Assignment Guidance and Front Sheet

This front sheet for assignments is designed to contain the brief, the submission instructions, and the actual student submission for any WMG assignment. As a result the sheet is completed by several people over time, and is therefore split up into sections explaining who completes what information and when. Yellow highlighted text indicates examples or further explanation of what is requested, and the highlight and instructions should be removed as you populate ‘your’ section.

**To be completed by the student(s) prior to final submission:**

Your actual submission should be written at the end of this cover sheet file, or attached with the cover sheet at the front if drafted in a separate file, program or application.

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| **Student ID or IDs for group work** | **e.g. 1234567** |

**To be completed (highlighted parts only) by the programme administration after approval and prior to issuing of the assessment; to be consulted by the student(s) so that you know how and when to submit:**

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| **Date set** | March 2025 |
| **Submission date (excluding extensions)** | Monday 31st March 2025 by 12:00pm (UK time) |
| **Submission guidance** | To be submitted electronically via Tabula |
| **Late submission policy** | If work is submitted late, penalties will be applied at the rate of **5 marks per University working day** after the due date, up to a **maximum of 10 working days** late. After this period the mark for the work will be reduced to 0 (which is the maximum penalty). “Late” means **after the submission deadline time as well as the date** – work submitted after the given time even on the same day is counted as 1 day late.  For **Postgraduate** students only, who started their **current course before 1 August 2019**, the daily penalty is **3 marks** rather than 5. |
| **Resubmission policy** | If you fail this assignment or module, please be aware that the University allows students to remedy such failure (within certain limits). Decisions to authorise such resubmissions are made by Exam Boards. Normally these will be issued at specific times of the year, depending on your programme of study. More information can be found from your programme office if you are concerned. |
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**To be completed by the module owner/tutor prior to approval and issuing of the assessment; to be consulted by the student(s) so that you understand the assignment brief, its context within the module, and any specific criteria and advice from the tutor:**

Post Module Assignment Submission form

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| **Module title &code** | WM9M3-15 Advanced Computer Graphics 24/25 |
| **Module owner** | Thomas Bashford-Rogers |
| **Module tutor** | Thomas Bashford-Rogers |
| **Assessment type** | Programming assignment and report |
| **Weighting of mark** | 100% |

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| **Word count** | 3000 words equivalent for the report and code |
| **Module learning outcomes (numbered)** | Have a comprehensive knowledge of physically-based rendering and shading  Reduce complex formulations of physically-based solutions for high performance in interactive environments  Review and critically evaluate state-of-the-art computer graphics research |
| **Learning outcomes assessed in this assessment (numbered)** | 1, 2, 3 will all be assessed in this assessment. |
| **Marking guidelines** | Please see Overview section. |
| **Academic guidance resources** | Reading list, module slides, standards and high-quality research and technical papers |

**The following is pre-populated for PGT assignments only:**

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| **Writing your Post-Module Assignment (PMA): specific additional advice for WMG’s Postgraduate Taught Students** |
| As a postgraduate level student in WMG you may have some concerns about your ability to write at the high standard required. This short guide is intended to provide general guidance and advice. It is important that if you have any questions you discuss them with your module tutor. Remember, in writing your PMA you need to meet the expectations of the reader and university. |
| **A good PMA generally requires you to answer the question and to include**…   1. A title, with your student number, module, lecturer’s name and any other documentation required by the university. 2. A contents page and if appropriate, an abstract. 3. An introduction which acts as a ‘map’ to the rest of the document, describing the aim or purpose of the work and explaining how this aim is achieved. At this point it is usually helpful to paraphrase your conclusion. 4. Evidence of an appropriate level of background reading of relevant texts. 5. Evidence of systematic and clear thinking, indicative of good planning and organisation. 6. Writing which makes sense, is clearly and carefully presented (proof-read and grammar checked). 7. A critical style of writing which compares and contrasts the main theories, concepts and arguments with conclusions that are based in evidence presented. 8. High levels of accurate academic referencing. 9. A logical and well-defined structure with headings and subheadings. 10. Clearly labelled and well-presented diagrams and other graphics that are discussed in the text. 11. Adherence to usual academic standards including length and a timely submission. 12. A reference section in which every source that is cited in the text is listed. |
| **Where to get help:**   1. **Talk to your module tutor if you don’t understand the question or are unsure as to exactly what is required.** 2. The university Academic Writing centre provides workshops and useful tools to help you in all aspects of your work. <https://warwick.ac.uk/services/skills/academicwriting/> 3. Avoiding Plagiarism, the university’s site to help you to reference properly <https://moodle.warwick.ac.uk/course/view.php?id=42224> 4. Wellbeing support services <https://warwick.ac.uk/services/wss> 5. Numerous online courses provided by the University library to help in academic referencing, writing, avoiding plagiarism and a number of other useful resources. <https://warwick.ac.uk/services/library/students/your-library-online/> |

Assignment Brief

This assignment is to develop an implementation of a rendering technique. The program needs to be developed in C++, and the code submitted with a report, details of which are outlined below. An executable should also be submitted.

Please read the entirety of the assignment before attempting any part of it, as thinking about the overall solution from the start will be beneficial for some of the later stages.

Show your code for all parts, even if you do not get the final result. If you cannot provide code, at least explain your reasoning around the problem and how you would solve it. Marks will be given for both code and explanations – more marks will be allocated for proper code that works. If you cannot provide the full functionality at any stage, provide part of it but state which part was provided.

Provide comments in the code – the more readable it is the easier it is to understand and allocate marks. Please include Visual Studio solutions and all the source code, or a link to a GitHub Repository. If you wish to use another compiler and IDE you are permitted to, but please contact the module tutor before you do so, such that arrangements for marking are made in a timely fashion.

Make sure you do not copy any code from the internet or online resources or from any other students. This includes the use of AI to generate code.

Use of the Standard Template Library is permitted and encouraged, although students may wish to write their own data structures for efficiency reasons. You are allowed to use and build upon code we developed in class including any tutor provided solutions.

This assessment will help you re-enforce the learning from the module. You will understand how to implement modern light transport simulation algorithms from the ground up and gain experience of implementing fast simulations which model optical phenomena.

# Implementation (85 Marks)

This section provides details of the type of algorithms which can be implemented as part of this coursework. We developed a path tracer during the in-class sessions, and it is expected that you will build on this to add further functionality. This assessment is split into two parts: one which extends the functionality of the path tracer, and the second which adds other light transport algorithms.

Extending the functionality of the path tracer (35 Marks):

* Add more materials:
  + Add a GGX Microfacet BRDF (Evaluation and sampling proportional to the NDF)
  + Add a Glass BRDF
* Exploit techniques to speed up render times
  + Use multiple threads to perform tile based rendering
  + Implement a tile based adaptive sampler
  + Integrate an existing denoiser into the renderer (Intel Open Image Denoise is recommended, you will need to render AOVs for this)
* Add environment lighting
  + Implement sampling and evaluating environment maps stored in latitude-longitude format
  + Combine with MIS to reduce variance

The second part of the coding assessment is the addition of other light transport or sampling algorithms. Each of these has a weight based on its implementation difficulty and they are grouped by common features and implementation challenge. Please choose one group to implement for this assessment. If you would like to implement an algorithm not on this list, please speak to the module tutor.

The groups are as follows:

* Instant Radiosity (25 Marks)
* Irradiance Cache (25 Marks)

OR

* Instant Radiosity (25 Marks)
* Photon Mapping (25 Marks)

OR

* Instant Radiosity (25 Marks)
* Light Tracing (25 Marks)

OR

* Progressive Photon Mapping (50 Marks)

OR

* Primary Sample Space Metropolis Light Transport (50 Marks)
  + You can integrate with the path tracer, or any other algorithm if this is implemented

# Report (15 marks)

The report should be structured as follows:

* Introduction which introduces what your report will discuss
* A section on each of the extensions to the path tracer you implemented which contains details about how the technique works and how you implemented it. Half of this section should cover theory; half should cover the relevant details about the implementation.
* An overview of the rendering technique you implemented, implementation details (i.e. how you implemented each step of the algorithm), and a comparison in terms of image quality to the path tracer for an equal render time.
* Conclusion which summarizes the report in a single paragraph

Also add to the report a small section on how you would have approached this project differently if you had to start from scratch after this learning experience.

It is highly recommended that you write the report in LaTeX using the template provided. This makes it much easier to typeset mathematics. Overleaf is a good online LaTeX editor and is recommended for this report.

You are expected to include screenshots of the game running and implementations of game systems. For this you can use an application such as the “snipping tool” in Windows to directly paste the results in your document – this is very quick. Windows 10 has a new screen capture facility using Shift+MSkey+S. Similarly, most of the latest versions of Mac OSX permit the use of screen capture via shift-cmd-4 (various numbers provide different functionality).

Do not add the code to the appendix but provide it separately and in a format such that it can be compiled directly (see Section 1).

**Important** :All samples of code shown in the text need to be in text format, **not** a screen capture from your editor. Code in screen captures **will be ignored**.

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| **Learning Outcome or Evaluative Criteria** | **80+** | **70-79** | **60-69** | **50-59** | **40-49** | **<40** |
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| **Outstanding** | **Distinction** | **Good Pass** | **Pass** | **Marginal Fail** | **Fail** |
| Have a comprehensive knowledge of physically-based rendering and shading | Demonstrates an exceptional understanding of physically-based rendering and shading, with the ability to explain and apply complex concepts accurately. Innovative approaches are evident. | Shows a strong understanding of the principles and application of physically-based rendering and shading, with minor gaps. Applies concepts effectively with some originality. | Displays a good understanding of physically-based rendering and shading, with correct application of most concepts. However, there may be some minor errors or a lack of depth. | Adequate understanding of basic concepts related to physically-based rendering and shading. Application is generally correct but may lack sophistication or contain minor inaccuracies. | Limited understanding of physically-based rendering and shading, with significant gaps. Application is often incorrect or superficial. | Little to no understanding of physically-based rendering and shading. Major misconceptions or errors are present, with little or no correct application. |
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| Reduce complex formulations of physically-based solutions for high performance in interactive environments | Demonstrates ability to accelerate complex physically-based formulations of rendering without sacrificing performance or visual fidelity. Innovative approaches are evident. | Shows strong skills in accelerating rendering speed, with a good balance between performance and visual quality. Some techniques may lack innovation but are effective. | Satisfactory ability to reduce complex formulations, resulting in acceptable performance. Acceleration techniques may be basic. | Displays an adequate ability to speed up the rendering process, but only basic techniques are implemented with limited speedups. | Limited ability to speed up the rendering process. Performance improvements may be minimal or at the cost of significant visual degradation. | Little to no ability to speed up the rendering process. Attempts result in poor performance or severely degraded visual quality, indicating a lack of understanding of optimization techniques. |
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| Review and critically evaluate state-of-the-art computer graphics research | Provides an exceptional and insightful critique of state-of-the-art research, demonstrating a deep understanding of the field. Analysis is thorough, original, and well-supported by evidence. | Delivers a strong and well-structured evaluation of current research, showing a solid grasp of the key concepts and methodologies. Analysis is supported by relevant evidence. | Offers a satisfactory review and critique of current research. The evaluation is correct but may lack depth or originality. Analysis is generally supported by evidence, but some areas may be underdeveloped. | Provides an adequate review of research with some critique. The evaluation is basic and may rely on summarization rather than deep analysis. Evidence may be used but not consistently or effectively. | Weak review and critique of research. Evaluation is superficial, with little understanding of the nuances of current research. Evidence is poorly used or lacking. | Fails to provide a coherent review or critique of research. Analysis is missing or incorrect, with little to no evidence supporting any claims. |