U624 (2 Years Part-Time)
10. Relevant QAA Subject Benchmarking Group(s) and/or other external/internal reference points: Engineering
11. Level(s) of programme within the Framework for Higher Education Qualifications (FHEQ) http://www.qaa.ac.uk/Publications/InformationAndGuidance/Pages/quality-code-A1.aspx

| Master’s (MSc, MRes, MBA, PG Diploma, PG Certificate etc.) | Level 7 |

Last updated July 2013.SJB
13. **Language of Study:** English

14. **Educational aims/objectives of the programme**

The programme aims/objectives are to:

- To provide a high level, one-year (if full time) taught course in aspects of aeronautical engineering with strong application also to non-aeronautical disciplines
- To attract academically talented and motivated students from home and overseas
- To offer a course with strong aerodynamics, computational fluid dynamics (CFD), structural analysis, control and flight mechanics. An important element is the combination of aerodynamics and structural analysis, that is aeroelasticity and fluid-structure interactions and flow management
- To graduate students with fundamental understanding of the course material and the ability to apply it to practical problems
- To ensure that students understand how to solve complex problems numerically, rather than simply using 'black box' commercial codes. Students have career opportunities in many areas, but we would hope that students are sufficiently well informed that they could write, rather than just use, commercial packages
- To support the theory and computing by simple experiments
- To ensure that not only do we provide enhanced engineering training but that we also encourage and provide opportunity for conversion to an advanced engineering discipline for graduates in mathematics and physics.

15. **Programme Learning Outcomes**

1. **Knowledge and Understanding**

**Knowledge and Understanding of:**

- The fundamental concepts and physical principles underlying CFD and structural analysis
- Mathematics underpinning the engineering and computational methods
- Numerical analysis, programming and computational methods

2. **Skills and other Attributes**

**Intellectual Skills**

- Understanding advanced analytical concepts
- Programming and identifying solution strategies
- Communicating work through course work submission and project reports
- Plan, conduct and report on a programme of original research

**Practical Skills**

- Data analysis for random processes
- Ability to write programs in a standard language

**Transferable Skills**

- Communicate effectively through report writing and data presentation
- Present results of individual research project in a lecture to staff and students
- Learn how to work effectively at an advanced level, to show independence and to manage time

In addition to the training embedded in the programme, the Graduate School runs a Professional Skills Development programme for Master’s level students. The programme,
consisting of the “MasterClass” workshops and e-learning modules, aims to help students develop the skills needed both in their academic studies and in obtaining and progressing in their future careers. The Careers Advisory Service also provides training and support for students on career options, job seeking and interviews.

16. The following reference points were used in creating this programme specification Student Handbook and information on the website:
http://www.imperial.ac.uk/engineering/departments/aeronautics/study/pg/advanced-computational-methods/

17. Programme structure and features, curriculum units (modules), ECTS assignment and award requirements Note that all the following courses are optional. Students select course combinations – with guidance from the Course Director. 25 units of examinable material are available but it would be an exceptionally talented student who could complete each of these (lectures, coursework, examinations). Each course is worth 1 or 2 units (corresponding to 10 or 20 lectures) and students are advised that the award requirements are: pass 12 units of courses at 50%, plus 50% minimum in the project, to gain an overall pass; 60% in 12 units of courses plus minimum of 60% in the project for a merit; achieve an average of 70% in 19 units of examinations and 70%+ in the project for a distinction.
10 lectures of courses is usually supported by 2 tutorials; 20 lectures by 3 or 4.
Where courses are examined by both exam/coursework the weighting is 70/30 respectively.

Autumn Term:

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Hours</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEM-ADV01 Introduction to Fluid Dynamics</td>
<td>10</td>
<td>non-examined</td>
</tr>
<tr>
<td>AEM-ADV02 Introduction to Programming</td>
<td>10</td>
<td>non-examined</td>
</tr>
<tr>
<td>AEM-ADV03 Introductory Mathematics</td>
<td>10</td>
<td>non-examined</td>
</tr>
<tr>
<td>AEM-M01 Technical Writing and Presentations</td>
<td>2</td>
<td>non-examined</td>
</tr>
<tr>
<td>AEM-CM02 Revision Stress Analysis</td>
<td>4</td>
<td>non-examined</td>
</tr>
<tr>
<td>AEM-ADV07 Fundamentals of Fluid Mechanics</td>
<td>20</td>
<td>2⁰</td>
</tr>
<tr>
<td>AEM-ADV08 Computational Linear Algebra</td>
<td>10</td>
<td>1⁰</td>
</tr>
<tr>
<td>AEM-ADV10 Compressible Flow</td>
<td>10</td>
<td>1⁰</td>
</tr>
<tr>
<td>AEM-ADV12 Hydrodynamic Stability</td>
<td>10</td>
<td>1⁰</td>
</tr>
<tr>
<td>AE3-401 Advanced Mechanics of Flight</td>
<td>10</td>
<td>1⁰</td>
</tr>
<tr>
<td>AEM-ADV19 Computational Fluid Dynamics</td>
<td>20</td>
<td>2⁰</td>
</tr>
<tr>
<td>AE3-302 Control Systems</td>
<td>10</td>
<td>1⁰</td>
</tr>
<tr>
<td>AAE06 Aircraft Performance and Flight Mechanics</td>
<td>12</td>
<td>1⁰</td>
</tr>
</tbody>
</table>

a  examined by exam only
b  examined by coursework only. This module runs in both Autumn and Spring term and students are required to attend lectures in both terms
c  examined by exam only in the Summer term. This module runs in both Autumn and Spring term and students are required to attend lectures in both terms
d  lectures start in latter half of Autumn term and continues in Spring, examined in Summer term

Exams for Autumn term courses will take place during the first two weeks of the Spring term.

Spring Term:

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Hours</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE3-302 Control Systems</td>
<td>10</td>
<td>1⁰</td>
</tr>
<tr>
<td>AE3-402 Separated Flows &amp; Fluid-Structure Interaction</td>
<td>20</td>
<td>2⁰</td>
</tr>
<tr>
<td>AE3-422 High Performance Computing</td>
<td>20</td>
<td>2⁰</td>
</tr>
<tr>
<td>AEM-ADV08 Computational Linear Algebra</td>
<td>10</td>
<td>1⁰</td>
</tr>
</tbody>
</table>

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AEM-ADV09 Aeroservoelasticity 10 1
AEM-ADV10 Compressible Flow 10 1c
AEM-ADV11 Finite Element Methods 10 1d
AEM-ADV13 Navier Stokes Equations & Turbulence Modelling 20 2
d  examined by coursework only
AEM-ADV15 Structural Dynamics 20 2
AEM-ADV16 An Introduction to Flow Control 20 2
AEM-CM16 Analysis of Laminated Composites 10 1a

a  examined by exam only
b  examined by coursework only. This module runs in both Autumn and Spring term and students are required to attend lectures in both terms
c  examined by exam only in the Summer term. This module runs in both Autumn and Spring term and students are required to attend lectures in both terms.
d  examined by coursework only

Exams for Spring term courses will take place during the first two weeks of the Summer Term

Summer Term:
Exams will take place for Spring term courses during the first two weeks of Summer term. Individual research project (internal and external)

18. Support provided to students to assist learning (including collaborative students, where appropriate).

- Tutorials associated with lecture course
- Extensive networked computing facilities allowing student computing classes to be taught at terminals. Ready access generally to computers and to tuition support from computer staff.
- Laboratories appropriate to the experimental programme. Lecture rooms equipped with white board, data projectors
- Library facilities within the college and guidance on online data searches
- Provision of introductory non-examined courses to help bring students to a common level
- Academic guidance provided by the course academic advisor, who monitors student progress, and the project supervisor where appropriate
- Organisation advice provided by the Postgraduate Administrator and Teaching Office
- Pastoral advice provided by the Course Director, plus college tutor system where appropriate
- Advice on disability procedures from the Departmental disability officer plus the college officer
- Ready access to extensive college library facilities, online publications and databases

Departmental/Course Induction Programme:

Induction for MSc students is the first Monday of the academic year and is compulsory for all students. Various timetabled events including:
Registration/Attendance Check
Welcome Talk by Head of Department
Briefing by MSc Course Director
Library Briefing
Computing Briefing
Health and Safety Briefing
Professional Development Briefing

Departmental Facilities:
The main facilities for the Advanced Computational Methods MSc students are the computing facilities. Due to the nature of the course, the computing facilities are the major and most
important resource provided to the students. There are dual-boot (Linux and Windows) PCs in E254 and ROH 265. In addition, MSc students have access to 230 Windows PCs shared with the Civil and Mechanical Engineering Departments. These computers are used for coursework, project and general use.

Available software includes PTC CREO 3.0, Abaqus, Electric Circuits, Intel Fortran compiler, Maple, Matlab, Microsoft Visual Studio, MStar CD, StarCCM+, and CES (both with unlimited and includes the complete set of all toolboxes, funded through contribution to the Faculty), Enthought Python, FEniCs, SU2 (CFD), Gmsh, Inksape, Incompact3d, MiKTeX, Notepad++, OpenMPI, Octave, OpenFoam, ParaView, PuTTY, VisIt, g95, gfortran, LaTeX, Enthought Python, FEniCs, SU2 (CFD), Gmsh, Inksape, Incompact3d, MiKTeX, Notepad++, OpenMPI, Octave, OpenFoam, ParaView, PuTTY, VisIt, g95, gfortran, LaTeX, OpenFOAM, Xming and Xfoil. The renewal plan for software to support project and experimental work includes annual licences for packages including Labview and Tecplot 360.

A small number of individual projects are experimental in nature. For such projects the Department's experimental facilities are available, with a budget of £200 and 70 hours of technician time.

**Departmental/Course Feedback Policy:**
Strict deadlines are provided to teaching staff as to when feedback and marks should be provided for each examination or assessment. These marks and feedback are then uploaded to Blackboard so that the students can access them. Students are informed immediately after this upload has taken place via an email or Blackboard announcement. The Postgraduate Administrator aims to ensure that all marks and feedback are provided to students within 3-4 weeks.

If there are any issues with the amount or quality of feedback then the two student representatives are able to discuss these concerns with the Director of Studies at the Student-Staff Committee meetings. These issues are then addressed by the Director of Studies by talking to staff responsible for the assessment and, if necessary, arranging further marking.

**Welfare and Pastoral Care:**
College student welfare services are the responsibility of the Director of Student Affairs who manages the Head of the Student Counselling Service, the Senior Disability Officer, the College Tutors and the Hall Wardens. The Director of Student Affairs acts as liaison between the College and the College Health Centre (NHS) and the Chaplaincy and works closely with the ICU Deputy President (Welfare) to enhance welfare, advice and support.

Departmental support comes in the form of:
- A Teaching Office which provides basic advice and administration for students, including a full-time Postgraduate (MSc) Administrator
- A Course Director and Deputy Course Director
- Two Student Representatives for the MSc programme who meet with the Course
Director, Deputy Course Director, Health and Safety Officer, IT Officer and other key staff every term to discuss any issues the students may be having. These items are then actioned by the Director of Post-Graduate Studies and the support staff. Students can request additional meetings at any time.

The Library
There are libraries at all Imperial College campuses; with print collections, PCs, study space and other amenities. The Library has extensive electronic resources, including electronic databases, electronic books and full text electronic journals. Students are able to search for electronic resources, using the on-line library catalogue and web pages, and access them from anywhere on and off campus.

Centre for Academic English (CfAE)
The Centre for Academic English (CfAE) offers classes, the majority of which are free of charge, to students and members of Imperial College London who are not native speakers of English.

19. Criteria for Admission
First Class or upper 2.1 (rare exceptions may be made depending upon other experience) or the equivalent for overseas (advice from Registry) in Engineering (Aeronautical, Mechanical, sometimes Civil, Chemical Engineering depending upon first degree modules taken) or in Mathematics and Physics.

20. Processes used to Select Students
- Academic standard (including guidance from Registry in interpreting overseas grades) and CV data from application form
- 2 academic references
- Interview where possible

21. Methods for Evaluating and Improving the Quality and Standards of Teaching and Learning

a) Methods for review and evaluation of teaching, learning, assessment, the curriculum and outcome standards:

The external examiner system and Boards of Examiners are central to the process by which the College monitors the reliability and validity of its assessment procedures and academic standards. Boards of Examiners comment on the assessment procedures within the College and may suggest improvements for action by relevant departmental teaching Committees.

At programme level, the Head of Department has overall responsibility for academic standards and the quality of the educational experience delivered within the department.

The Faculty Studies Committees and the Graduate School Master’s Quality Committees review and consider the reports of external examiners and accrediting bodies and conduct internal routine reviews of programmes. The Quality Assurance and Enhancement Committee conducts external periodic reviews at departmental level. Regular reviews ensure that there is opportunity to highlight examples of good practice and ensure that recommendations for improvement can be made.

Most of the College’s undergraduate programmes are accredited by professional engineering and science bodies or by the General Medical Council. Accreditation provides the College with additional assurance that its programmes are of an appropriate standard and relevant to the requirement of industry and the professions. Some postgraduate taught courses are also accredited.

Last updated August 2015
b) **Committees with responsibility for monitoring and evaluating quality and standards:**

The **Senate** oversees the quality assurance and regulation of degrees offered by the College. It is charged with promoting the academic work of the College, both in teaching and research, and with regulating and supervising the education and discipline of the students of the College. It has responsibility for approval of changes to the Academic Regulations, major changes to degree programmes and approval of new programmes.

The **Quality Assurance and Enhancement Committee** (QAEC) is the main forum for discussion of QA policy and the regulation of degree programmes at College level. The QAEC develops and advises the Senate on the implementation of College policies and procedures relating to quality assurance, enhancement and internal audit of quality and arrangements necessary to ensure compliance with national and international frameworks and codes of practice relating to academic standards, quality assurance and enhancement.

The **Faculty Studies Committees** and the **Graduate School Master’s Quality Committees** are the major vehicle for the quality assurance of undergraduate / Master’s level courses respectively. Their remit includes: setting the standards and framework, and overseeing the processes of quality assurance, for the areas within their remit; monitoring the provision and quality of e-learning; undertaking reviews of new and existing courses; noting minor changes in existing programme curricula approved by departments; approving new modules, changes in module titles, major changes in examination structure and programme specifications for existing programmes; and reviewing proposals for new programmes, and the discontinuation of existing programmes, and making recommendations to Senate as appropriate.

The **Faculty Teaching Committees** maintain and develop teaching strategies and promote inter-departmental and inter-faculty teaching activities to enhance the efficiency of teaching within Faculties. They also identify and disseminate examples of good practice in teaching.

**Departmental Teaching Committees** have responsibility for the day-to-day oversight of a department’s programmes including the approval of minor changes to course curricula and examination structures and approval of arrangements for course work.

c) **Mechanisms for providing prompt feedback to students on their performance in course work and examinations and processes for monitoring that these named processes are effective:**

- Examinations are held in first two weeks of the Spring and Summer terms. For the Spring examinations course lecturers are asked to return marks within 6 weeks. We do not provide exact marks to students but indicate PASS or FAIL on our Virtual Learning Environment (VLE) Blackboard Learn student system for them (to enable them to select their Summer term examinations). Students are given guidance on an individual basis if required following release of these results by the academic course organisers, especially if these result have an impact on their Spring term course selections. We are conscious at the MSc level, where students have not had the ‘long history’ of a student completing the degree year of an undergraduate degree course, that this form of feedback is of considerable importance. No results are issued to students following the Summer term examinations.

  - Some courses are assessed fully by course work or exam only; in others a minimum of 30% of marks comes from course work assignments. All submissions are via Blackboard Learn and all feedback/marks to be returned to students within 4-6 weeks again via Blackboard Learn.

  - The academic course organisers are always available for discussion with individual students on their performance.

Last updated August 2015
d) Mechanisms for gaining student feedback on the quality of teaching and their learning experience and how students are provided with feedback as to actions taken as a result of their comments:

Students are invited to participate in surveys so that student feedback on the College and its courses can be obtained and used to enhance provision. External surveys in which students participate include:

- Postgraduate Taught Experience Survey (PTES)

Internal surveys include:
- PG SOLE (Master’s student online evaluation exercise)

Staff-Student committees are the primary arenas for staff-student engagement at a departmental level. Staff-student committees are run slightly differently according to the size and UG:PG ratio of the department. Most departments have separate committees for undergraduates and postgraduates. A range of issues are discussed from SOLE and PG SOLE reports, external examiner reports and curriculum changes to practical issues, such as the availability of computers and pastoral care. Staff-Student Committees elect a Chair each year, which could be either a member of staff or a student. If the Chair is a member of staff, the Deputy Chair should be a student, and vice versa. The Chair will liaise with the department and students to agree an agenda for the meeting in advance.

Students are invited to make an appointment, individually, if they wish to do so, to see the academic course organiser. They have been told that they are free to approach the Head of Department if they prefer to do so.

e) Mechanisms for monitoring the effectiveness of the personal tutoring system:

The academic course directors act as personal tutors to all students. Regular meetings are not scheduled but it is made clear to the students that he is available for consultation. The course directors are not monitored by a higher authority but students can again approach the Head of Department if they prefer to do so.

f) Mechanisms for recognising and rewarding excellence in teaching, research supervision, pastoral care and supporting the student experience:

Staff are encouraged to reflect on their teaching, in order to introduce enhancements and develop innovative teaching methods. Each year College awards are presented to academic staff for outstanding contributions to teaching, pastoral care, supporting the student experience or research supervision. A special award for Teaching Innovation, available each year, is presented to a member of staff who has demonstrated an original and innovative approach to teaching. Nominations for these awards come from across the College and students are invited both to nominate staff and to sit on the deciding panels.

g) Staff development priorities for this programme include:
- Staff to consider other developing other lecture course modules, recognising growing new areas, possibly with overlap with final year undergraduate courses
• Endeavour to increase the number of external/industrial project placements since these are regarded as highly attractive by MSc students

22. Regulation of Assessment

a) Assessment Rules and Degree Classification:

For Master's programmes:
The Pass Mark for Master's level programmes is 50%.

Examiners have the discretion to award a result of merit or distinction to candidates who have fulfilled the requirements for the award of the Master's degree as specified in the Examination Regulations. Postgraduate Diplomas and Postgraduate Certificates are unclassified and are pass/fail only.

In order to be awarded a result of merit, a candidate must achieve at least 60 per cent in each element; in order to be awarded a result of distinction, a candidate must achieve at least 70 per cent in each element.

Where appropriate, a Board of Examiners may award a result of merit where a candidate has achieved an aggregate mark of 60% or greater across the programme as a whole AND has obtained a mark of 60% or greater in each element with the exception of one element AND has obtained a mark of 50% or greater in this latter element.

Where appropriate, a Board of Examiners may award a result of distinction where a candidate has achieved an aggregate mark of 70% or greater across the programme as a whole AND has obtained a mark of 70% or greater in each element with the exception of one element AND has obtained a mark of 60% or greater in this latter element.

Further information is available in the Academic and Examination Regulations

The Pass Mark for the individual taught lecture courses and the project is 50%. Students must pass 12 units of courses and the project, to gain an overall pass; they must achieve 60% in 12 units of courses plus a minimum of 60% in the project for a merit; they must achieve an average of 70% in 19 units of examinations and 70%+ in the project for a distinction.

b) Processes for dealing with mitigating circumstances:

The College's Extenuating Circumstances Affecting Academic Performance: Policy and Procedures makes provision for Boards of Examiners to use their discretion where extenuating circumstances are independently corroborated and are judged by the advisory panel to be of sufficient severity to have substantially affected performance.

c) Processes for determining degree classification for borderline candidates:

For undergraduate programmes: Candidates who fall no more than 2.5% below the minimum mark for a higher honours classification shall be eligible for review of their final classification; this review could include an oral examination or practical test or other mechanism appropriate to the discipline. Candidates whose marks are below the 2.5% borderline may be considered for a higher honours classification where certain provisions apply. Where the Board of Examiners determines that a candidate should be awarded a higher honours classification extra marks should be applied to bring their final marks into the

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higher range. Detailed records of all decisions should be recorded in the minutes of the meeting of the Board.

For **Master's programmes**: Candidates should only be considered for promotion to pass, merit or distinction if their aggregate mark is within 2.5% of the relevant borderline. Nevertheless, candidates whom the Board deems to have exceptional circumstances may be considered for promotion even if their aggregate mark is more than 2.5% from the borderline. In such cases the necessary extra marks should be credited to bring the candidate's aggregate mark into the higher range. Detailed records of all decisions should be recorded in the minutes of the meeting of the Board.

d) Role of external examiners

The external examiner system and Boards of Examiners are central to the process by which the College monitors the reliability and validity of its assessment procedures and academic standards. External examiners’ primary duties are to ensure that the standard of the College’s degrees is consistent with that of the national sector; to ensure that assessment processes measure student achievement rigorously and fairly and that the College is maintaining the threshold academic standards set for its awards in accordance with the frameworks for higher education qualifications and applicable subject benchmarks statements. External examiners gather evidence to support their judgement through the review of course materials, approval of draft question papers, assessment of examination scripts, projects and coursework, and in some instances, through participation in viva voce and clinical examinations. External examiners are members of Boards of Examiners and participate in the determination of degree classifications and student progress.

External examiners submit their reports to the Provost. The reports are scrutinised by the Vice- Provost (Education) and by the Registry QA team to identify any points of concern. These are then referred to the Head of Department and Chairman of the Board of Examiners, with a request to comment on the points raised and to explain how any concerns will be addressed. The reports and departmental comments are subsequently considered by the relevant Faculty Studies Committee or Graduate School Master’s Quality Committees, which may seek further assurances from a department on the resolution of a particular problem. The Committees will also consider examples of good practice raised by the external examiners. Following consideration of the reports, the Registry provides feedback to external examiners. From 2012-13 external examiner reports, and the departmental responses to them, are available on the College’s intranet.

23. Indicators of Quality and Standards

- The Royal Aeronautical Society Accreditation Report
- External examiners reports
- Although this is not quantifiable, many students apply to us because they have been told by their first-degree tutors that it is a high calibre course
- The calibre and number of student applicants

24. Key sources of information about the programme can be found in

http://www.imperial.ac.uk/engineering/departments/aeronautics/study/pg/ provides online information for applicants together with further information from the Registry web link http://www3.imperial.ac.uk/registry/admissions/howtoapplypg.

Further information for current students (prospective applicants can also view) can be found at http://www.imperial.ac.uk/engineering/departments/aeronautics/study/pg/advanced-computational-methods/

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