PART IB EXPERIMENTAL ENGINEERING

SUBJECT: **MATERIALS** **EXPERIMENT M1**

LOCATION: **MATERIALS TEACHING LABORATORY** **(SHORT + LONG)**

MATERIALS CHARACTERISATION

Note: A Moodle site accompanies Experiment M1, containing further information and copies of the supplementary lab handouts, for reference (hard copies of supplementary handouts will be provided during the lab). To find the site go to:

https://www.vle.cam.ac.uk/

and log in with your Raven password.

Introduction to M1

A key theme of the IB materials course is the connection between the microstructure of materials and their properties. This extended lab exercise focuses on the mechanical properties of materials and the methods used to obtain them. It is synoptic in nature, drawing not only on the materials course, but aspects of dynamics, vibrations and structural mechanics. The specific objectives are:

- To introduce a wide variety of materials characterisation techniques, from cheap and simple approaches to more expensive commercial testing machines.
- To evaluate the accuracy of experimental measurements, and assess the strengths and weaknesses of different approaches.
- To consider the relationship between the material, its microstructure, the property of interest and the most appropriate measurement technique.
- To apply these ideas in order to solve a realistic, open-ended materials characterisation problem, and then report in a clear and concise way on the methods used and the final results.

M1 is an extended exercise consisting of three sessions, including two timetabled lab slots (refer to the IB coursework timetable) and one additional afternoon session:

Session 1: introduction to materials characterisation methods

- Timing: This is a 2 hour lab which takes place during the first timetabled M1 lab slot.
- Location: Materials Laboratory, Inglis Building, ground floor.

The objective of this short lab exercise is to introduce a variety of materials characterisation techniques. A series of exercises will be completed, each introducing a particular measurement methodology. By the end of Session 1, you should have a sense of the strengths and weaknesses of each of these approaches. Six techniques will be presented in total:

- *Commercial testing instruments:* (i) an 'Instron' materials testing machine, (ii) a dynamic mechanical analyser ('DMA') and (iii) microscopy (video microscope). These instruments are typical of the equipment found in many materials testing labs in industry and research.

- *Low cost techniques:* (i) beam bending using hanging weights, (ii) beam vibration measurement and (iii) measurement of plate vibrations using 'Chladni patterns'. Often it is possible to obtain good materials property data with much simpler apparatus.

The six characterisation techniques are split into two sets: A and B. Each student will attempt the exercises in either set A or set B. Groups should spend no more than 30 minutes at each station. It is important to keep to time - the demonstrator must rotate the groups after 30 minutes. The lab demonstrator will lead a discussion of all six test methods at the end of the lab.

Note: Detailed instructions for each set of exercises, A and B, will be handed out during the lab session. If you wish to read through these in advance they are available to view on the Moodle site.

Session 2: characterisation mini-project

- Timing: This session is not formally timetabled – equipment in the Materials Laboratory may be booked out at any time during the afternoons between the two timetabled M1 lab slots. Booking sheets are provided in the lab. It is expected that each lab group pair should aim spend approximately 1-2 hours in the lab.
- Location: Materials Laboratory, Inglis Building, ground floor. A post box is provided in the lab for handing in summary reports.

In Session 2, you will apply the techniques learned in Session 1 to solve a more open-ended materials characterisation problem. Each group will select one mini-project from a list of six options. Each project investigates some aspect of materials characterisation. **Note:** you should work in **lab group pairs** for the mini-project.

You will need to complete the following tasks:

1. As a lab group, plan your strategy for investigating the problem. Decide what measurements to take and how best to perform them, using the information from the Session 1 handouts and the Moodle site for guidance.
2. Book the apparatus you think you will need to carry out your measurements. Equipment may be booked out during the afternoons. Plan your time carefully, to make sure you have time to complete the necessary measurements before the report deadline (see below).
3. You should expect to spend approximately 1-2 hours in the lab performing the experiments. Use your lab books to record your measurements and experimental methodology. You will need this information when reporting on your mini-project.
4. Write up your mini-project in the form of a short report.

Note: Briefing notes for each mini-project are provided in the Materials Laboratory. If you wish to read through these in advance they are available to view on the Moodle site. The Moodle site also contains information on all pieces of test equipment, for reference during the planning process.

Practical arrangements:

You are encouraged to use the following four pieces of equipment to tackle the mini-project. The apparatus is versatile, and in many cases can be adapted for a variety of tests. Each piece

of equipment may be booked out during the afternoons, using the booking sheets in the Materials Laboratory, and used without supervision:

1. Video microscope. This can be used to investigate microstructures, deformed specimens, fracture surfaces etc. It may also be useful to create illustrations for the report and presentation (see below).
2. Beam vibrations rig. Useful for measuring elastic properties, the results are clearest for materials with low damping.
3. Hanging weights rig. This rig may be used for performing beam bending experiments. The knife edge supports are adjustable, to vary the beam length. This rig is also supplied with a compression platen for compression testing (place the specimen directly onto the steel supporting plate, put the compression platen on top and hang the weights from this).
4. Plate vibrations rig. Take care to place the box over the loudspeaker during tests to protect your hearing.

The following pieces of kit have **restricted access** for the mini-projects:

1. Instron testing machine. For safety reasons the Instron **must not be used unsupervised** under any circumstances. Although most mini-projects can be tackled using the apparatus listed above, if your experimental plan calls for the Instron test machine it may be booked out for limited periods when a technician is available. The booking sheets are in the Materials Laboratory.
2. Dynamic mechanical analyser. For safety reasons, the DMA apparatus **may not be used** for mini-project work.

Written report

A short summary report must be written after completing your mini-project. This must not exceed **2 A4 pages** in length **excluding** figures. Reports should be **word processed** in 12 pt font, single spacing. Figures should be clear, readable and well labelled. All figures should have a number and a short caption. **Reports should be written individually – copying and pasting from your lab partner's work is not acceptable**. The top of the first page should contain your name, your lab group number, the date and the title of the mini-project. The report should contain the following:

1. Introduction. A brief outline of the mini-project, and the problem to be solved.
2. Experimental method. How you decided to tackle the mini-project. What tests you chose to perform and why. Do not reproduce details of standard experimental techniques (refer instead to the appropriate section of the handouts if needed).
3. Results. Your measurements, including any graphs and brief calculations.
4. Concluding discussion. Some interpretation of the results. What you found out.

Note: The report must be handed in before Session 3. The deadline for handing in your report is listed on the Moodle site. Reports should be handed in using the post box in the Materials Laboratory.

Session 3: feedback session

- Timing: This is a 1 hour session which takes place during the second timetabled M1 lab slot. **Exact times and locations for each lab group pair are listed on the Moodle site.** The feedback session will take place approximately two weeks after Session 1, to allow time to complete the mini-project.

- Location: Refer to the timetable posted on the Moodle site.

In this session, a short presentation will be given by each lab group pair, outlining the task, the chosen method and the results. Feedback will be provided on the presentation and the short report. Session 3 replaces the usual long lab mark-up arrangement. The session will last for 1 hour – the remainder of the lab slot is free.

- Each lab group pair will give a short presentation, summarising in a concise and clear way the findings of the characterisation mini-project. The presentation should be a brief summary of your task, methodology, results and conclusions, and should be **5 minutes** in length. Each partner will be expected to contribute equally to the talk.
- You should prepare some slides to accompany your presentation. A networked computer and projector will be available during the presentation session. Your slides should be clear and easy to read. As a guideline, 1-2 slides per minute of presentation, depending on the content, is usually the most you will be able to cover without over-running.
- Think carefully about the structure of your talk, to make sure you convey your findings clearly in the time available.
- 6 lab group pairs will attend each hour-long presentation session, each delivering a 5 minute talk followed by 5 minutes of questions and feedback. The written report will also be returned at the presentation session, and marks awarded.

Assessment and standard credit

A total of 8 marks of credit are available for this exercise, with a standard credit mark of 6. This is broken down as follows:

- *Session 1:* 2 marks of standard credit are available for satisfactory completion of the exercises.
- *Sessions 2 and 3:* 6 marks are available, with a standard credit mark of 4, for satisfactory completion of the mini-project, submission of a report and presentation of the results. Failure to attend either session will result in all 6 marks being lost.

T. Savin
G.J. McShane
J. Woodhouse
September 2015