ES98B A02/A03 Predictive Modelling Group Project

This briefing covers all submissions for the Predictive Modelling Group project.

Submission Information

General Assignment Information

Module	ES98B Predictive Modelling Group Project	
Assignment	A02: Group Predictive Modelling Project Specification	A03: Predictive Modelling Group Project Portfolio
Assignment Weighting / Credits	40 % (12 CATS)	50 % (15 CATS)
Submission Deadline	Noon, Thursday week 10 (7 December 2023)	Multiple deadlines from Thursday week 33 (16 May 2024)

Intended Learning Outcomes

Intended Learning Outcome(s) (ILOs)	Task / Criterion / Section
LO1: Create a complex piece of predictive modelling research software implementing methods and using software design principles introduced in previous modules in the course, addressing a cross-discipline research computing challenge.	A02: Specify, design and plan the predictive modelling research project. A03: Implement the challenge, creating the code.
LO2: Plan and manage the predictive modelling software project from the specification phase to a deliverable outcome, including documentation.	A02: Create a workplan and task list for the project. A03: Submit documentation with your code.
LO3: Formulate and quantify the uncertainty in the output of the predictive modelling code, thus giving a measure of the reliability of a computed quantity.	A03: Include uncertainty estimates for outputs of your code.
LO4: Demonstrate the ability to work as a member of a team to achieve shared objectives within the scope of the project and monitor and adjust a personal programme of work on an ongoing basis.	A02: Workplan to cover activities for all team members. A02, A03: Work as a group to achieve a successful outcome, distributing tasks and responsibilities.
LO5: Evaluate: regulatory requirements including IPR and codes of practice, industry/sector standards; risk (including health and safety, environmental and commercial); sustainability; ethics, diversity, cultural, societal considerations.	A02: In the workplan, consider risks to the project and mitigation strategies.
LO6: Demonstrate advanced communication and documentation skills, both within the group and for the benefit of a future software user.	A02: Write concise and precise specifications. A03: Present your code and results in a report and a 1-h presentation. A02/A03: Communicate with your team members.

Notes

- A total mark below 40% indicates that the ILOs have not all been met at threshold level;

- A total mark in the range 40 – 48% indicates that the ILOs have all been partially met to at least threshold level;
- A total mark of at least 50% indicates that the ILOs have all been met.

Submission Details

A02: Group Predictive Modelling Project Specification

The submission details for assignment are:

- **Deadline:** 7 December 2023, 12 noon.
- **Method:** Group submission on Moodle. Additional Individual Peer Assessment on Moodle.
- **Format of submission:** PDF document.
- **Submission length:** Maximal 10 pages. You will lose **5 marks** per extra page over the limit.
- **Formatting instructions:** Use a minimum 11-point Calibri (or equivalent) font for the text, with 1.5 line spacing and 25 mm margins all round.

A03: Predictive Modelling Group Project Portfolio

The portfolio consists of the following parts: Report, code (including tutorial and documentation), presentation, individual contribution statement, peer assessment.

	REPORT	CODE	PRESENTATION	ICS/PA
DEADLINE	Thu week 33, 16 May 2024		Week 34 TBC	Thu week 35, 30 May 2024
METHOD	Group submission on Moodle		Presentation (submit slides)	Individual submission on Moodle
FORMAT	PDF document	ZIP archive	PDF/PPTX	PDF document, Peer assessment
LENGTH	10 pages	N/A	40 minutes, 10 minutes Q&A	500 words
FORMATTING	As A02	N/A	N/A	As A02
ASSESSOR		Other supervisors		Your supervisor

A 5-mark penalty will be applied for every 10 % excess length (page limit or word count)

Note: Submissions should be of an appropriate file size and students are responsible for ensuring that work is uploaded successfully before the deadline. If there are technical issues when submitting online, please contact the Engineering Student Office (eng.eso@warwick.ac.uk).

Guidance and Referencing Style

It is serious Academic Misconduct to pass off the work of others (including peers or AI-based chatbots such as ChatGPT) as your own and you should not permit other teams to copy from you. Sources must be appropriately and properly acknowledged every time reference is made to another's work, using the Harvard or Numeric Referencing system. Failure to do so amounts to plagiarism which breaches university regulations and falls short of the Academic Integrity expected in the department and

university. The use of Artificial Intelligence is permitted in this assignment, following the University's guidance*, as long as its use is acknowledged, and the mode of its use is documented.

Assignment Feedback

A02: Students will receive written group feedback on their Project Specification Submission, with a particular view towards improving the documents to successfully implement the program for A03. They will also receive anonymised peer feedback.
A03: Students will receive written group feedback on report, code (including documentation and tutorial) and presentation. Students will receive individual feedback on the individual contribution statements. Students will also receive peer feedback.

The Project

The task is to predict where a de-orbiting satellite will hit the surface of the earth.

The situation

A satellite is orbiting earth with a decaying orbit. Around its perigee, its orbital motion has started to become affected by atmospheric drag. The satellite is no longer controllable. It is observed by a number of ground-based radar stations, which can get periodic fixes on its position. Aerodynamic drag will cause the satellite to slow down until it impacts the ground. For obvious reasons it would be interesting to know where this will happen.

The task

Create a simulation of the orbital decay of a satellite around earth. This will consist of two parts. The predictor assimilates measurement data from the radar stations, and thus updates the predictions on the final landing site. As there is no radar data publicly available, you will also create a simulator that produces the measurement data you feed into your landing site predictor.

The knowns and unknowns

Here we have to distinguish between the predictor and the simulator. For the simulator you will have to assume mass, size, shape of the satellite and initial orbital parameters, and use those to simulate its position in space. The predictor will not "know" these, but infer some information from prior assumptions and the incoming measurements. The simulator will generate noisy measurement data to feed to predictor.

Assumptions

This project can be made arbitrarily complicated by including more and more effects. However, it may be useful to step back and start from a greatly simplified picture: Assume that the surface of the earth is a straight, horizontal line. The forces acting on the satellite are gravity (pointing downwards, and of the magnitude $\frac{Gm_s m_E}{r^2}$, where G is the gravitational constant, m_s and m_E are masses of satellite and earth, and r is the distance of the satellite from the "centre" of the earth, one earth radius below its straight and horizontal surface) and atmospheric drag (pointing opposite the velocity relative to the atmosphere, and of magnitude $\frac{1}{2}\rho v^2 C_d A$, where ρ is the density of the atmosphere, v is the velocity of the satellite, C_d its drag coefficient and A its cross-section). The radar data in this case could just be a noisy measurement of position of the satellite, obtained periodically and with appropriate measurement noise. The atmospheric density depends on height and can be estimated from the barometric formula. For your simulator, you can make reasonable assumptions about the parameters and initial conditions; your predictor should obtain them from its priors and update them from measurements.

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* cf. https://warwick.ac.uk/services/aro/dar/quality/az/acintegrity/framework/artificial-intelligence/

In the next step, you could move to a spherical, rotating earth and an equatorial orbit (which is still a two-dimensional problem). At this point, you could then replace the measurement of position with a more realistic radar measurement of distance from the radar station and altitude (in degrees/radians), taking into account that these measurements have an angular resolution and a radial resolution (and a limited visibility – satellites with negative altitudes cannot be observed). Initially you may assume your radar posts spaced equidistantly around the equator. You will also need to account for earth's rotation – the atmosphere will rotate with it.
You can then introduce an almost limitless amount of model refinements:

- Non-equatorial orbits.
- Improved atmospheric models (e.g., US standard atmosphere, NRLMSIS, …).
- Specific locations for radar stations.
- Non-spherical earth.
- Tumbling satellite.
- ...

In general, you may want to make your simulator more sophisticated than the predictor (thus making the generated measurement data more realistic than the internal model of the predictor). This would give the predictor a chance to handle model error.

Baseline

The baseline model for this project is for a satellite de-orbiting from an equatorial orbit, observed by base stations located on the equator, using constant parameters for mass, drag coefficient and cross-sectional area and a simple barometric atmospheric model.
Your project should deliver at two further features from the model refinements listed above, to discuss with your supervisor.

Bonus Feature

Assume the satellite has one final thrust left (a fixed amount of impulse – units Ns), which can be used in its direction of motion. When would you need to fire it to minimise the probability of landing in a populated area?

A note about coordinate systems

Dependent on the chosen geometry, you want to consider an appropriate coordinate system. For the initial planar 2d geometry, Cartesian coordinates seem appropriate. And while two- and three-dimensional Cartesian coordinates will also work in a way for equatorial and non-equatorial orbits, polar and spherical coordinates feel a bit more natural, with the centre of the earth at the origin. In whichever coordinate system you choose to work, you will need to use coordinate transformations.
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Deliverables

A02: Project Development Plan

A document containing the project specification, design document and workplan. As discussed in the lectures (Unit 4), the specification should list what your tools will be able to do. This will be reasonably brief (1-2 pages). The design document should say how you do it. It should form the basis for your collaborative efforts to deliver the projects: Which parts do you need, how will they interface with the other parts? How do the features relate to functions, what is their input and return values, which format does your data have? The workplan finally should outline how you can implement the project in term 3. Who is doing what (and when), what are the main risks, and what do you do to mitigate this? A table linking features and marks is appended to this document. A list of references is not required, but you can (and should) use footnotes and hyperlinks to provide further information. Formatting requirements: 11 pt font size, 2.5 cm margins all around, 1.5 line spacing.

A02: Peer assessment

Peer assessment for the Project Specification phase is due 24 hours after the submission deadline of the A02 assignment. You will assign a score between 0 and 5 to your peers and provide a brief justification for your score.

A03: Report

This technical report should take the format of a journal article, describing background, theory, features of your program and include results with their uncertainties as well as a conclusion. It should be fully referenced. Appendices are not permitted, and everything must be included within the 10-page limit. A formatting guideline is found below with the marking scheme.

A03: Code, Documentation, Tutorial

Your code, including documentation and a tutorial. This should allow your assessors to install and run your code, explain the meanings of parameters and how to set them. It should also provide a way to run an example calculation. Please submit this as an archive.

A03: Presentation

The presentation itself should be timed to last 40 +/- 5 minutes and leave 10 minutes for questions from the audience. It is expected that all group members share in delivering the presentation, as far as the technology allows this. The presentation should focus on the software package developed and results that demonstrate achieving the set criteria in context, i.e., providing motivation and some background. The presentation should be pitched at recent graduates in the field (e.g., the next cohort of PMSC students). After the presentation, please upload your slides to Moodle by 5pm on the same day.

A03: Individual Contribution Statement

The individual contribution statement should outline your contributions to the group and include a reflection on the outcome of the project: What went well, what could have been improved, which lessons were learnt. 500 words maximal length. Formatting requirements: 11 pt font size, 2.5 cm margins all around, 1.5 line spacing.

A03: Peer assessment

As at the end of term 2, you will provide a peer assessment, assigning a score between 0 and 5 to your peers. This will be used to modify the collective marks of the A03 submission (report, code, presentation).

ES98B A02 Project Development Plan

The Project Development Plan (PDP) consists of the Software Specification, Design Document and Work Plan. Suggested page lengths are 1–2 pages for the Software Specification and up to 4 pages each for the Design Document and Work Plan. There is a 10-page limit, and conciseness is a positive feature (cf. references to clarity in the level descriptors below). The group mark will be modified based on peer feedback. It is worth 40% of the module credit (12 CATS) and will be assessed on the following scale:

Mark	Generic Level Descriptors	Specific Level Descriptors
100 92 84	(High Distinction) Work which, over and above possessing the qualities of the 70-79% descriptor, demonstrates excellence – the nature of which will vary according to the assignment but may include: comprehensive answers, complete and correct proofs or calculations, project work that extends the original brief, deep and critical analysis, originality, and advance in scholarship, a highly professional approach.	In addition to fulfilling the Distinction requirements, the specification is complete to a professional standard, and could form the basis of a software development contract. The design document could allow external developers to develop features for the project.
78 75 72	(Distinction) The work demonstrates mastery of the subject matter, methodologies, and, where appropriate, laboratory techniques. It also provides evidence of near complete conceptual understanding, high level technical competence, and depth of analysis or mathematical understanding. Where applicable, the statement and proof of theorems is handled with confidence, and their application to unseen material is sound. Accuracy and precision will be strong throughout and, if applicable, presentation will be excellent. Minor mistakes may nevertheless appear occasionally. Where appropriate, the work shows evidence of originality.	The specification gives the requirements of the software to be implemented, provides a logical overview of the desired program structure and shows how the various parts are going to interact. The design document facilitates project collaboration by allowing to separate the implementation into individual tasks. The work plan clearly lists all tasks and their dependencies. Presentation is to a high standard.
68 65 62	(MSc Pass) The work demonstrates a sound and thorough grasp of subject matter and methodologies. Conceptual or mathematical understanding and technical competence are solid, but applications, arguments, or data analysis may contain minor flaws. Examined work will be well organised and structured, while good presentation and a logical approach to the material will be evident in projects or dissertations. Overall, the work reveals a high level of effort and commitment, but lacks breadth, depth, and fluency in parts.	The specification provides a reasonably complete description of the requirements of the software project. The design covers almost all of the tasks required by the specification, with only minor inconsistencies and ambiguities. The work plan lists most of the tasks required.
58 55	(MSc Pass) The work reveals an underlying grasp of the subject matter, but with areas of confusion or	Submission provides the software specification with some gaps and

52	some gaps in conceptual/mathematical understanding or methodology. Answers are fairly well structured but may tend towards the factual or derivative. In project or dissertation work, general conclusions or outcomes are reasonable, but there is room for substantial improvement in the individual's ability to apply theorems, analyse problems or execute technical skills.	occasional unclarities. Software design covers most of the tasks but may have some inconsistencies and/or may not cover the entirety of the requirements. Work plan gives a rough idea of implementation tasks.
48 45 42	(Fail) Though it reveals some familiarity with the subject matter, and a basic grasp of factual and conceptual material, there are frequent and important gaps and/or misconceptions. Some effort has been made to reflect on and analyse questions or problems, or to apply theorems, but with little evidence of organisation or insight. Technical competence is poorly developed and general conclusions are unreliable or unsubstantiated.	Submission shows some evidence of attempting to align the specification with the project requirements, but falls short of providing a coherent specification. Some software design information is present, but does not provide information on how a specification could be implemented.
38 32 25	(Fail) The work is insufficient to demonstrate a basic grasp either of factual or conceptual subject matter. Technical competence is at a very low level and, if appropriate, laboratory work has required constant supervision. Data used in project work may be both inaccurate and irrelevant. Overall, answers and arguments reveal little effort towards analysis or conceptualisation. Important issues may have been ignored or seriously misconstrued. There is little evidence of an individual contribution to the material.	Insufficient requirements or highly unaligned to overall project requirements with regards to functionality and software capability. Design document severely lacking, and insufficient to form the basis of collaborative software development.
12 0	(Fail) Inadequate work: poorly argued, written and presented; conceptual confusion throughout; demonstrates little or no knowledge of the field. Failure to address the issues raised by the question. Project work contains little or no data. Sparse or no evidence for technical competence or individual contributions.	No requirements discernible from submitted documents. No designs provided on software structure.

ES98B A03 Report

The report has the format of a journal article describing the tool, its background, and results, discussion and conclusion. It is fully referenced. A list of the formatting requirements is given below. There is a 10-page limit. It is worth 15% of the module credit (4.5 CATS) and will be assessed on the following scale:

Mark	Generic Level Descriptors	Specific Level Descriptors
100 92 84	(High Distinction) Work which, over and above possessing the qualities of the 70-79% descriptor, demonstrates excellence – the nature of which will vary according to the assignment but may include: comprehensive answers, complete and correct proofs or calculations, project work that extends the original brief, deep and critical analysis, originality, and advance in scholarship, a highly professional approach.	In addition to fulfilling the Distinction requirements, the report is composed to a publishable standard, presented attractively. Graphics used are at a professional standard. The uncertainty quantification is using current approaches. The conclusions demonstrate an excellent level of insight. Referencing is flawless.
78 75 72	(Distinction) The work demonstrates mastery of the subject matter, methodologies, and, where appropriate, laboratory techniques. It also provides evidence of near complete conceptual understanding, high level technical competence, and depth of analysis or mathematical understanding. Where applicable, the statement and proof of theorems is handled with confidence, and their application to unseen material is sound. Accuracy and precision will be strong throughout and, if applicable, presentation will be excellent. Minor mistakes may nevertheless appear occasionally. Where appropriate, the work shows evidence of originality.	The report gives a very good overview over the project. The background and methods are clearly described and well referenced. Results are presented convincingly, with their uncertainties. Their interpretation in the discussion section is thorough, and they support the conclusions drawn. The report has a clear narrative. Graphics are used effectively to visualise the outcomes. Referencing is complete. All formatting and content requirements are fulfilled.
68 65 62	(MSc Pass) The work demonstrates a sound and thorough grasp of subject matter and methodologies. Conceptual or mathematical understanding and technical competence are solid, but applications, arguments, or data analysis may contain minor flaws. Examined work will be well organised and structured, while good presentation and a logical approach to the material will be evident in projects or dissertations. Overall, the work reveals a high level of effort and commitment, but lacks breadth, depth, and fluency in parts.	The report covers all required aspects adequately and in reasonably clear fashion. Results are presented well and are used to support the conclusions drawn. The results are presented with their uncertainties. The report has a clear narrative with only minor inconsistencies. Language and presentation are good. Graphics are used to support the discussion. The referencing is good, drawing on a diverse selection of references. The report follows the formatting guidelines provided.
58 55	(MSc Pass) The work reveals an underlying grasp of the subject matter, but with areas of confusion or	The report provides basic cover of all required aspects, but may have some gaps

52	some gaps in conceptual/mathematical understanding or methodology. Answers are fairly well structured but may tend towards the factual or derivative. In project or dissertation work, general conclusions or outcomes are reasonable, but there is room for substantial improvement in the individual's ability to apply theorems, analyse problems or execute technical skills.	and/or lack clarity in description. There are results present, but the discussion and conclusion may lack depth and/or insight. Uncertainty quantification is present. References are adequate, with some limited gaps in coverage and/or formatting issues. The language and presentation are adequate and largely adhere to the style requirements.
48 45 42	(Fail) Though it reveals some familiarity with the subject matter, and a basic grasp of factual and conceptual material, there are frequent and important gaps and/or misconceptions. Some effort has been made to reflect on and analyse questions or problems, or to apply theorems, but with little evidence of organisation or insight. Technical competence is poorly developed and general conclusions are unreliable or unsubstantiated.	Report shows some evidence of attempting to cover all aspects required of this work, but falls short of providing a coherent description, with significant gaps in one or more components. Uncertainty quantification falls short of expectations. References exist, but have gaps in coverage, missing core pieces. Language and presentation are not quite as expected, with limited violations of the style requirements.
38 32 25	(Fail) The work is insufficient to demonstrate a basic grasp either of factual or conceptual subject matter. Technical competence is at a very low level and, if appropriate, laboratory work has required constant supervision. Data used in project work may be both inaccurate and irrelevant. Overall, answers and arguments reveal little effort towards analysis or conceptualisation. Important issues may have been ignored or seriously misconstrued. There is little evidence of an individual contribution to the material.	Report with insufficient information about the project, its background and/or results obtained with it. No quantification of the uncertainty. Unjustified conclusions. Insufficient references, with significant gaps. Language and presentation fall short of expectation, with significant violations of the style requirements.
12 0	(Fail) Inadequate work: poorly argued, written and presented; conceptual confusion throughout; demonstrates little or no knowledge of the field. Failure to address the issues raised by the question. Project work contains little or no data. Sparse or no evidence for technical competence or individual contributions.	Non-existent submission. Limited information about background, theory, methods, results and conclusions. Inadequate referencing, no or only a few references.

Appendix A: Requirements for the Paper

The following is based on typical requirements for an academic paper. (All academic journals are however slightly different and require the author to follow the guidelines meticulously).

- **No separate title page. Front information should include:**
  - The name(s) of the author(s)
  - A concise and informative title

  Abstract

Please provide an abstract of 150 to 250 words. The abstract should not contain any undefined abbreviations or unspecified references.

Keywords

Please provide 4 to 6 keywords which can be used for indexing purposes.

Text Formatting

Single column of text
Submission must be in PDF format.
Page size A4
Maximum length 10 pages; includes references.
Font: Calibri (or similar) 11pt
Text Line Spacing 1.5 lines.
Margins: Top 2.5cm, bottom 2.5cm, left 2.5cm, right 2.5cm
All references to be included as the final section of the report.

Headings

Please use the decimal system of headings with no more than three levels.

Abbreviations

Abbreviations should be defined at first mention and used consistently thereafter.

Footnotes

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.
Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data).
Footnotes to the title or the authors of the article are not given reference symbols.
Always use footnotes instead of endnotes.

Acknowledgments

Acknowledgments of people, grants, funds, etc. should be placed in a separate section on the title page. The names of funding organizations should be written in full.

Scientific Style

Please always use internationally accepted signs and symbols for units (SI units).
Please use the standard mathematical notation for formulae, symbols etc.:
Italic for single letters that denote mathematical constants, variables, and unknown quantities
Roman/upright for most units, numerals, operators, and punctuation, and commonly defined functions or abbreviations, e.g., cos, det, e or exp, lim, log, max, min, sin, tan, d (for derivative)
Bold for vectors, tensors, and matrices.

References

Reference citations in the text should be identified by numbers in square brackets. Some examples:

1. Negotiation research spans many disciplines [3].
2. This result was later contradicted by Becker and Seligman [5].
3. This effect has been widely studied [1-3, 7].

Reference list

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and

unpublished works should only be mentioned in the text. Do not use footnotes or endnotes as a substitute for a reference list.

The entries in the list should be numbered consecutively.

Tables

All tables are to be numbered using Arabic numerals.

Tables should always be cited in text in consecutive numerical order.

For each table, please supply a table caption (title) explaining the components of the table.

Identify any previously published material by giving the original source in the form of a reference at the end of the table caption.

Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data) and included beneath the table body.

Figure Lettering

To add lettering to figures, it is best to use Helvetica or Arial (sans serif fonts).

Keep lettering consistently sized throughout your final-sized artwork, usually about 2–3 mm (8–12 pt.).

Variance of type size within an illustration should be minimal, e.g., do not use 8-pt type on an axis and 20-pt type for the axis label.

Avoid effects such as shading, outline letters, etc.

Do not include titles or captions within your illustrations.

Figure Numbering

All figures are to be numbered using Arabic numerals.

Figures should always be cited in text in consecutive numerical order.

Figure parts should be denoted by lowercase letters (a, b, c, etc.).

Figure Captions

Each figure should have a concise caption describing accurately what the figure depicts.

Figure captions begin with the term Fig. in bold type, followed by the figure number, also in bold type.

No punctuation is to be included after the number, nor is any punctuation to be placed at the end of the caption.

Identify all elements found in the figure in the figure caption; and use boxes, circles, etc., as coordinate points in graphs.

Identify previously published material by giving the original source in the form of a reference citation at the end of the figure caption.

Figure Placement and Size

Figures should be submitted in the text where they should appear.

ES98B A03 Code Submission

The PX915 Code submission (15 % of module credit = 4.5 CATS) consists of three components: Documentation, Software Usage Tutorial, The three parts will be assessed separately on a 20-point scale as below, with the final mark resulting from an average of the three components. The level descriptors for the three components are given in the table below.

Mark	Generic Level Descriptors	Specific Level Descriptors: Documentation	Specific Level Descriptors: Tutorial	Specific Level Descriptors: Code
100 92 84	(High Distinction) Work which, over and above possessing the qualities of the 70-79% descriptor, demonstrates excellence – the nature of which will vary according to the assignment but may include: comprehensive answers, complete and correct proofs or calculations, project work that extends the original brief, deep and critical analysis, originality, and advance in scholarship, a highly professional approach.	In addition to fulfilling the Distinction requirements, the documentation is written to a professional standard, and provides significant added value to users and developers. Information is easy to locate. The documentation would almost allow to write simulations (for users) or new functionality (for programmers) on its own.	In addition to fulfilling the Distinction requirements, the tutorial is written to a professional standard, and extremely valuable to new users. It makes creative use of interactive features in presentation of results. The tutorial works flawlessly, and provides feedback if used incorrectly.	In addition to fulfilling the Distinction requirements, the performance of the code is excellent, making excellent use of available resources, and no bugs are evident. The code provides good feedback on operator errors.
78 75 72	(Distinction) The work demonstrates mastery of the subject matter, methodologies, and, where appropriate, laboratory techniques. It also provides evidence of near complete conceptual understanding, high level technical competence, and depth of analysis or mathematical understanding. Where applicable, the statement and proof of theorems is handled with confidence, and their application to unseen material is sound. Accuracy and precision will be strong	User-facing documentation covers all aspects of user interaction with the code and provides comprehensive and consistent documentation of all aspects on how to influence the simulations the code performs. Limitations of the code are set out, as are some recommendations on effective code usage (e.g. performance tuning). Developer-facing documentation sets out the standards so that new functionality	Tutorial provides a comprehensive and insightful walkthrough for the main functionality of the software. It provides a complete use case from setup to analysis of results. Tutorials at this level are interactive, i.e. react to user input and encourage the user to explore e.g. the effect of changing a parameter. The	Code can be obtained and deployed comfortably, with dependencies fulfilled automatically. The code completely covers the requirements set out in the Software Design. The code calculates quantities of interest making good use of the available resources and with only minor evident bugs. Operator errors are

	throughout and, if applicable, presentation will be excellent. Minor mistakes may nevertheless appear occasionally. Where appropriate, the work shows evidence of originality.	can be integrated into the existing code base, and gives clear instructions on how to perform this integration.	interactive segments run without issues.	mostly handled gracefully, providing useful error messages.
68 65 62	(MSc Pass) The work demonstrates a sound and thorough grasp of subject matter and methodologies. Conceptual or mathematical understanding and technical competence are solid, but applications, arguments, or data analysis may contain minor flaws. Examined work will be well organised and structured, while good presentation and a logical approach to the material will be evident in projects or dissertations. Overall, the work reveals a high level of effort and commitment, but lacks breadth, depth, and fluency in parts.	User-facing documentation is comprehensive, with only minor gaps. It is generally instructive and helpful. The documentation is mostly factually correct and consistent with the actual code. Developer documentation gives significant information on variable and functions used, with a particular view to facilitate introduction of new functionality.	Tutorial provides a competent walkthrough for the main features, with only minor gaps of coverage. Tutorial useful to new users, e.g. by highlighting key parameters. Interactive segments run with only minor issues and allow the user to explore e.g. a parameter range.	Code can be obtained and deployed with only minor issues, and dependencies are highlighted. The code covers almost all functionality required and can obtain results using a mostly reasonable use of resources. Code contains some error handling.
58 55 52	(MSc Pass) The work reveals an underlying grasp of the subject matter, but with areas of confusion or some gaps in conceptual/mathematical understanding or methodology. Answers are fairly well structured but may tend towards the factual or derivative. In project or dissertation work, general conclusions or outcomes are reasonable, but there is room for substantial improvement in the individual's ability to apply theorems, analyse problems or execute technical skills.	User-facing documentation largely covers the main functionality of the code. A significant share of the options and parameters accessible to the user are explained, and documentation and actual code are frequently consistent. Developer-facing documentation may give rough pointers on how to extend code, and basic information on function and variables used in the code.	Tutorial provides a basic walkthrough for the main features of the software, with limited gaps of functionality. Tutorial of some use to new users. Interactive segments mostly run, with maybe some issues in their execution.	Code can be downloaded and installed/setup with rare major issues. Code fulfils a significant share of the functionality set out in the design document and can be used to calculate the desired quantities. Deployment facilities are basic, but functional.
48 45	(Fail) Though it reveals some familiarity with the subject matter, and a basic grasp of	Rudimentary user-facing documentation is present. There are	Very basic tutorial, with considerable gaps. Interactive	Code exists and can be downloaded. Basic deployment

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38 32 25	(Fail) The work is insufficient to demonstrate a basic grasp either of factual or conceptual subject matter. Technical competence is at a very low level and, if appropriate, laboratory work has required constant supervision. Data used in project work may be both inaccurate and irrelevant. Overall, answers and arguments reveal little effort towards analysis or conceptualisation. Important issues may have been ignored or seriously misconstrued. There is little evidence of an individual contribution to the material.	Insufficient documentation. Overall usage of software remains unclear. Functionality is very sparsely documented. Documentation is disjointed. Developer documentation fails to facilitate modifications to the code.	Insufficient tutorial. May exist, but gives no or very limited insight in using the code.	Some code exists, but does not run nor compile, if applicable. No deployment facility, limited setup information.
12 0	(Fail) Inadequate work: poorly argued, written and presented; conceptual confusion throughout; demonstrates little or no knowledge of the field. Failure to address the issues raised by the question. Project work contains little or no data. Sparse or no evidence for technical competence or individual contributions.	No documentation discernible.	Tutorial non-existent	Code does not exist or cannot be obtained.

ES98B A03 Presentation

The ES98B Presentation should be a scientific presentation presenting the code and results obtained with it. It counts for (10% = 3 CATS) of the Module credit. It will be assessed on a 20-point scale as below, where level descriptors covering content, slides, narration and response to questions are given.

The presentation should be timed to last 40 +/- 5 minutes, and leave 10 minutes for questions from the audience. It is expected that all group members share in delivering the presentation, as far as the technology allows this. The presentation should focus on the software package developed and results that demonstrate achieving the set criteria in context, i.e. providing motivation and some background. It should also cover performance considerations and, if available, comparisons to pre-existing results.

The presentation should be pitched at an audience of recent graduates who might consider studying for an MSc in Predictive Modelling and Scientific Computing, i.e. from a diverse background in physical sciences, mathematics and engineering. Basic familiarity with simulation methods can be assumed.

Mark	Generic Level Descriptors	Specific Level Descriptors
100 92 84	(High Distinction) Work which, over and above possessing the qualities of the 70-79% descriptor, demonstrates excellence – the nature of which will vary according to the assignment but may include: comprehensive answers, complete and correct proofs or calculations, project work that extends the original brief, deep and critical analysis, originality, and advance in scholarship, a highly professional approach.	In addition to fulfilling the Distinction requirements, the excellent presentation has a flawless narrative arch and provides novel and original insights into the processes described and their result. The code is shown to fulfil all set tasks. Slides are spotless, consistent and coherent. Narration is engaging, pitched at the correct level and (excluding technical issues) always comprehensible. Questions are addressed comprehensively demonstrating excellent familiarity with the subject matter.
78 75 72	(Distinction) The work demonstrates mastery of the subject matter, methodologies, and, where appropriate, laboratory techniques. It also provides evidence of near complete conceptual understanding, high level technical competence, and depth of analysis or mathematical understanding. Where applicable, the statement and proof of theorems is handled with confidence, and their application to unseen material is sound. Accuracy and precision will be strong throughout and, if applicable, presentation will be excellent. Minor mistakes may nevertheless appear occasionally. Where appropriate, the work shows evidence of originality.	The presentation is very good, and has a coherent narrative from background and motivation, over implementation and results obtained to quantitative comparisons with other codes and published numeric results, with only minor gaps and flaws. The code is shown to fulfil almost all of the set tasks. The level of the presentation is mostly adequate for the target audience. The very good slides support the narrative, provide the appropriate amount of information and detail and are of consistent design. The narration is highly competent, and (technical issues excluded) very well understandable. Questions are handled

		very competently and evidence a deep understanding of the subject matter.
68 65 62	(MSc Pass) The work demonstrates a sound and thorough grasp of subject matter and methodologies. Conceptual or mathematical understanding and technical competence are solid, but applications, arguments, or data analysis may contain minor flaws. Examined work will be well organised and structured, while good presentation and a logical approach to the material will be evident in projects or dissertations. Overall, the work reveals a high level of effort and commitment, but lacks breadth, depth, and fluency in parts.	The presentation provides a good overview of the project, both the code and the results obtained with it. This is presented in context, giving motivation and background, and drawing conclusions based upon the information presented, with few gaps. The code is shown to fulfil many of the set tasks. The presentation is generally pitched at the right level. Evidence of quantitative comparison of results and performance with alternative approaches is presented. The slides are good, and communicate information very well. Narration is competent and mostly confident. Questions are addressed competently and evidence a good understanding of the subject matter.
58 55 52	(MSc Pass) The work reveals an underlying grasp of the subject matter, but with areas of confusion or some gaps in conceptual/mathematical understanding or methodology. Answers are fairly well structured but may tend towards the factual or derivative. In project or dissertation work, general conclusions or outcomes are reasonable, but there is room for substantial improvement in the individual's ability to apply theorems, analyse problems or execute technical skills.	The presentation gives some insights into the code and shows some results obtained with it. There may be some gaps in the background, motivation, results and conclusions, but an overall narrative is recognisable. Large parts of the presentation are considerate of the targeted audience. The slides are a reasonable attempt at communicating, and the narration is generally understandable. Questions are answered in a way that shows a reasonable understanding of the subject matter.
48 45 42	(Fail) Though it reveals some familiarity with the subject matter, and a basic grasp of factual and conceptual material, there are frequent and important gaps and/or misconceptions. Some effort has been made to reflect on and analyse questions or problems, or to apply theorems, but with little evidence of organisation or insight. Technical competence is poorly developed and general conclusions are unreliable or unsubstantiated.	Presentation gives some basic insights into the code and rudimentary glimpses of results obtained with it. Information is presented without context, and there are significant gaps in structure. Slides are difficult to read and/or not conducive to comprehension. Narration is halting, and difficult to understand. Simple questions are addressed at a basic level, but responses to more complex questions do not evidence deeper comprehension.
38 32 25	(Fail) The work is insufficient to demonstrate a basic grasp either of factual or conceptual subject matter. Technical competence is at a very low level and, if appropriate, laboratory work has required constant supervision. Data used in project work may be both inaccurate and irrelevant. Overall, answers and arguments reveal little effort towards analysis or conceptualisation. Important issues may have been ignored or seriously misconstrued. There is little	Presentation provides only the most basic information about either code or results obtained. Slides are difficult to read, if at all present. Narration is incoherent, and the flow of the presentation is highly disjointed. Questions are not addressed satisfactorily.

	evidence of an individual contribution to the material.	
12 0	(Fail) Inadequate work: poorly argued, written and presented; conceptual confusion throughout; demonstrates little or no knowledge of the field. Failure to address the issues raised by the question. Project work contains little or no data. Sparse or no evidence for technical competence or individual contributions.	No slides shown. Presentation does not convey any results, nor give information about the code. No answers to questions.

ES98B A03 Individual Contribution Statement

The ES98B Individual contribution statement contains a factual description of your contribution to the project (both to deliverables and to the project management) and a brief critical reflection on the project: what went well, what could have been better, what did you learn. It counts for (10% = 3 CATS) of the Module credit. It will be assessed on a 20-point scale as below. Length: 500 words. 5 marks penalty for every 50 words over the limit. Formatting requirements: 11 pt font size, 2.5 cm margins all around, 1.5 line spacing.

Mark	Generic Level Descriptors	Specific Level Descriptors
100 92 84	(High Distinction) Work which, over and above possessing the qualities of the 70-79% descriptor, demonstrates excellence – the nature of which will vary according to the assignment but may include: comprehensive answers, complete and correct proofs or calculations, project work that extends the original brief, deep and critical analysis, originality, and advance in scholarship, a highly professional approach.	In addition to fulfilling the Distinction requirements, the statement provides an excellent summary of the student's contribution, covering all aspects of the project. The reflections demonstrate an excellent insight into the progress of the project. The lessons learned are further related to the student's career aspirations.
78 75 72	(Distinction) The work demonstrates mastery of the subject matter, methodologies, and, where appropriate, laboratory techniques. It also provides evidence of near complete conceptual understanding, high level technical competence, and depth of analysis or mathematical understanding. Where applicable, the statement and proof of theorems is handled with confidence, and their application to unseen material is sound. Accuracy and precision will be strong throughout and, if applicable, presentation will be excellent. Minor mistakes may nevertheless appear occasionally. Where appropriate, the work shows evidence of originality.	The statement provides a very good description of the student's contribution, with only very minor omissions. The reflections demonstrate a critical engagement with the entire project. The lessons learnt show how the group project will influence future work.
68 65 62	(MSc Pass) The work demonstrates a sound and thorough grasp of subject matter and methodologies. Conceptual or mathematical understanding and technical competence are solid, but applications, arguments, or data analysis may contain minor flaws. Examined work will be well organised and structured, while good presentation and a logical approach to the material will be evident in projects or dissertations. Overall, the work reveals a high level of effort and commitment, but lacks breadth, depth, and fluency in parts.	The statement provides a good overview of the student's contribution, without significant gaps. The reflections show a good level of insight into the progress of the project. The student shows how the experience will influence future work and learning.
58 55 52	(MSc Pass) The work reveals an underlying grasp of the subject matter, but with areas of confusion or some gaps in conceptual/mathematical understanding or methodology. Answers are fairly well structured but may tend towards the factual or derivative. In project or dissertation work, general conclusions or outcomes are reasonable, but there is room for substantial	The statement provides a basic, reasonably complete summary of the students contributions to most aspects of the project. The reflections cover most of the project, but remain largely superficial. There are basic attempts to relate learning to future tasks.

	improvement in the individual's ability to apply theorems, analyse problems or execute technical skills.	
48 45 42	(Fail) Though it reveals some familiarity with the subject matter, and a basic grasp of factual and conceptual material, there are frequent and important gaps and/or misconceptions. Some effort has been made to reflect on and analyse questions or problems, or to apply theorems, but with little evidence of organisation or insight. Technical competence is poorly developed and general conclusions are unreliable or unsubstantiated.	The statement provides some insight into the contributions of the student, but with gaps (e.g., relating to project management or coding). Reflections cover some aspects of the project, but may have significant omissions. There is no discernible effort to relate experience to future work.
38 32 25	(Fail) The work is insufficient to demonstrate a basic grasp either of factual or conceptual subject matter. Technical competence is at a very low level and, if appropriate, laboratory work has required constant supervision. Data used in project work may be both inaccurate and irrelevant. Overall, answers and arguments reveal little effort towards analysis or conceptualisation. Important issues may have been ignored or seriously misconstrued. There is little evidence of an individual contribution to the material.	Submitted statement provides little insight into student's contributions to the group project. The reflections are barely related to the project and/or do not appear to be based in reality.
12 0	(Fail) Inadequate work: poorly argued, written and presented; conceptual confusion throughout; demonstrates little or no knowledge of the field. Failure to address the issues raised by the question. Project work contains little or no data. Sparse or no evidence for technical competence or individual contributions.	No submission, or no description of the student's contributions. No reflection on the group project.