EPSRC Centre for Doctoral Training in
Sensor Technologies and Applications
in an Uncertain World

Principles of Sensing Coursework

05/11/25 v0

For this coursework, you will be demonstrating your prototyping, documentation, and report writing skills. Your objectives are:

- design and build a prototype spectrophotometer,
- create documentation so that someone can replicate your device,
- write a report about your design choices and the evaluation of the device.

1 Introduction

A spectrophotometer (also known as a photospectrometer or UV/VIS) is a device that can quantitatively measure the amount of light absorbed or reflected by a material at varying wavelengths. They are widely used in scientific research and industry, for example for concentration measurement, reaction monitoring, DNA/RNA quantification, and material science.

They are expensive pieces of equipment, and so your task is to make an open-source version that could be reproduced from inexpensive components in other laboratories. Over the next few weeks, you will need to design and build the device, write the documentation, and produce a report.

2 Design brief

You have been contracted by a fruit juice company to create a device that can test small samples of fruit juices. The minimum requirements are that your spectrophotometer should be able to classify different types of juice (apple, orange, pineapple etc), and their concentrations in water. As an extension to the brief, your device should be able to classify the age of the juice, to check whether it is fresh.

The device must be easy to use and provide a clear response for a non-technical user and should also log the data produced. Due care must be taken that the device is safe, and to minimise the risk of liquid damage (if in doubt, speak to the makerspace technicians). The juice should be contained within a removable cuvette while being analysed in the device.

3 Design of the device

There are two methods that you could consider for your device. The first is to use a thin slit, a diffraction grating, and a camera, and the second is to use a multispectral sensor (such as the AS7343). There are advantages and disadvantages to both, and you should consider both carefully. Of course, you may think of your own method, in which case you can try that!

Whichever method you choose, I would advise building and testing as soon as possible. There is only so much improvement you can make without trying it out.

We will have some samples for you to test the device. There is also a spectrophotometer in the Teaching lab, which you can use to calibrate and benchmark your prototype.

4 Documentation

Open source hardware is increasingly important for scientific research. In the same way that, where possible, it is good practice to release your data, releasing your hardware designs is crucially important for others to be able to replicate your experiments.

With that philosophy in mind, you should write documentation so that your device is replicable. You should write this documentation for another engineer who is not able to contact you. Therefore, all 3D design files, components, and tools should be listed, and the instructions clear enough for them to build it. The documentation should also include operation instructions for the non-technical user.

You can either write your documentation using an online tool, or in a word/latex document. The complete documentation should be included as an appendix in your report.

5 Report

The report should be written for a technical audience (e.g. postgraduate students and researchers), should be concise, and use all the usual conventions of technical writing (such as section headings, figures, tables, and references). You will be given a LaTeX template.

The maximum word count is 2000 words (not including appendices). The recommended structure is:

- Abstract (200 words)
- Introduction (100 words)
- Physical principle of method (200 words)
- Description and justification of the device design (including bill of materials and costs) (800 words)
- Evaluation (600 words)
  - Evaluation of the device's performance
  - Quantitative and qualitative assessment of the device's uncertainties
  - Improvements you would make in the next iteration of the device
- Conclusion (100 words)
- Appendix: Documentation

6 Submission

You should submit your report on Moodle, with your documentation as an appendix, by Tuesday 16 December at 5pm.

7 Logistics

Like the challenges given to you in the practicals, this project is an opportunity for you to expand your knowledge and skills, and so you should make full use of the resources available.

7.1 Budget

You have a budget of £75. This includes all components and materials (not including the testing samples and cuvettes). A key consideration for the justification of your design should be the cost and availability of the components. You can also use your Arduino or Raspberry Pi boards.

To order components, please complete the order form. All components must be bought from a University approved supplier. Yuqi will be able to help you with ordering. Materials from the Makerspace and CEB stores can be charged to the Sensors account following their procedures, but remember to keep a track of your spending.

7.2 Makerspace

You should make full use of the makerspace and the technicians. Get the training for the machines that are in Tier 1, and ask Josh if you would like use of the machines in the Tier 2 space.

7.3 Drop in sessions

There are weekly drop in sessions scheduled in the MRes calendar, for you to ask questions or for advice. Of course, you can also email or speak to me at other times.

Assessment Rubric

Report (70%)

Criteria	Marks	Outstanding (≥85%)	Distinction (75-84%)	Pass (60-74%)	Unsatisfactory (<60%)
Scientific explanation of method	20	Clear, detailed and logical explanation of method; Includes all scientific principles; Uses precise terminology	Coherent explanation of method with minor gaps in detail or reasoning; Shows understanding of relevant scientific principles; Uses appropriate terminology	Provides a basic description of the methods; Limited or superficial reference to scientific principles; Lacks clarity in terminology	Explanation is unclear, incomplete, or incorrect; No reference to scientific principles; Inappropriate terminology
Description and justification of device design	40	Clear, detailed description of the device; Strong, logical justification for all design choices; Links choices to functionality and constraints	Description is mostly clear with some minor omissions; Good justification for most design choices, but some reasoning could be stronger; Mentions constraints but lacks depth in explanation	Basic description with limited detail and some inaccuracies; Limited justification and reasoning is superficial or incomplete; Constraints are acknowledged superficially	Vague or incorrect description and lacks essential details; Little or no justification, choices appear arbitrary; constraints ignored or misunderstood
Evaluation	25	Comprehensive critical evaluation of the device's performance. Includes a clear test plan, uncertainty analysis; Data is well presented with insightful interpretation and realistic improvement suggestions	A thorough evaluation of the device's performance; Includes some uncertainty analysis; Data is presented clearly, and conclusions are logical, with some improvement ideas	A basic evaluation of the device's performance; Limited discussion of uncertainties; Includes some data but interpretation is minimal and suggestions are generic	Evaluation is incomplete or superficial; Lacks meaningful uncertainty analysis; Lacks data and no clear conclusions or improvement suggestions
Presentation of report	15	Report is exceptionally clear, professional, and well structured; Includes logical flow, accurate headings, well-labelled figures/tables, correct units, and consistent formatting; Writing is concise and free of errors	Report is clear and well-organised with appropriate headings and mostly correct formatting. Figures and tables and labelled and relevant; Minor language or formatting issues do not affect readability	Report is adequate and organisation is basic; Some headings or labels are missing, and figures/tables are unclear or poorly formatted; Writing contains noticeable errors but meaning is understandable	Report is poorly presented; Disorganised structure, missing or incorrect headings, unlabelled or irrelevant figures/tables; Numerous language errors make interpretation difficult

Documentation (30%)

Outstanding (≥85%)	**Distinction (75-84%)**	**Pass (60-74%)**	**Unsatisfactory (<60%)**
Documentation is complete, clear, and highly professional. Includes all essential elements: detailed assembly instructions, bill of materials (with part numbers and sources), wiring diagrams, firmware/software setup, troubleshooting guide, and licensing information. Uses consistent formatting, diagrams, and clear language. Enables full reproducibility without external clarification.	Documentation is well-structured and mostly complete. Includes assembly steps, parts list, and basic diagrams. Minor gaps exist (e.g., limited troubleshooting or unclear formatting), but device can be reproduced with minimal effort.	Documentation is basic and partially complete. Provides some assembly instructions and parts list but lacks clarity, diagrams, or troubleshooting information. Reproduction is possible but requires significant interpretation or guesswork.	Documentation is incomplete or unclear. Missing critical elements (e.g., parts list, diagrams, or setup instructions). Device cannot be reliably reproduced from the provided information.